MIPALCON Conference Proceedings - Volume 2

MIPALCON 2014

Climate Change – A Global Challenge. Contribution of Infrastructure Planning

Second International Alumni Conference

Stuttgart (Germany), 23rd – 26th September 2014

University of Stuttgart

Master's Program Infrastructure Planning

Pfaffenwaldring 7

70569 Stuttgart

Supported by:

DAAD Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

finanziert aus Mitteln des Bundesministeriums für
wirtschaftliche Zusammenarbeit und Entwicklung

ISBN: 978-3-9816754-9-8

Table of Contents

Foreword

More than 30 years after its foundation in 1983, the Master´s Program Infrastructure Planning (MIP) has qualified around 400 alumni who are now helping in various ways in 70 developing and emerging countries all over the world. And the number is rapidly growing as in the last years more than 40 new students enrolled every year. There have been successes, setbacks and challenges but through it all a formidable force of intellectuals and professionals had been brought up from this interdisciplinary program. One big success factor is without doubt the multicultural background of the alumni and the present students.

In the past there have been alumni meetings as singular events on the occasion of the 10th and 20th anniversary of the study program, but the idea behind the "MIPALCON" (MIP ALumni CONference) is to establish a regular sequence of alumni conferences in order to foster the continuous exchange of knowledge and experience between the members of the MIP network. In 2010 we started with the first MIPALCON. This year MIPALCON 2014 again brought together experiences, challenges and best practices from various professionals who have already gone through the MIP studies since 1983. Supported by the DAAD and selected by review of the Scientific Advisory Committee, 15 alumni presented their current work, discussing their ideas with current MIP students, lecturers and experts from the field of infrastructure planning. This publication contains all contributions presented at the conference.

On behalf of the Master's Program Infrastructure Planning and the University of Stuttgart I hope you will find the MIPALCON 2014 proceedings both informative and inspiring.

Prof. Dr.-Ing. Markus Friedrich
Master's Program Infrastructure Planning
University of Stuttgart

Brownfields Redevelopment in the Greater Cairo Region, Potentials and Challenges

Rania Ahmed Aglan
17 Shams El-Din El-Zahaby St.,
Heliopolis, 11341Cairo, Egypt
r_aglan@yahoo.com

Abstract:
Brownfield redevelopment is a new approach for urban development that became a movement since 1980s. It is widely acknowledged as one of the major tools to achieve sustainable development. The process of industrial change, the change from an industrial to a service oriented society, has resulted in the creation of so called 'Brownfields' particularly in urban areas.
The paper is drawing a study on urban brownfiels redevelopment in the Greater Cairo Region, providing a better understanding of what brownfields are, their unique characteristics, benefits, and barriers for redevelopment, in order to improve the quality of life in the region. And trying to introduce brownfield projects competitive with greenfield projects within the future urban development plan for the Greater Cairo Region.

Key Words: Greater Cairo Region (GCR), urban redevelopment, brownfield, smart growth

1. Brownfields Background

The term 'brownfield' was initially introduced to describe sites which had been previously in use, in contrast to 'greenfield' land which had not previously been used for development (CLARINET, 2002).
Brownfileds are sites that:

- have been affected by former use of the site and surrounding land.
- are derelict or underused.
- have real or perceived contamination problems.
- are mainly in developed urban areas that require intervention to bring them back to beneficial use.

(CLARINET, 2002)
The general decline in the coal, steel, and textile industries led to the abandonment of heavy industrial facilities, which was the main reason for the redevelopment of urban brownfield sites approach worldwide especially in the industrial countries.
On the other hand, urban brownfield sites redevelopment is one of the major tools for supporting the reduction of greenfield consumption and the avoidance of urban sprawl, which had been identified as a key indicator for sustainable development and smart growth.

2. The Greater Cairo Region

Cairo is Egypt and Egypt is Cairo. (Sims, 2012) Since its establishment more than 1000 years ago, Cairo has continued to represent the main historical, economic and urban pole for Egypt. (ElKouedi & Madbouly, 2007) Cairo is not only the capital of Egypt, but also the most important city in Africa and Middle East, and one of the world's largest metropolises when we include the adjacent urbanized areas.
The "G.C.R." Greater Cairo Region was defined by the General Organization for Physical Planning GOPP in 1982, which is the urban agglomerate that consists of the whole governorate of Cairo in addition to, Giza and Qaliobeya governorates, besides another eight new towns located around Cairo. The G.C.R.'s population reaches about 16 million and it is expected to reach 24 million in 2020 with an area of 850,000 acres. (GOPP, 2009)
Two third of the country's gross national product is generating in the G.C.R., and almost 25 % of the population occupies in the G.C.R. (UN-Habitat, 2011)
The economy of the G.C.R. is probably contributing half of the GDP. (Sims, 2012)

3. The Greater Cairo Region Challenges

The Greater Cairo Region is the prime engine of economic growth and the main population center in Egypt, this fact comes with many key challenges; most importantly planning, infrastructure and service delivery which has been managed to barely keep up with the very rapid urban growth over the past four decades.
Besides, being the seat of Government and the concentration of main services and facilities has contributed to the excessive growth of the region. (ElKhouedi & Madbouly, 2007) The G.C.R. has been the main attraction point in the country, and the terminus for internal migration from rural areas and small size cities, almost 40% of job opportunities and major educational, health and other facilities exist in the region (GOPP, 2009). Over 50 % households live in informal settlement, out of which 80 % built on agricultural land. More then 90 % have access to utilities. (ElKhouedi & Madbouly, 2007) Informal housing in the G.C.R. is generally of good construction quality, but its growth has not been well guided. The main challenges facing the GCR due to the population increase:

- The unplanned growth of the built-up area
- The excessive pressure on infrastructure
- Environmental degradation and high rates of pollution
- Major traffic and transportation problems within the region
- Weak connectivity between existing built-up area and new urban communities
- The economic competitiveness of the region

(ElKhouedi & Madbouly, 2007)

4. Dynamics of urban growth

4.1 Building on state desert lands

Large areas of desert have been converted and developed informally over the years. Others areas have been, and continue to be, developed in the intense public and private building rush that is creating the new cities, industrial areas, gated

communities and other ‘elite spaces’ or new settlements around Cairo. Many of these developments were allegedly purchased and developed under the regulatory mechanism.

4.2 Building on agricultural lands

Large areas of the G.C.R. were, and continue to be, developed informally on agricultural lands. Most of them are low income informal housing that had developed on the precious agricultural land due to:

- Housing built on agriculture land costs less than housing built in the desert.
- The type of housing provided by private developers on agriculture land corresponds to the actual demand of a large segment of the population.

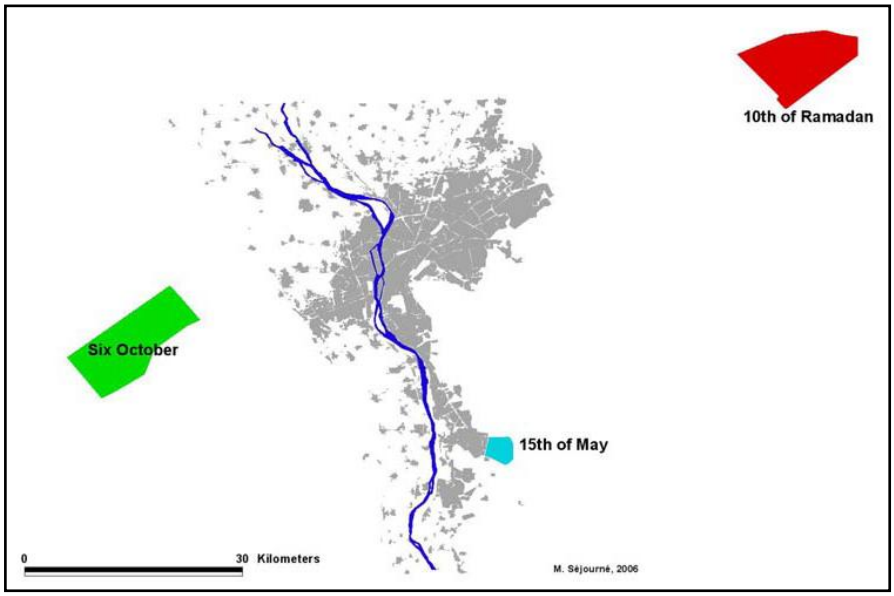


Figure 1: The G.C.R., New Towns & Satellite cities (end of 1970s) (Source: ElKhouedi & Madbouly, 2007)

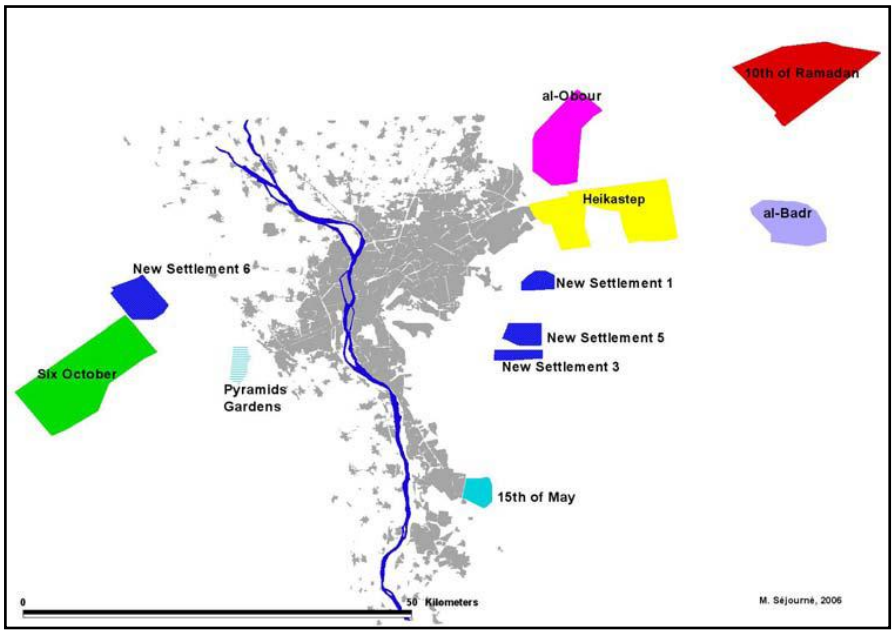


Figure 2: The G.C.R., New Towns & Satellite cities (up to the mid 1980s) (Source: ElKhouedi & Madbouly, 2007)

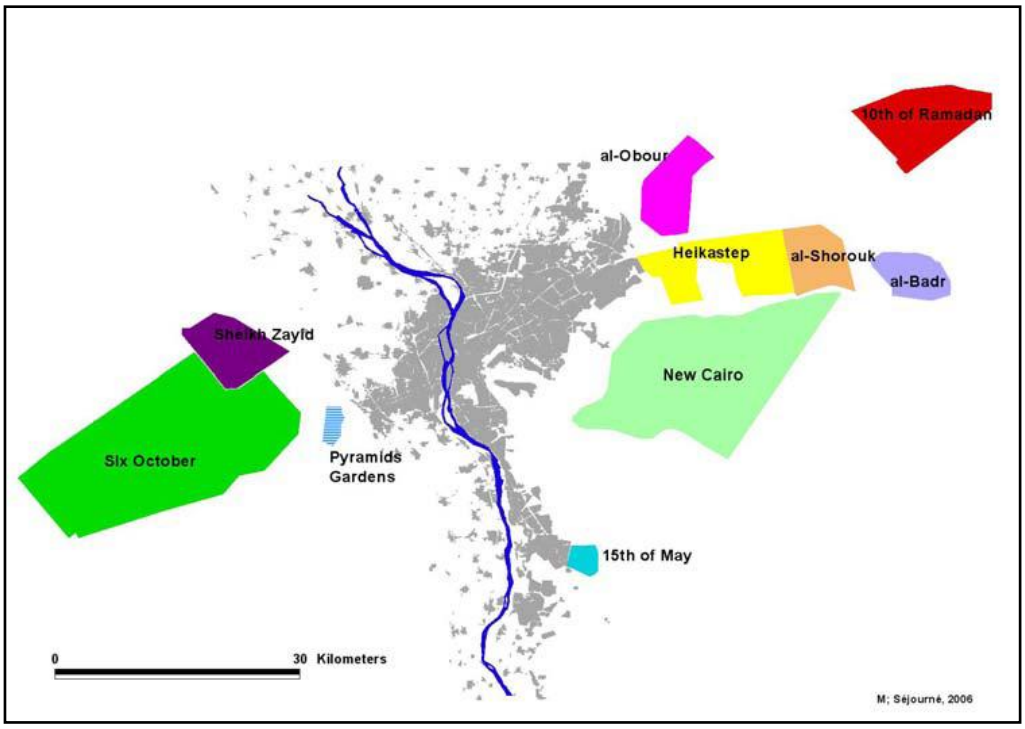


Figure 3: The G.C.R., New Towns & Satellite cities (early 1990s) (Source: ElKhouedi & Madbouly, 2007)

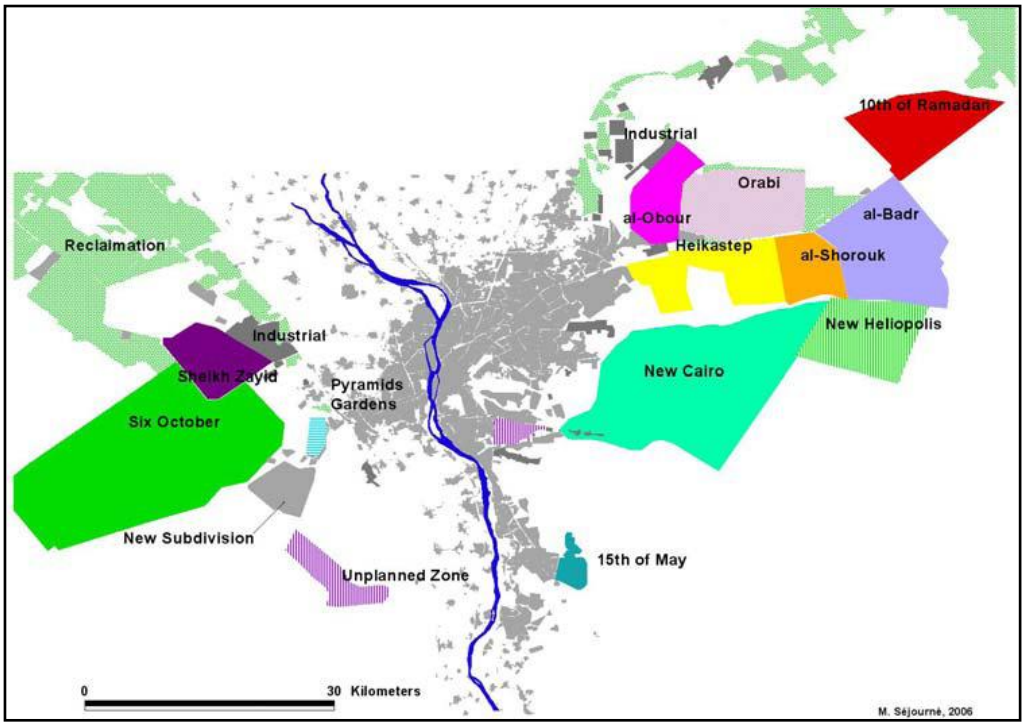


Figure 4: The G.C.R., New Towns & Satellite cities (in the 2000s) (Source: ElKhouedi & Madbouly, 2007)

5. Where and How to Grow and What are the Priorities

There are questions have to be asked, after the huge expansions outside the region as shown before. And with the answers, the urban development strategies might

need to be shifted again to inside the region:

- Is the current spatial fabric the most efficient?
- To what extent have new towns and satellite cities met the population target?
- What about relocation of polluting industries and workshops from core urban areas?

5.1 Brownfield vs. Greenfield

Despite that greenfield development (on the desert or on agriculture land) still has more attraction since the process is simpler, cheaper, and quicker, brownfield redevelopment is becoming an important tool to achieve sustainable development and reduce sprawl.

- The advantage of compact city design:
  - Saving resources (land / agricultural land, energy, water … etc.)
  - Reducing transport needs "City of short routs".
  - Upgrading the existing infrastructure instead of developing a new one.
  - Efficient land use.

- The advantage of the rehabilitation of old deteriorated areas:
  - Finding remedy for the problems.
  - Environmental clean up.
  - Regeneration of the building stock and the existing infrastructure.
  - Growing value of real property.
  - Attracting investors.
  - Creating places for work

On the other hand, the development around the region on the desert has not been able to provide a complete alternative to informal urban growth on agricultural land for at least four reasons:

- High standard plots which are not within the financial means of at least three – quarters of the population.
- The lack of affordable and efficient public transportation systems. Also, the level of services (schools health services, and entertainment facilities) is considered less than adequate.
- Development of infrastructure in anticipation of demand which places a heavy financial burden on the government.
- “Concession” planning in the Greater Cairo agglomeration, often with a lack of functional consistency between concessions, this creates wastage of infrastructure and public facilities and an imbalance between employment and residential areas.

In addition, the development around the region on the desert did not solve the problems of the crowded Cairo because they are mostly housing and commercial projects and the whole residence of these projects are traveling crossing the capital everyday for other activities. These projects could solve the housing problem for a small group but with a high economical cost.

5.2 Why brownfield redevelopment?

Brownfield reuse preserves undeveloped green space, protecting it as a scarce resource and common good, and decelerates urban sprawl. In addition, the redevelopment of city's brownfield sites brings missing or new uses to urban areas where infrastructure already exists. Infrastructure as a common resource has to be built and maintained. However, the more disperse settlements are, the more expensive their infrastructure becomes. Urban redevelopment, principally through brownfield sites reuse, can be the major strategy to maximize the utilization of existing urban infrastructure.
Brownfields in the G.C.R. offer the best chance to create something completely new function within the existing texture of the urban space. Improving the urban fabric and the urban land use plan, by the redevelopment process, will reformat the economic map of the city and will generate economic benefits.

6. The Greater Cairo Region Sustainable Brownfields

Urban brownfield sites have become an inevitable need across the Greater Cairo Region's urban development challenges which cannot be alleviated by the normal process of modernizing the built environment of cities. Many sites can be restored to improve the environment and to attract new investment for jobs, housing or public facilities. At the same time the G.C.R. is expanding outwards, containing large amounts of unused, derelict land 'brownfield sites' and high number of empty or non effectively used properties. These unused derelict areas need to be brought back into productive use to alleviate pressure for new development outside the region.
Brownfield sites have a good position, being centrally located, good access to public transportation, and location in an urban environment. Their central location provides them with opportunity for a broad spectrum of uses.
The G.C.R. needs land for housing, including affordable housing; for parks and green spaces; for schools and community centers; and for commercial and retail. Therefore Cairo's stock of brownfield land is an important national resource that should be used effectively to meet many of the region's land use needs for the future.

6.1 Definition of 'Brownfield' in Egypt

There is no definition specifies the term 'Brownfield' in the Egyptian laws, however, the law identified areas to be renovated and developed through the strategic plan of the city. According to the General Organization for Physical Planning (GOPP) the term 'Brownfield' has not been used before in any of the previous governmental studies or plans except in "Cairo 2050" the previous regime's national urban scheme. But there was no common agreement on the criteria used to define the relevant sites or building in the redevelopment process.

6.2 Economic and social changes that caused the creation of brownfield sites in the Greater Cairo Region

- The change of the economic activities in the G.C.R.
- The shift from old industries to new highly productive activities.

- The raise of new industrial zones in the new towns around the region.
- The raise of satellite cities and gated communities around the region.
- The issue of informal settlements.
- The deterioration within the historical and old districts.
- The deterioration within the city centre.

6.3 Benefits of brownfield sites redevelopment in the Greater Cairo Region

- Improve the urban fabric and the urban land use plan, which will generate new activities and economic benefits.
- Increase the rate of employments.
- Raise the value of land, especially in the deteriorated areas.
- Maximize use of existing infrastructure.
- Control air pollution by relocate industrial areas.
- Raise the rate of green areas and open spaces.
- Brownfield redevelopment will allow using the new technologies and the new methods for sustainability in the redeveloped sites.

6.4 Challenges and barriers for the re-developing process

- The contaminated land and highly polluted areas.
- The resistance from people to change / land use change and redevelopment, probably because of not being consulted.
- Absence of trust between people and the government.
- Current mechanism of public land tenure and disposition is complex, contradictory and overlapping as: public land is classified into 3 main categories with different controlling entities within each one. 9 Ministries have direct or indirect control over land in addition to 3 Governorates.
- Uncoordinated policies & plans.
- Ineffective land use planning.
- Lack of information & integrated database for land and infrastructure.

7. How to Bring Life to the City?

The task is re-planning the city to enhance the urban productivity along with the priorities of reducing urban poverty and enhance the city environment. Study the urban fabric for the neighborhoods of the city trying to figure out what is missing, and at the same time trying to figure out the potential areas which can carry out the missing activities. The re-development process should evaluate:

- Needs and wants of the population.
- Land characteristics and value.
- Various solutions or scenarios to land uses before changes are made.

7.1 Potential brownfield sites within the Greater Cairo Region

a. Old industrial areas / factories / workshops / yards.
b. Unplanned and deteriorated areas which located at zones with high potential for new projects (Nazlet ElSeman near to Giza pyramids, Maspiro along the Nile side,

Nile's islands).

c. Old buildings in the historic places at Cairo centre (Islamic Cairo, Khedive Cairo).
d. Ignored / unused land or buildings which located inside the city.
e. The whole cemeteries which located inside the city (City of the dead: Salah Salem cemeteries).
f. Old railway depots downtown (Ramsis street).
g. Old ports and storages on the Nile River (West bank of the Nile, Embaba Nile's front).
h. Some of the military camps which located inside the city
i. Informal settlements:
    - Area sanitation: a complete demolition and a complete new construction (insecure / unsafe areas).
    - Area improvement: upgrading unplanned and poor areas by redeveloping some brownfield sites (unplanned areas).

In the 2009, the latest survey contained all parts of the G.C.R. made by the GOPP and UN-Habitat, the total areas of brownfields inside the region are about 2,484,305 meters squares, with land values range between 1,000 to 40,000 Egyptian pounds per meter square. The ownership of these brownfields is varied between governmental bodies, private sector and associations. The governmental bodies represent more than 60% of the total area of brownfields in the region.

Figure 5: Nazlet ElSeman Area
Source: GOPP, 2009

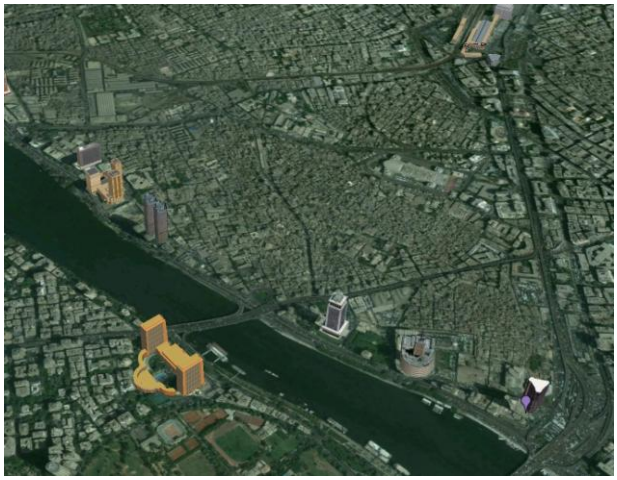


Figure 6: Maspiro Area
Source: Google Earth, 5th of Oct. 2010

Figure 7: El-Dahab Island
Source: GOPP, 2009

Figure 8: Khedive Cairo
Source: GOPP, 2009

Figure 9: Salah Salem cemeteries
Source: GOPP, 2009

8. Conclusion

The Greater Cairo Region is the prime engine of economic growth and the main population center in Egypt. The redevelopment of urban brownfield in the G.C.R. is realized as a potential 'win – win' situation, since brownfield sites have a great potential to shape the urban fabric of the future, create jobs and tax revenue, and improve the environment and the social life. Giving the chance to relocate the activities and the services by changing the land use, will motivate or attract investments and can solve many of the people problems and the G.C.R problems.

Shifting the urban planning tasks from greenfield development to brownfield redevelopment, will lead to new planning objectives, requirements, policies and challenges. To give support to the process of urban brownfield redevelopment, the following issues should be put forward:

a. The Greater Cairo Region needs a new strategic plan based on sustainable principles. Integrate the urban brownfield redevelopment in the future strategic plan for the G.C.R.
b. New strategies, policies, and laws for urban planning and design, are needed. There must be a section in the Unified Building Low to define what meant by “Brownfield”, how to classify them, how to deal with them.
c. Carry out a detailed survey on the whole potential brownfields in the G. C. R.
d. Establish a new authority body to be responsible for brownfields in the G.C.R., to manage, to monitor, and evaluate the new projects.
e. Set a new economic and productive framework for the urban communities, including the connections and the changes of the physical form of the city.
f. Identify and assess potential brownfield sites within the region, draft a redevelopment strategy, get the private sector involved in developing those sites.
g. Promote the redevelopment and the reuse of brownfield sites within the Egyptian planning strategies context.

References:

Contaminated Land Rehabilitation Network for Environmental Technologies (CLARINET): Brownfields and redevelopment of urban areas, August 2002

Koll-Schretzenmayr, Martine: From Greenfield development to Brownfield redevelopment, DISP 139, 1999

Sims, David: The case of Cairo, Egypt, Understanding slums, case studies for the global report on Human Settlements, 2003

Sims, David: Understanding Cairo, The logic of a city out of control, The American University in Cairo Press, 2012

General Organization for Physical Planning (GOPP): The national urban development plan in the Arab Republic of Egypt, 2009

General Organization for Physical Planning (GOPP): Vision of Cairo 2050 within a national vision of Egypt, Ministry of housing, utilities and urban development, 2009

ElKouedi, Hazem & Madbouly, Mostafa: Tackling the shelter challenge of cities – thinking it through together, Cairo, Egypt, General Organization for Physical Planning (GOPP), Ministry of housing, utilities and urban development, 2007

UN-HABITAT: Cairo, a city in transition,ISBN NO. (Volume):978-92-1-132353-5, 2011

Social Housing Programs for Risk Areas in Fortaleza (Brazil)

Renato Pequeno
Universidade Federal do Ceará, UFC – Departamento de Arquitetura e Urbanismo
Laboratório de Estudos da Habitação, LEHAB
Rua Vicente Leite, 2121 – 301, CEP 60170.151 Fortaleza – CE, Brasil
renatopequeno@gmail.com

Abstract: This paper presents the results of researches developed at the Laboratory of Housing Studies, within the Architecture and Urbanism Department at the Federal University of Ceará, dealing with the responses provided by public and private sectors for solving housing issues, as well as the reactions of excluded groups. The metropolitan region of Fortaleza has been the main target of these studies. Its urban growth is closely associated with the concentration of investments by the State resulting in significant migration flows from the semiarid regions, where climate conditions are shown increasingly adverse. It is important to mention that Fortaleza is the 5th biggest Brazilian metropolis with 3.6 million people, an example of macro-cephalous process of uncontrolled urban growth dominated by lack of urban infrastructure, land illegality and precarious buildings. Among the reasons of its urban problems: the lack of metropolitan governance, the absence of a plan for metropolitan development and the increase of urban poverty. Fortaleza is marked by the spread of illegal occupation, and brings together more than 620 favelas in their territory, of which 103 are under risk situation. Land slides, the collapse of river borders and floods become more and stronger due to the intense rains, concentrated in a few hours. Due to pressure from social movements, these areas have been the main targets for public policies on social housing over the last decade. Currently the on going actions make use of resources from federal programs, usually dissociated from urban planning processes and disconnected from other sectorial policies. Two phases were identified, considering the social housing policies for families living on risk areas implemented by the Foundation of Social Housing of Fortaleza: - firstly, the resettlement of families in small nearby sets aiming to preserve social and economic relations of the families with the surroundings; - secondly, the displacement of families to large peripheral housing estates destroying old and socially made neighbourhood links and grouping several communities into one set, which is diametrically opposite to the other. Among recent actions, the Maranguapinho project deserves a highlight. Focused on more than 40 communities attending more than 10,000 families to be resettled in 13 housing projects, this plan also involves: the construction of dams to contain flooding in the headwaters of the rivers that form this watershed, the urbanization of the Maranguapinho river banks and the implementation of infrastructure. Although the planned actions have not been performed in its entirety, it is possible to identify some problems directly associated with its fragile planning process. In summary, it appears that projects undertaken without considering their inclusion in urban planning processes and fragile institutional conditions tend to have serious problems such as waste of resources and serious inconvenience to the families involved. The adoption of participative planning process should be a way to improve new development projects.

Key Words: housing programs, urban policies, squatter settlements, risk areas

1 Introduction

Brazilian urbanization stands out for the intensity as the population has progressively moved from the countryside to the cities during the second half of the XX Century. These results in a process of demographic distribution extremely concentrated in metropolitan areas and intermediate cities, deeply marked by the socio-spatial inequalities in access to infrastructure and urban services. This paper intends to analyse the results of this process in Fortaleza, fifth most populated municipality in Brazil (2.6 million inhabitants), whose size of its metropolitan area reaches more than 3.6 million people. This metropolis is also distinguished by its large region of influence, whose demographic quota exceeds more than 20 million inhabitants, only smaller than São Paulo and Rio de Janeiro.

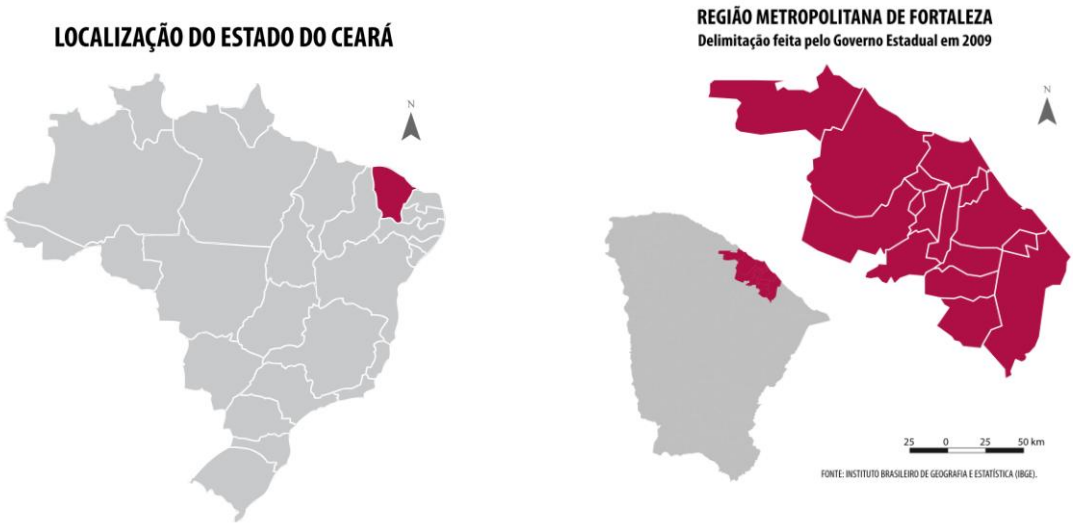


Figure 1. Localization of Metropolitan Region of Fortaleza in Brazil

Along its history, Fortaleza has shown many different urban standards directly linked to housing market entrepreneurs and their targeted social groups, among which we highlight: - settlements produced by formal real estate sectors, with good infrastructure for populations with high purchasing power; - neighbourhoods made out of social housing units developed by State, mostly located on urban outskirts, with sanitation networks, paved roads and basic social infrastructure; - precarious districts out of popular quarters and slums with neither infrastructure nor basic services, marked by informal land tenure and poor urban quality.

Considering the problems associated with flooding and landslides, worsened by climate changes, it is observed the selectivity as they affect and aggravate in precarious neighbourhoods. Recognized as environmental risk areas, the presence of these urban fragments in many cityscapes in Brazil has increased, gaining space in the media as a challenge to be faced by politicians and urban managers.

Occupied by low-income families, which in the past have migrated from rural areas escaping the drought and in search of facilities present in urban areas, the precarious neighbourhoods have exposed the most impoverished social segment of Fortaleza to new problems associated with environment conditions. In fact, due to urban infrastructure shortage, residual spaces are intended to socially excluded groups,

where floods become a large issue such as those located on river banks, creeks, lagoons and slopes.

However, from mid-1990s the problem of environmental risk areas gained wider evidence. Coincidently, the process of municipalisation of public housing policies in Brazil has intensified, shifting responsibility onto local authorities, not really prepared to deal with them. This occurred specially between 1986 and 2002 when federal public investments for social housing production and slum upgrading were deeply reduced. (Cardoso, 2001) Little by little, the issues related to these areas began to guide public housing policies, leaving behind other demands such as a quantitative housing deficit, the enormous number of slum areas and squatter settlements.

At the time, a progress in terms of urban policy was just tiny. Despite the existence of the Statute of City, a Federal Law enacted in 2001 and considered quite advanced and reformist, it turns out that the vast majority of municipalities, Fortaleza among them, remains without defining a programme for squatter areas regularization and without allocating vacant land to the resettlement of poor families threatened by floods or other environmental risks.

Since 2003, when the Ministry of Cities was founded, many programs were implemented by the Federal Government in order to encourage the debate on town planning issues linked to urban mobility, environmental sanitation, land-use informality, housing shortage and risk areas. Through a framework of actions dispersed, Brazil watches the resumption of a housing multi-oriented policy, which can be confirmed by the broad spectrum of projects implemented in Fortaleza.

However, it is noticeable the dissociation between urban and housing policies as well as the evident preference of the municipality for punctual actions and small, strategically linked to traffic system building works, clearly intending the increase in value of real estate far ahead of formal housing market expansion. In fact, only in the mid 2.000 the allocation of resources to deal with the housing problem has increased. Therefore housing policies have been widely reactivated with the aim to enhance the country's economy and simultaneously to tackle the serious social problem of housing. Since then, smaller programs come to be part of much larger programs, which supplanted the idea of a multi-oriented policy.

This article aims to present, how the public housing policy has been developed in order to solve the problem here pointed to, and identify the agents involved in their roles and interests. Likewise it wishes to highlight possible representative case studies, considering the area of removal and the resettlement conditions, differentiated by dimension, site and location. In its first part, some numbers regarding the evolution of the problem of hazardous areas in Fortaleza are shown up. Then, two types of intervention are identified as the most applied: - small communities replaced in the vicinity of the area of removal in small sets; - the grouping of communities resettled on the outskirts in large sets. Finally, some guidelines are proposed in order to improve the urban insertion conditions, whether they are small or large.

2 First steps by tackling risk areas problem

As most of Brazilian cities, Fortaleza has a high population growth rate connected to the rural exodus all over the past decades, when agriculture mechanization, concentration of land ownership, lack of public investments for family farming and misappropriation of funds spent in irrigation by private sector can be identified as some of its main causes.
It is a fact that urban sprawl in Fortaleza has been marked by unplanned growth, discontinuity of its urban tissue and unequal access to urban infrastructure and services. Therefore, it is possible to mention as the main urban macro dynamics: speculation in real estate, residential segregation and increase in squatter settlements. All these phenomena came associated with unequal development conditions, resulting in more urban impoverishment. In this sense, the housing conditions should be pointed out like the variable that best explains the socio-spatial inequalities in Fortaleza.

The first survey developed by the Municipality to identify squatting areas in Fortaleza - the so-called favelas - in 1973 reported 35,000 households gathered in 81 different communities. Later, in 1985, a new survey was taken, accounting for 254 squatting areas, where at least 70,000 households were living in. In 1991 the study was once more updated, revealing the increase in the total number of favelas - 314 areas - with approximately 108,000 households, reaching more than 31% of Fortaleza's total population.

So far the issue of risk areas had not had enough attention, even though the majority of them lied on floodable areas, along rivers banks and lagoons, or on slopes of dunes. It is noticeable that the housing problem spreads in the form of irregular settlements nevertheless the State did not implement any urban or housing policies to cope with them, even though thousands of houses had been built.

In order to better understand the environmental dynamics of those settlements, it is important to call attention to some its features related to environmental conditions of Fortaleza and its surroundings: - the increase of drought cycles and the concentration of rainfall in short periods along the year; - the topographical conditions favourable to flooding where steady flowing rivers and lagoons draw the landscape in its meanders; - the presence of clay soils along the river banks and streams leading to an increase in wetland areas; - the reduction of large-scale vegetation coverage, combined with the devastation of riparian forests; the presence of areas with greater declivity exposing the topsoil to landslides, as well as the slopes of dunes; - the expansion of urbanization along the peripheral fringes occupying areas with environmental vulnerabilities; the increase of impermeable zones due to the urbanization of the most valuable neighbourhoods.

Only in the late 1990's, the problem of hazardous areas came to be highlighted, due to pressures from social movements and NGOs towards the Government agencies. At that time, according to the data of the social movements, Fortaleza had 79 risk areas, where more than 9,500 families lived. Mostly they were located on the borders of the two major rivers, which actually constitute corridors of environmental degradation.

This brought on the development of the first intervention in a risk area, by means of a partnership between the Municipality, NGOs and social movements. This project comprised the building of 228 housing units on a vacant land located nearby the risk area where their future residents were living. Both dwellings and social facilities, and infrastructure were built up as well as some social projects aimed at generating jobs and income. Moreover the project also included the construction of an urban park on the river bank where families lived before, as a way to prevent any kind of future resettlement there. However, results were not fully accomplished since political conflicts between social movements and Municipality happened, indicating a remarkable institutional weaknesses.

Nevertheless at the same time there was the opportunity for the municipality to be included into the Program Habitar Brazil (HBB), which was being implemented with financial resources from the Federal Government and the Inter-American Development Bank (IDB). This program focused on promoting institutional capacity building for local authorities so that they would be able to tackle housing issues, giving emphasis on intervention in risk areas.

HBB's main results in Fortaleza, in its first phase, were more of institutional diagnosis and the elaboration of a general intervention plan for environmentally endangered squatter areas. This planning process has identified 79 risk areas (approximately 10.000 families), which were carefully analysed through social and environmental criteria. Afterwards, one of them was selected to be a project target, receiving construction works by implementing infrastructure and improving the housing conditions. The main goal herewith was to enable local professionals to deal with these issues by promoting their capacity building.

This first intervention area selected was located close to the international airport – best known for Opaia Lagoon Community – with 500 families living on floodable areas just along its borders. They were resettled just nearby, in multi-familiar buildings. Moreover, land legalization process, social works and technical infrastructure were implemented for people living in the neighbouring quarters, who were also in conditions of illegal land ownership. It is important to be mentioned that the main legacy of this program was the creation of the Foundation for Social Housing in Fortaleza (HABITAFOR), where the actions directed to the implementation of housing projects started over. Little by little, there was an enhancement on technical assistance and new born housing programs emerging.

3 Urban intervention and housing standards in hazardous areas

Since 2003, due to creation of specific housing programs for risk areas by the Ministry of Cities, several interventions were promoted by HABITAFOR, which tries to keep the focus of housing strategies on risked areas. In 2003, the figures of families in precarious urban settlements in environmental risk kept growing. The survey published at that year estimated that more than 20,000 families living in risked housing conditions.

Despite the elaboration of a planning process for intervention in risk areas, projects performed just completely disconnected to the plan, since the selection of risked areas for intervention did not follow any scale of priorities.

As a reason for this procedure, it is possible to point out specificities of multiple programs created by the Ministry of Cities, showing limitations of the population of the communities, the predominance of shacks bordering rivers and lakes, the availability of vacant areas at the surroundings for resettlement, among other factors.

Subsequently, at the Federal Government level, the many programs were amalgamated into two: the Acceleration Growth Program (Programa de Aceleração do Crescimento – PAC) oriented an upgrade of squatter settlements, including risk areas; the Program My House My Life (Minha Casa Minha Vida – MCMV), for producing social dwellings, to supply the social housing deficit, and to properly accommodate households removed from risk areas, or cases of displacement related to construction works on urban mobility.

Nowadays, after 10 years of existence, from HABITAFOR is possible to identify two different phases related to the number of families living at the area under intervention and its location in the city.

The first phase comprises small social housing estates with up to 500 units, many of them built on land nearby communities of origin, following municipal master plan guidelines. Prior to the implementation of any project, there was a participatory diagnosis process, which at least, in theory, aimed at debating with directly affected communities, which were their wishes and proposals for alternative solutions in urban development.

These projects had as its main characteristics: - high density and intensive land occupation; - typological diversity with housing units of 2 and 3 bedrooms, as well as mixed-use units, with room for small business or services; - construction of social facilities; - complementary projects implementation regarding sanitation and environmental education as well as land entitlement for secure tenure, and income and employment generation.

In addition, some of the implemented projects had as important component an urban improvement of the surrounding areas that were not exactly under environmental risk, allowing hundreds of families the access to networks of urban infrastructure and enhancing their living conditions.

Big challenge for this type of intervention is related to obtain vacant areas for the resettlement in the vicinity of the removed community, due to the shortage of land and the increase of the land value. Moreover, the real estate sector, sometimes in partnership with the governors, has created difficulties for this resettlement in the surroundings, pushing the families to the outskirts.

Among the positive examples of intervention on risk area, the project for the community Maravilha should be pointed up, due to the procedure adopted. In this case, families were gradually removed and resettled at a neighbouring land acquired by the city, through the use of small multi-family buildings with low rise and high density. This has ensured the permanence of social relations among the families and their community, as well as the links with the surroundings, where the families have historically realized informal jobs, and taken benefit of social facilities promoted by government and churches.

In fact, despite the availability of inclusionary zoning, like the special zone of social interest (ZEIS) that could warrant land for resettlement, this phase of small housing estates has been replaced by another one, completely different regarding the size and location of the new settlements. (PEQUENO and FREITAS, 2013)

This second phase is characterized by greater housing estates. They intend to tackle diverse communities located at the same drainage basin, or similar environmental conditions, which in absence of vacant land urbanized, have been replaced at the outskirts of Fortaleza. Moreover, these new projects have brought up the problem of relocation of juxtaposed communities at the same housing estate, each of them with their specific characteristics.

The greater presence of the real estate entrepreneurs and construction management sector in decision-making process has contributed to the selection of this alternative. On the one hand, these sectors have focused on the increase of the contract in terms of the number of housing units to be built, and on the other, they have promoted the urban development of surrounding areas where the removed families were living. In this way, this second phase could be closely related to the old practice of removal and resettlement in huge peripheral social housing estates, which have been used for different cases of removals: risk areas, roads works and transport systems.

Among their urban and architectural characteristics, it could be mentioned: - the location nearby older housing estates resulting in ghettos; - the contiguity to squatter settlements increasing the socio-political fragmentation; - the discontinuity among the new and older settlements close to huge empty spaces, which quickly become the target of irregular occupations and social conflicts; - the urban morphology of the housing estate breaking the continuity of main roads; - the size of the housing estate leading to the necessity of social infrastructure; - the monotony of the urban and architectural design by adopting an unique type of building with high density.

Although part of the housing estates have been built up for the resettlement of the families of risk areas, it turns out that some problems still remains, since the urbanistic projects have not taken into account the environmental features of the site, neither considered the most suitable areas for the replacement.

Between some cases of project fails of this second phase, the Maria Tomazia social housing estate merits special attention. It has been located almost 15 km far from the centre of Fortaleza and 9 km far from the area of removal. With more than 1.200 single-family units, this social housing estate gathered families removed from two risk areas (Lagoa da Zeza and Vila Cazumba) which were located around two lagoons. Hampered mobility, lack of social facilities, social exclusion and large vacant lands nearby has brought unrest and insecurity to their residents. In addition, the population resents the stigma from other neighbourhoods. Afterwards, the number of families who have abandoned their homes has continuously increased, resulting in their return to favelas better located compared with this peripheral housing estate.

Furthermore, considering this second phase of resettlement at the outskirts, it should be mentioned that due to the availability of financial resources of the Federal Government, other spheres of government have tried to come back to the housing sector as a stakeholder. This is the case of the State Government, which had disbanded the provision of social interest housing during the beginning of the 1990s.

In fact, since 2007, the governor has taken over these activities through the Secretariat of Cities that carries forward the largest social housing project for resettlement of families of risk areas - the Maranguapinho Project described below. Among recent actions, the Maranguapinho project deserves a highlight. Focused on more than 40 communities and aiming to resettle more than 10.000 families, this plan also involves: - the construction of dams to contain flooding in the headwaters of the rivers that form this watershed; - the urbanization of the Maranguapinho river banks and the implementation of infrastructure.

Although planned actions have not been entirely performed, it is possible to identify some problems directly associated with its fragile planning process: - resettlement of communities in several large housing complexes on city outskirts; - lack of urban control in previously occupied risk areas bringing back the risk of a new squatter area; - lack of employment and income generation programs for ensuring the sustainability of assisted families; - location at the outskirts favouring the ghettoization of the housing complexes and the slummy of its edges; - Integration of urban housing estates in peripheral areas devoid of social facilities, bad mobility conditions, poor infrastructure and very high density; - the quality of urban projects worsens neighbourly relations.

Figure 2: Risk areas along the border of Maranguapinho and the resettlements

Figure 3: Housing conditions before and after the urbanization process at the risk areas on the border of Maranguapinho

Finally, it should be mentioned that newer social housing estates projects tend to present similar problems considering the urban insertion and the sites conditions. The housing estate named Aldeia da Praia is a good example. It is designated to 1,200 families removed from favelas placed in strips of land close to the beach and to the touristic harbour. Despite the proximity of relocation near the removal area, the resettlement covering a fragment of dunes merits to be better studied in function of their geotechnical conditions.

Another case that requires a deeper investigation is the Cidade Jardim, which includes more than 5.500 housing units by using the same design. The large size of this social housing estate inaugurates a new procedure that consists in the elaboration of a matrix of responsibility, considering the involvement of different agents, to ensure the deployment of social facilities such as hospitals, schools and key, crèches and leisure areas. However, its proximity to water-ponds and streams tends to generate negative impacts on the environment.

4 Final considerations

This study aims to bring out the way as the environmental risk areas came to be the main target of social housing policies in Brazilian cities through a case study done for Fortaleza, the fifth largest city in the country. This corresponds to a representative case of many other Brazilian cities, which hitherto did not possess specific institutional apparatus to tackle this problem. However, they had to face a new reality in which the problems linked to urban slums, squatter settlements and housing deficit have been delegated to them. In this context, areas of environmental risk have emerged as potential target of natural disasters associated with climatic changes.
In addition, this paper has highlighted the existence of two distinct phases, considering the social housing policies for families living on risk areas: - firstly, the resettlement of families in small nearby sets aiming to preserve social and economic relations of the families with the surroundings; - secondly, the displacement of families to large peripheral housing estates destroying old and socially made neighbourhood links and grouping several communities into one set, which is diametrically opposite to the other.

Facing this situation, some guidelines should be proposed for the attainment of new programs: - the elaboration of an objective prior study of the communities to be served in order to understand its origins and identify their specificities and their yearnings; - the compatibility of the social housing estate projects to the master plan and the social housing plan by drawing up an urbanistic implementation plan for the sector where the project will be deployed to provide main road system, mobility, social equipment, clearances, especially considering environmental conditions; - the identification of conventional and unconventional social infrastructure that may be included in the program of housing design needs in order to reduce the stigma of future residents and to insure greater integration of the project to the surroundings; - make option for projects with smaller demands in terms of number of families, as well as by the location as close as possible to the area of removal; - warrant typological diversity of buildings and housing units in terms of area, number of rooms, form and function; - consider when defining the siting of buildings the conditions of environmental comfort and privacy of the housing units.

Finally, it is important to recognize that this problem deserves an inter-sectorial public policy of medium-long term, which also requires complementary efforts: firstly, in terms of urban control, avoiding the resettlement of environmental risks areas freed from squatting; secondly, in terms of social and economic aspects, guarantying the empowerment of resettled families with enabling policies, ensure favourable conditions of resistance in the city.

References

Cardoso, A. L.. Política Habitacional: a descentralização perversa. Cadernos IPPUR/UFRJ, Rio de Janeiro, p. 105-122, 2001.

Denaldi, Rosana (org). Ações Integradas de Urbanização de Assentamentos Precários. Brasília/São Paulo: Ministério das Cidades/Aliança de Cidades, 2009.

Maricato, Ermínia. Brasil, cidades. Petrópolis: Vozes, 2001.

Município de Fortaleza (City Government - Comissão de Habitação/Housing Committee), Plano de Intervenção em Áreas de Risco, Fortaleza, 2001.

Pequeno, Renato, Desenvolvimento e Degradação do Espaço Intra-urbano de Fortaleza, PhD Thesis submitted to FAUUSP, São Paulo, 2002.

Pequeno, Renato, Intra-urban social-occupational structure and Housing inequalities. In: Public Versus Private Planning: Themes, Trends and Tensions - International Planning History Society - 13th Biennial Conference, Chicago, 2008.

Pequeno, Renato, Como Anda Fortaleza. Rio de Janeiro: Letra Capital, 2009.

Pequeno, Renato, Freitas, C. F. S., Programa Minha Casa Minha Vida em RMF: Primeiros Resultados in Cardoso, Adauto Lucio (org.), O Programa Minha Casa Minha Vida e seus Efeitos Territoriais, Coleção Habitação e Cidade - volume 1, Rio de Janeiro: Letra Capital, 2013.

A Practical Sustainable City in the Making: Planning & Development of Sino-Singapore Tianjin Eco-City

Dr. Zhou Yuliang[i]
Sino-Singapore (Chengdu) Innovation Park Development Co Ltd
Unit 10-12/19 Floor, Avic City Centre, 88 Middle Fucheng Avenue, Chengdu, China 610041
Yuliang.zhou@gmail.com

Abstract: Currently in its 6th year of development with 4 km^2 Startup Area already taking shape, Tianjin Eco-City is a large scaled township project built from scratch with systematic eco-features. The paper takes an overview and looks at various issues of its development, from initial masterplanning to implementation.

Key Words: Eco-city, sustainable development, urban solution, Master Plan, development control, eco-technology, renewable energy, green building, implementation

1 Project

Strategically located in Tianjin Binhai New Area (TBNA), the new economic engine of China after Pudong/Shanghai, Tianjin Eco-City (TEC) is a flagship project between the government of China and Singapore, envisioned to become a sustainable model for urbanizing China and beyond in today's context of resource depletion and environment degradation.

With a land area of 30 km^2 and population of 350,000, TEC features an integrated new town built on non-arable wasteland. The development will be operated fully on commercial basis, so as to be practical and replicable in other cities in China and beyond on different scale.

The term "Eco-city", as conceived by Richard Register is the healthy relationship among its parts to make an organic whole. In practice, his Eco-City linked more to the practice of green design etc[ii]. "Eco-city" means more to TEC, subscribing to the tenant of sustainable development that is environment friendly, resource efficient and social harmonious. References have been taken from Singapore's nation building process, on various unique urban solutions and particularly the mass housing/New Town experiences, which are vital to this tiny island state with scarcity of resource.

2 Master Plan

2.1 Sustainable framework

The Master Plan started at higher ministry level of both countries, who formulated a set of 26 KPIs covering 4 board aspects of sustainable development, ie. Ecological, Social and Economic, as well as Regional consideration (cf. table 1 below). This set was mainly based on pragmatic not exhaustive consideration. 26 KPIs were further

analyzed in details with regard to core factor, key process and control target, breaking down into 700+ operable control measures.

The KPI system defines the unique urban solutions of TEC and its sustainable development framework. It can also be referred to measure the success of TEC's follow up implementation.

Healthy Ecological Environment		**Social Harmony & Progress**		**Dynamic & Efficient Economy**
100% potable water	zero loss of natural wetlands	≥60% recycling rate	100% barrier-free access	≥20% renewable energy use
CO_2 emission <150 tons-C/GDP unit growth	noise levels = env.noise standards in urban areas	<120 ℓ water consumption per person/day	<0.8 kg domestic waste generation per person/day	≥50 R&D scientists & engineers /10,000 labor force
ambient air quality grade II	grade IV water standards	≥20% affordable housing	recreation & sports amenities within 500m	≥50% non-traditional water source
≥70 % native vegetation	≥12sqm²/person in public green space	100% non-toxic waste treatment	100% services network connectivity	≥50% employment-housing equilibrium index
100% green buildings		≥90% green trips		
Integrated Regional Cooperation				
Promote a safe & healthy ecology to encourage green consumption & low carbon operations				
Adopt innovative policies to ensure the improvement of surrounding areas				
Preserve history & culture to give prominence to the river estuarine cultural character				
Promote regional development through sound economic and administrative policies				

Table 1 22 quantitative and 4 qualitative KPIs of TEC (source: Master Plan report)

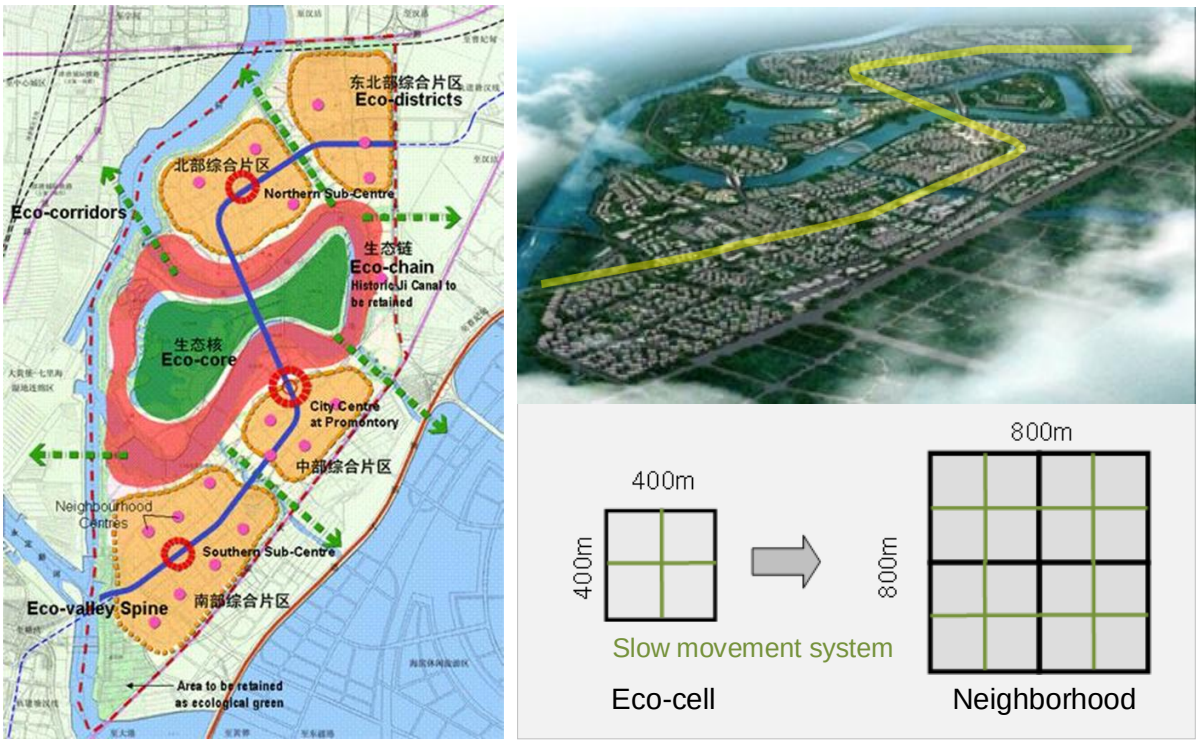


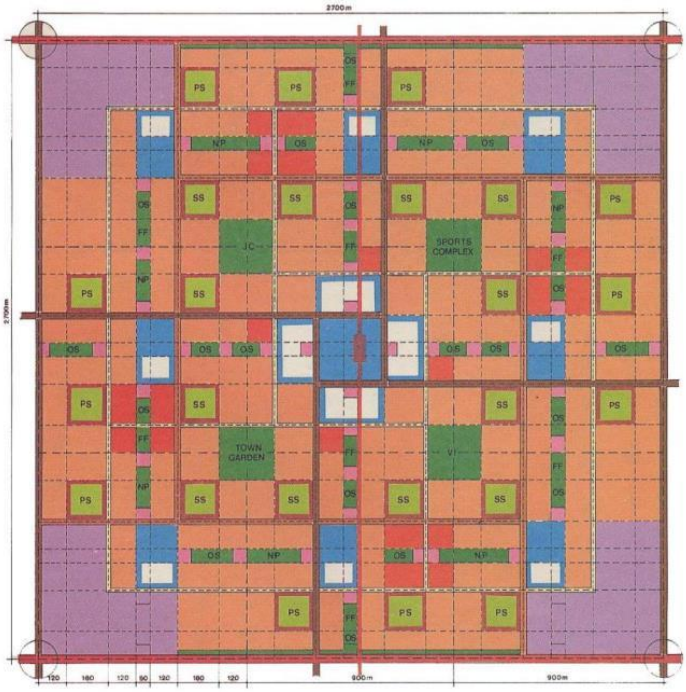
Figure 1 Master Plan structure of TEC (from left to right clockwise: Master Plan, aerial view and spatial model. Source: Master Plan report)

2.2 Spatial structure

Translating sustainable principles into spatial planning (cf. figure 1 above), a linear compact city emerged: 5 districts together with 3 urban centers were linked by the transit and activity corridor, the 12 km long Eco-valley. Within each district,

- Eco-Cell is the basic module measuring 400m by 400m, no further vehicular access allowed except for slow movement ie. walking and cycling etc (cf. the green line in spatial model diagram)
- Eco-neighborhood takes form by combining 4 Eco-Cells
- Both are walkable. Homes and jobs are planned with hierarchical allocation of services and facilities, integrating live, work and play in close proximity. Close references from Singapore New Town could be found (cf. figure 2 below)

Proximity and density are both true to TEC. In Asian context, high density living is in general acceptance and does not necessarily link to lower standard of living/quality of life, which was otherwise commented on TEC by western experts. In fact, compact and high density development demands less land/resources, but offer better share of public utilities/facilities; the demand both for travel and heavy investment on traffic infrastructure is reduced as well, resulting in a cleaner, quieter and more human scaled built environment.



Area: 600 – 900 ha,

Population 100,000 – 200,000

- Connected by highways for easy accessibility
- Arterial roads dividing the neighbourhoods
- Comprehensive facilities and open spaces at different planning level
- Well distribution of facilities and green
- Integrating light industries
- Community bounding and racial harmony
- Integrated lifecycle approach (plan/design/implement/manage) and cost effective solution

Figure 2 Singapore HDB New Town Structure (Source: Surbana internal briefing)

2.3 Development control

High density (plot ratio) can be obtained either with high-rise or larger footprint of buildings, typified by the following 2 scenarios (cf. table 2 below): the typical European Street Block (mid-height and larger footprint) vs. Singapore New Town Estate model (high-rise and smaller footprint). During Urban Design (UD) stage, various schemes were discussed/ debated, specifically on the scale of street/block, vehicular/pedestrian movement, as well as building footprint/height etc. The compromised

yet innovative solution was reached: the Eco-Cell as basic street block but with dedicated slow movement system crisscrossing inside the cell to make its grain finer[iii].

	Height	***Foot print***	***Features***
European Street Block	Mid-rise	larger	Human scaled and vibrant street, mixed use, flexible and adaptable
Singapore HDB Estate	High-rise	smaller	Quieter street, more green and dedicated living and amenity area (neighborhood center etc.)

Table 2 Comparison of different density model

Efficient road traffic is always a concern for new cities, but Eco-city should give more preference to green transport. To cater both to the car and pedestrian, Eco-City Administration Committee (ECAC) proposed a deck-city concept, ie. to segregate car and pedestrian vertically below and above the deck respectively, for hassle free movement of both. The priority of main urban street was actually given to the car instead of pedestrian/cyclist, conflicting with the key idea of TEC. Although the proposal was finally dropped, the roads were widened together with more car park provision for adjacent developments, to avoid congestion often experienced by the local[iv]. At present stage, it wouldn't be realistic to persuade people from driving, but the rapid increase of car uses and unavailability of quality public transport would make TEC less relevant, with its long term target set to achieve 90% green trip; changes must be made step by step.

Like other UD studies, good urban form/cityscape is always the concern; and moreover TEC should have something unique. Many design schemes were discussed, weighing imaginative proposal with pragmatic requirements; all were translated into Detailed Control Plan and UD guidelines that can be used for effective control over follow up land sale and project development.

2.4 Eco-technology

When visiting TEC, Richard Register was impressed that TEC took a systematic approach in making Eco-city, esp. with regard to the application of Eco-technology. One of the key applications is the use of Renewable Energy (RE), the 2020 target of which is set to 20%, a challenging task considering the current national average is far below 10%. This is aggregated requirement for TEC as a whole, including large dedicated RE projects and all other relevant individual projects within TEC.

Considering the reliability and cost of available technology, 5 major types of RE were deployed, ie. solar thermal & solar PV, geothermal, wind turbine and biomass/biogas. ECAC invested on large standard alone RE projects, like solar farm and large wind turbines at key corridor and gateway area of TEC, supported by special state funds to promote uses of RE. Centralized solar thermal and GSHP were mandated to be installed on all residential, commercial and industrial buildings, with potential incentive/subsidy for developers to offset partly the initial high investment[v]. The smart grid system installed in TEC, also made possible to integrate RE into the main network for better practice of energy saving.

Besides energy saving, development must all comply with Green Building Evaluation Standard (GBES), a code derived from Singapore, China and other international standards. Various practical steps are taken to ensure developments are optimized for efficient use of land, energy, materials and water, as well as efficient operations/management and eco-friendly provision of indoor/outdoor environments, in the course of full lifecycle of development, from design, construction to maintenance and operation.

3 Implementation

Implementing Master Plan started from preparation and sale of land, and then project development on the land. For the latter, ECAC and its agent are responsible for most public projects including infrastructure, public amenity and open spaces etc; 2nd tier development projects including industry, residential and commercial etc. are mainly undertaken by various developers (including SSTEC, the master developer).

Comparing with the timely implementation of public projects, as seen in TEC, good designed parks, branded school and kindergarten, Singapore styled neighborhood center and public housing etc were effective pull-in factors for move-in population; implementation of real estate projects may be influenced by the fluctuation of market[vi]. Moreover, priority on development type may vary, ECAC would opt more for industry that provides job and revenue; developers may find both the land sale and project development for industry the least profitable, but residential, retails or offices could be a better deal in terms of cash flow and return etc. There should be shared belief among stakeholders of development and effective coordination, so that conflicts of interests can always be reconciled with concerted efforts.

While effective project/construction/contract management etc are critical to the success of individual projects, it is good for TEC to build up its smart features with ICT infrastructure, providing a reliable common platform for overall management of city and its implementation[vii]. Smart system for Environment monitoring, Urban management, Industry support and Public service, can also be used for KPI tracking. By close real time monitoring, the implementation and success of Eco-city can be more effectively monitored and secured.

4 Observation

In essence, TEC introduces a paradigm shift to development, from functional efficiency towards resource efficiency. This calls for a more integrated approach in planning and managing of development, so as to ensure optimal resource allocation over time (from planning to implementation) and space (from city to the region), preferred by different stakeholders (the public and private). A good Master Planer or development manager needs to have a holistic understanding of the project, and to incorporate these dimensions although operating at different stage with different focus.

TEC, a full-fledged integrated township, is far more complex than a demo of certain features or a residential/commercial project. A sustainable city takes decades to mature, while “white elephants” and “new cities” are mushrooming in China’s overheated

real estate boom. Will TEC be just as one among them or a meaningful undertaking instead, leading the trend towards eco/sustainable living? Let's wait and see.

Notes

[i] The author was General Manager of Planning & Design Dept, Sino Singapore Tianjin Eco-City Investment & Development Co Ltd (SSTEC) for 3 years since May 2011. He was in the core masterplanning team (as physical planning consultant from Subana International Consultant, Singapore) for TEC in 2007-2009.

[ii] Please refer to related chapters esp. "Why Ecocities" and "Richard Register" on Eco-builder's website: http://www.ecocitybuilders.org/

[iii] Will still need time to get feedback from real life uses, in order to assess or to prove the relevance of this proposal. The amenity was planned spreading both along the road and slow movement system, the street space is less vibrant due to wider separation of road and less shops directly fronting the road.

[iv] Road space had further been widened with larger set back control of buildings, as more grandeur and formal image of road was expected, influenced by ECAC per local practice.

[v] Developers should also be responsible to source for cost effective solutions, as they will eventually benefited from Green Building measures esp. considering the overall cost over the full lifecycle of the project including those both for initial construction and operation/maintenance in later stage.

[vi] For example, change in real estate policy like the enactment of restricting second home ownership etc. would have great impact on the sale of residential properties, the construction sometimes have to slow down when encounter uncertainty and risk.

[vii] In 2013, TEC acquired the official status as China national demonstration project and Test-base for Smart City. The shift of industry to digital and service, virtual interaction of smart initiative is to adopt Eco/low carbon mode of production and consumption; smart system can facilitate a more intelligent use of energy in particular. Thus, smart system adds one more layer to TEC, making it a smart Eco-city.

Stakeholders Approach to Sustainable Urban Land Use Planning and Management: the Case of the Awutu Senya District Assembly in Ghana

Richard Amponsah
Ghana Institute of Management and Public Administration
Business School
P.O. Box AH 50, Achimota, Accra, Ghana
Tel: +233302401681-3
Email: ramponsah@gimpa.edu.gh

Ebenezer Adaku
Ghana Institute of Management and Public Administration
Business School
P.O. Box AH 50, Achimota, Accra, Ghana
Tel: +233302401681-3
Email: eadaku@gimpa.edu.gh

Abstract: Urbanisation is perceived as a global phenomenon. However, the phenomenon of urbanisation appears to be more critical for most developing countries, recently. The world population is expected to increase in the future and a significant share of this future global population increase would have to be accommodated by developing countries. The demographic rise – which is already manifested in most urban areas in developing countries – is and will occasion many challenges in those urban areas in developing countries. These challenges include undesirable spatial expansions, climate change, slum developments, poverty, crimes and rapid resource depletion. Consequently, this study sought to use a stakeholder analysis – a rare approach in Ghana – as a tool in ensuring a sustainable urban land use planning and management. Basically, the Awutu Senya District Assembly in the Central region of Ghana was selected as the case study area. Data for this study was collected through questionnaires, interviews and direct observations in the community. The study then concluded that the lack of stakeholder analysis in urban land use planning and management in the Awutu Senya District Assembly is the spine of the numerous urban challenges facing the District Assembly. This finding appears to be a pointer to the root cause of similar urban challenges being faced by other urban areas in Ghana.

Key words: Stakeholder analysis, urban, land use planning, Awutu Senya District Assembly

1 Introduction

Urbanisation is fast gaining prominence in global development, especially from the perspective of developing countries. The world population is expected to increase in the future and it is posited that a significant share of the increment will be

accommodated by developing countries (United Nations' Department of Economic and Social Affairs, 2007). This will invariably put pressure on lands and their management in developing countries. Incidentally, land management is central to agrarian development, environmental security, rural and urban governance, citizenry livelihood and poverty reduction. However, in most developing countries – especially in Ghana – urban land use planning which is deemed as one of the ways of managing urban lands has failed on this mandate. The reasons for this being poor or lack of proper legal and administrative framework, inadequate technical skills and financial resources, lack of participation by citizenry in planning and emphasis on "western-based" planning philosophies with assumptions that are unrelated to or inappropriate in a local context (UN-Habitat, 1996). One of the outcomes of this poor land use planning and management is what Afrane (2006) calls as "reverse development" process, where the development process – largely in Ghana – begins with land acquisition, building, occupation, services and planning instead of the conventional process of land acquisition, planning and services, building and finally occupation. The poor land use planning and management coupled with increasing population in the urban areas is increasingly leading to social, economic and environmental problems. Socially, the urban areas are confronted with the challenges of expanding slum developments, poverty and crimes. On the other hand, economically, there is a rise in motor traffic congestion, deteriorating and over-burdened infrastructure. Air pollution, surface and ground water pollutions, soil contamination, soil erosion, erosion of green fields, poor sanitation are some of the environmental challenges confronting Awutu Senya District Assembly (ASDA) and other urban areas in Ghana. Bartone et al. (1994) further indicate that the poor development control underpinned by poor land use planning and management – coupled with increasing urban population – leads to unsustainable extraction of ground water by urban dwellers. This is evident in ASDA and other urban areas in Ghana where increasing number of households are sinking domestic wells to meet their domestic water needs due to the inadequate or over-burdened public water infrastructure systems.

In Ghana, the traditional land management structures embedded in the institution of chieftaincy and the official state land management structures usually lead to confusions and litigations in land administration (Owusu-Ansah and O'Connor, 2006). There appears to be no clear, consistent and transparent method for allocation of lands at the Metropolitan, Municipal and District (MMD) levels in Ghana. Generally, land management at the MMD levels starts from the traditional authorities, families and – sometimes – individuals who allocate lands to prospective land users. Though physical planning schemes are developed by planners at the MMD levels after the provision of base maps by the state survey and mapping division, the traditional authorities and families owning large tracts of lands often engage the services of private surveyors to furnish them with their own plans and sub-divisions for land sales' purposes. Those private plans and sub-divisions are usually not in conformity with the official state base maps and plans which thus underpins the chaotic and unsustainable urban land use planning and management and its attendant effects in Ghana. Hence, this study attempts to deal with the menace of urban land use planning and management, in Ghana, by using a stakeholders' approach. Essentially, the study seeks to examine the land use planning and management practice in Ghana and seeks how stakeholder issues can be integrated into the planning process to ensure a more sustainable land use by using ASDA as the case study area.

1.1 Geographic and economic profiles of the case study area: Awutu Senya District Assembly

The Awutu Senya District is a district under one of the ten regions in Ghana – Central Region. The district is situated between latitudes 5°20' north and 5°45' north and 0°25' west and 0°37' west on the eastern part of the Central Region of Ghana as seen in Figure 1. The district covers an estimated area of 512km^2. The population of the district is estimated at 274, 584 (projected from the 2000 housing and population census of Ghana) with an annual growth rate of 2.83%.

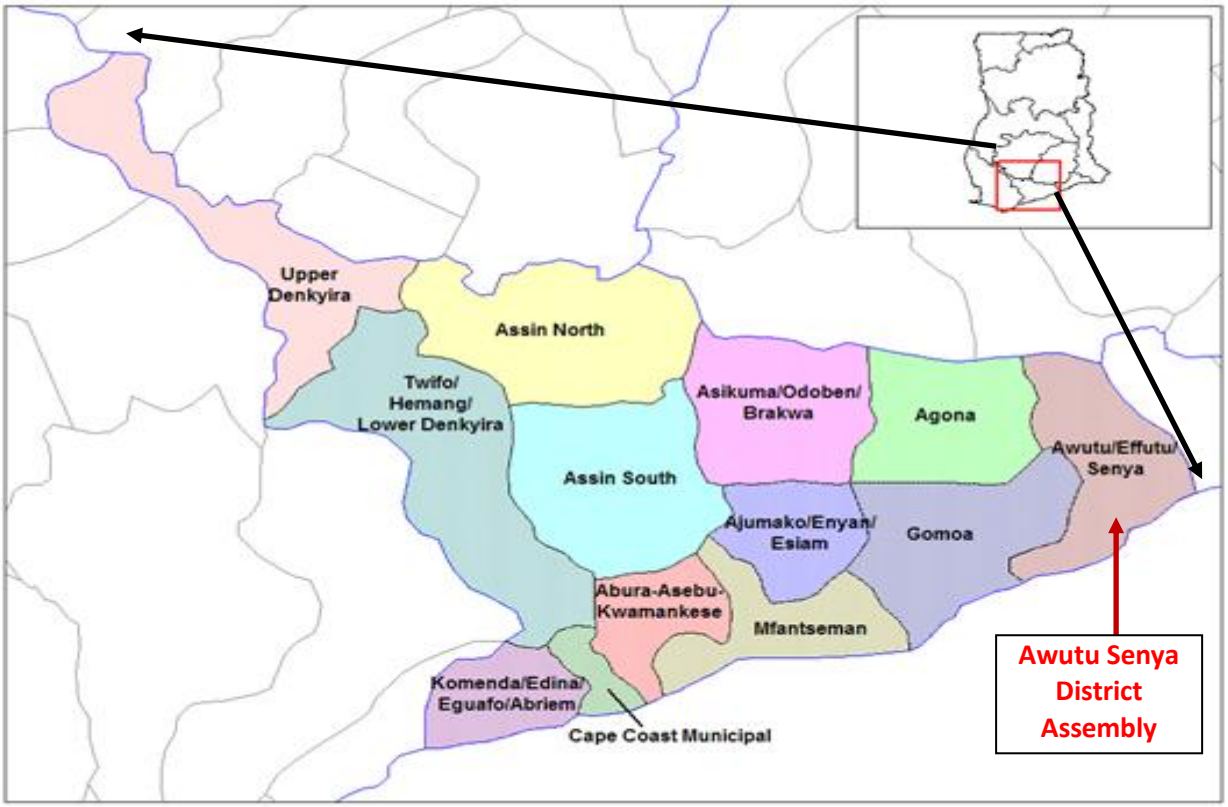


Figure 1: The location of Awutu Senya District Assembly in the Central Region of Ghana
Source: Wikipedia (2014)

The main economic activities in the district include agriculture (fishing and farming), wholesale/retail, agro-processing (pineapple, maize, vegetable and cassava processing) and services (banking, information and telecommunication services, hotels and restaurants).

2 Study approach

Generally, the study proceeds by articulating the poor and unsustainable land use management in urban areas in Ghana by using ASDA as a case study area. The choice of ASDA as the case study area is on the basis that lands in this district are vested in the president of the Republic of Ghana and the traditional chiefs and hence managed by the government through the Lands Commission and Traditional Council respectively, a situation similar to most urban areas in Ghana. Hence, any attempt to address the urban land use management menace underpinned by the current administrative structure (state and traditional structures) will largely be relevant for

majority of urban areas in Ghana. Besides, for ease of data accessibility, the ASDA was selected as the case study area.

Data was collected through literature review, in-depth interviews with planning and land use agencies as well as observations to establish a baseline planning processes and structure in ASDA. Based on the baseline information, a stakeholder approach is proposed for an effective and a more sustainable way of managing urban land use in ASDA and Ghana as a whole. The framework of the study is as shown in Figure 2.

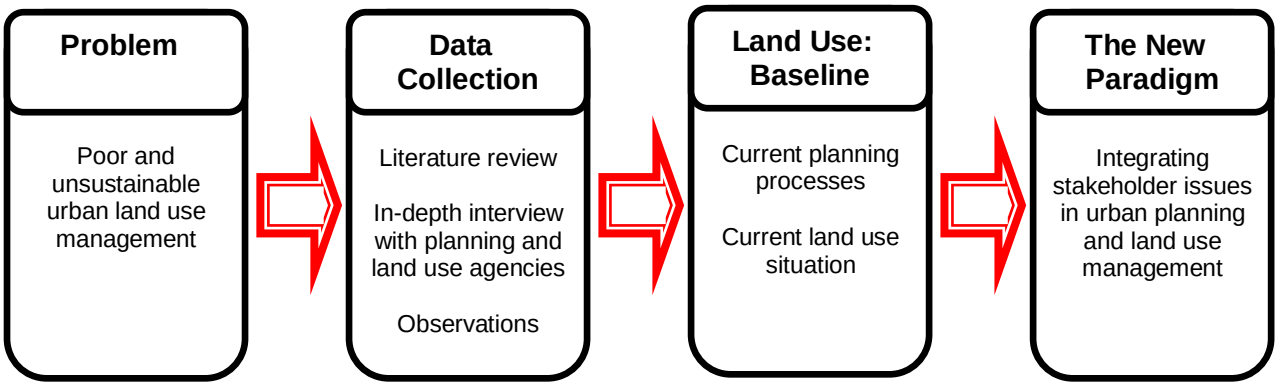


Figure 2: Framework of study

2.1 Data collection

The study employed a mixed data collection approach – primary and secondary data collection approaches. Data for the study, from the case study area, was sourced through literature review, interviews and observations.

Literature on national development planning in Ghana, national building code, land use (structure) plans were reviewed to ascertain the planning processes and procedures from the national to the district level.

Besides, interviews were also conducted among planning and land use agencies in ASDA to also confirm and fill some of the gaps identified during the literature review stage. In all there were seven respondents to the interviews from different agencies belonging to planning and land use management in ASDA as shown in Table 1. The respondents were purposefully selected on grounds of their knowledge on planning and land use management. Local observations were made at the case study area to also triangulate some of the data and information obtained from the literature review and the interviews conducted. Some of the issues observed include the degree of enforcement of planning regulations, local acceptance of urban planning, physical conditions and settlement layout as well as environmental conditions. The observation was carried out by means of field notes and photographs.

Institution	Number of respondents	Function
Town and Country Planning	2	Preparation of land use (structure) plans and development control
Public and Vested Land Management Division	1	Land management and administration
Survey and Mapping Division	1	Preparation of base maps
Environmental Protection Agency	1	Environmental standards and control
Traditional Council	2	Customary lands management and administration
Total	7	

Table 1 Respondents of interviews

3 Land use planning and management: baseline

In the Awutu Senya District Assembly, the district Town and Country Planning Department (T&CPD) under the district assembly is directly responsible for the planning of the district. The T&CPD has functions including the formation of goals and standards related to land use, the design of plans, development of proposals to direct growth and settlements within the district. As of 2011, the T&CPD in the district had two professional planners and eight draughtsmen. Planning in the district is largely – undertaken by the old practices of using drawing boards and tracing sheets with partial incorporation of a new planning tool (Map Maker).

Generally, planning in the district begins with the T&CPD notifying the Lands Commission of areas due for development. The Lands Commission upon notification officially commissions the Survey and Mapping Division to survey the area in question and prepare base maps (indicating existing natural and man-made features) for the T&CPD. Draft land use (structure) plans are developed by the T&CPD after the base maps and submitted to the district's Statutory Planning Committee (SPC) for vetting and inputs. The SPC has the District Chief Executive (DCE) as the chairman, the director of T&CPD as the secretary. Other members of the committee include representatives from Public and Vested Lands Management Division, Survey and Mapping Division, Department of Feeder Roads, Ghana Water Company, Electricity Company of Ghana, Ghana National Fire Service, Environmental Protection Agency, Public Works Department, Public Health Department, Waste Management Department, representatives of traditional authorities and some assembly members. After vetting and inputs by the SPC, the draft land use (structure) plan is required to be posted on the public notice board at the district assembly's office for public study and inputs. However, it was revealed during the interviews with the land use planning and management institutions that in practice, the stage of public inputs to the land use (structure) plan is omitted due to logistical and financial constraints.
The SPC meets once in every two months to consider development applications. The applicants first submit their development applications to the district T&CPD which in conjunction with the technical sub-committee of the SPC vets the applications, processes and submits comments on the applications for the following SPC meeting. The applications are approved, deferred or declined with a reason during the SPC meeting and subsequent communication made to the applicants.

The current land use planning and management in ASDA is faced with some constraints and these were revealed during interviews with planning institutions. The

constraints are summarised in Table 2 and – largely – underpin the poor or unsustainable land use planning and management in ASDA.

Constraint	Responding institution
• Inadequate or lack of land use information such as base maps	Lands commission
• Uncoordinated laws and regulations regarding land use and management	Town and country planning department, Public works department
• Lack of motivation and inadequate skilled personnel within the planning institutions	Town and country planning department, Lands commission, Public works department
• Outmoded or lack of planning logistics and equipment	Town and country planning department, Lands commission, Public works department
• Lack of funding or poor government subvention to planning institutions and activities	Town and country planning department, Public works department

Table 2: Constraints to urban land use planning and management

Incidentally, it was confirmed through interviews with the planning institutions and also through local observations at the case study area that the current land use planning and management constraints have led to poor developments in ASDA from social, environmental and economic perspectives. The effect of the constraints – underpinning poor land use management in ASDA – is developments in flood plains and flood prone areas by residents in ASDA with residents suffering from perennial floods. Besides, there is absence of drainage or sewage systems in most neighbourhoods. Hence, liquid wastes are usually flushed out of households through natural courses in the neighbourhoods. This practice in tandem with run-offs after heavy rains leads to excessive soil erosion and creation of gullies in the neighbourhoods. This, sometimes, undermines the foundations of buildings, roads and other structures. Figure 3 shows images of soil erosion and gullies in Akweley, a locality within ASDA.

Figure 3: Excessive soil erosion and gullies at Akweley, a locality in ASDA

Figure 4: Final disposal sites for solid and liquid wastes at Kasoa, an urban centre in ASDA

Due to poor or lack of development enforcement and control, the green fields at the peri-urban areas are fast eroding under intensive developments, which are mainly residential. The management of solid waste in ASDA is unsustainable due to poor planning and enforcement. Solid wastes are merely collected from households (without separation), transported and dumped at disposal sites which are not properly managed. The poor management of the refuse disposal sites poses a threat to ground water quality due to seepages of contaminants into ground water. Besides, developments – residential in nature – spring around and are usually close to the dumping sites. Hence, the improper management of the dumping sites coupled with the close proximity of residences to the dumping sites always pose health problems to residents with the persistent outbreak of cholera disease. Figure 4 shows solid and liquid waste dumping sites in Kasoa, an urban centre in ASDA.

4 Adopting stakeholder issues in urban planning and land use management in Awutu Senya District Assembly

The interviews and surveys made indicated that the district T&CPD does not involve stakeholders (residents and land users) in the preparation of planning schemes in the district. This practice, largely, has resulted in anti-authority phenomenon in the district leading to building in water ways, poor infrastructure planning and development, poor waste management, poor health, traffic congestion and slums with its attendant problem of crime and streetism. Hence, it is proposed that a stakeholder approach is adopted in land use planning and management in ASDA for a more sustainable land use management. The stakeholder approach must begin with the identification of stakeholder groups with regard to land use and management in a stage called stakeholder analysis. In this case the stakeholder groups will comprise any person/group who/which affects or is affected by land use and management. The stakeholder analysis stage must seek to address each stakeholder with respect to:

- Functions or roles played in land use management
- Problems created or posed

- Challenges faced
- Expectations or interest

The stakeholder analysis will then provide the basis for a problem analysis with regard to land use and management. The problem analysis stage should bring together stakeholders to brainstorm and discuss the problem of land use and management in ASDA. The problem analysis stage will essentially seek to establish a cause-effect relationship as shown in Figure 5

.

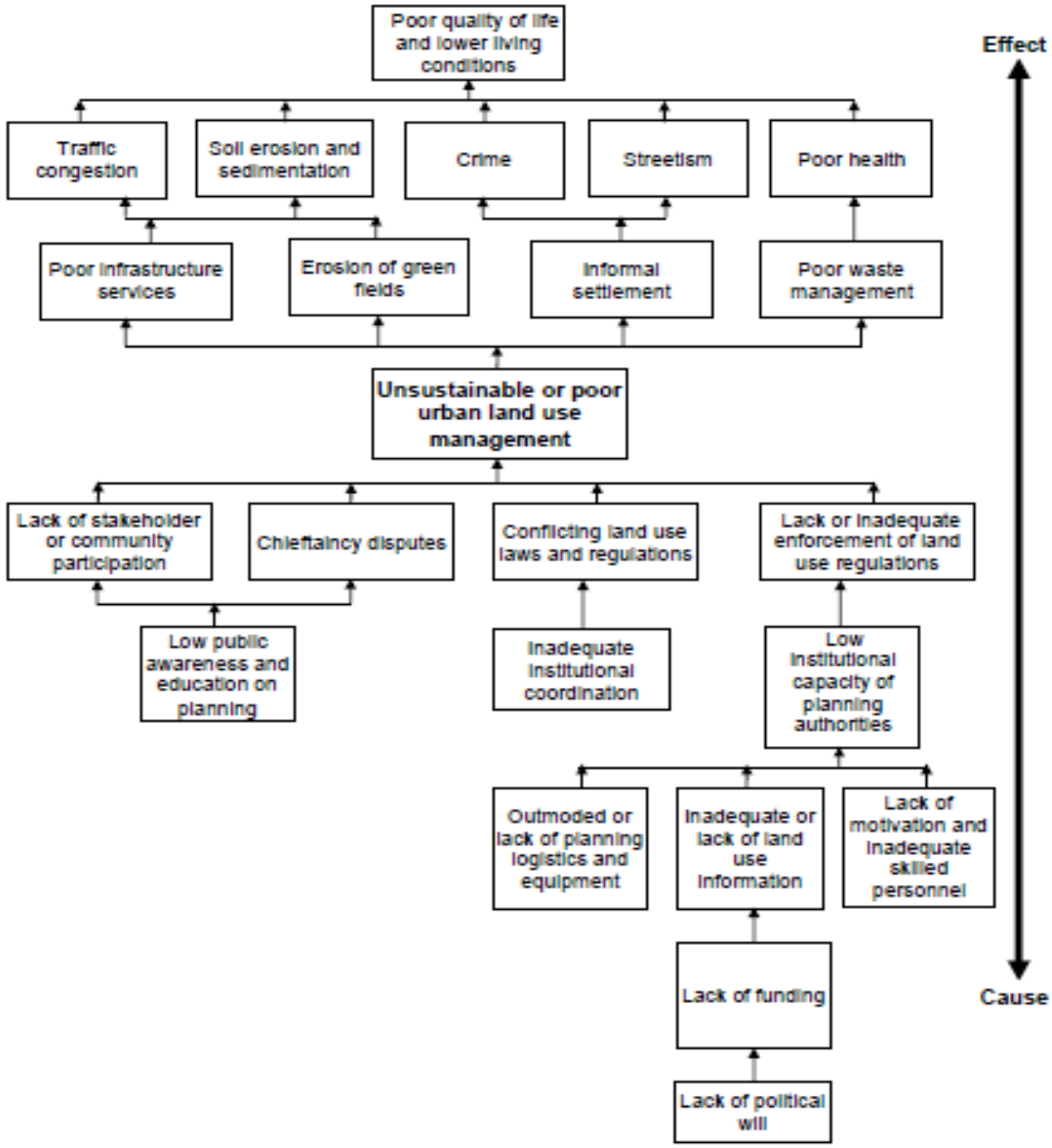


Figure 5: Problem analysis of unsustainable or poor land use management in ASDA

The problem analysis stage, further, provides the basis for solving the problem of land use and management in ASDA in the next stage of solution analysis. The

solution analysis stage is where stakeholders respond, positively with measures, to the problems (negative situations) prior identified at the problem analysis phase. The inputs and measures of the various stakeholders are consolidated and transformed into a plausible land use (structure) plan with accompanying local or implementation plans. Generally, well facilitated and managed stakeholder, problem and solution analyses will invariably influence the choice of strategy at the implementation stage of the district land use plan as some stakeholders could offer to take up some responsibilities with regard to the implementation. This will then assist in alleviating some of the land use planning and management constraints prior identified in ASDA. A model of the stakeholder approach to land use planning and management is as shown in Figure 6. As it can be seen in Figure 6, the district land use plan must seek to be coherent with higher tier plans.

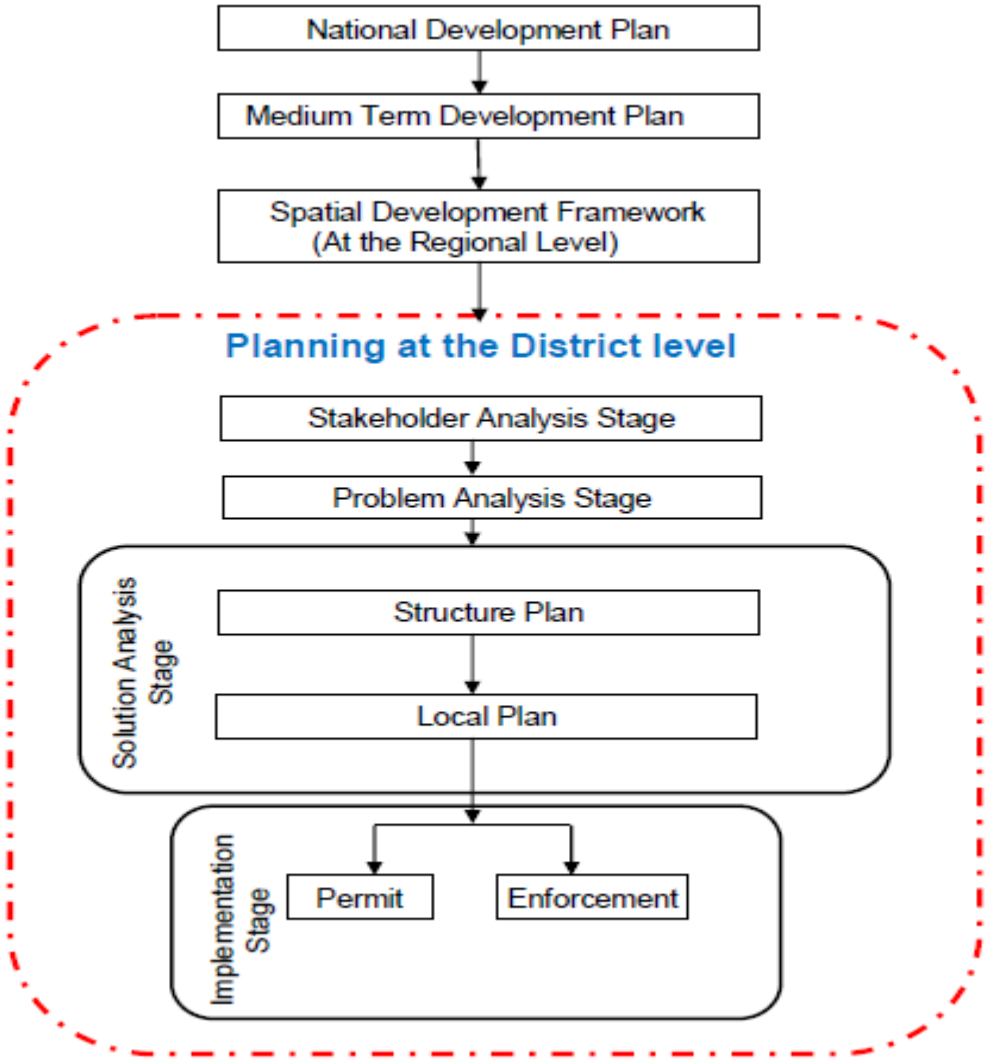


Figure 6: A model of stakeholder approach to land use planning and management in ASDA

5 Conclusions and recommendations

Land use planning and management in Awutu Senya District Assembly (ASDA) in Ghana is certainly not sustainable and has several ramifications socially, economically and environmentally. This study has shown that a number of

constraints to urban land use planning and management underpin such an unsustainable development which includes:

- Inadequate or lack of land use information such as base maps
- Uncoordinated laws and regulations regarding land use and management
- Lack of motivation and inadequate skilled personnel within the planning institutions
- Outmoded or lack of planning logistics and equipment
- Lack of funding or poor government subvention to planning institutions and activities

These constraints coupled with lack of stakeholder participation in land use planning and management have created an anti-authority phenomenon in ASDA where developments take place haphazardly with dire social, economical and environmental consequences. However, this study has posited that an integration of stakeholder issues in urban land use planning and management in ASDA holds the potential in dealing with the menace of unsustainable urban land use planning in ASDA. Besides, the stakeholders (land users or community) are not just purposefully excluded from planning by planning institutions but are also not interested in participating in planning activities of ASDA. This attitude of disinterest, in planning, on the part of the stakeholders (land users or community) is underpinned by lack of planning education among the stakeholders and partly by lack of confidence in planning institutions. Hence, ASDA should consider embarking on planning education among the stakeholders (land users or community) through radio or FM stations, print media, brochures, posters and public address systems through the information ministry to sensitize stakeholders about the importance of planning and citizenry participation. This should also go along with strengthening of the planning institutions.

References

United Nations' Department of Economic and Social Affairs: Urban Population, Development and the Environment, Population, 2007, Retrieved October 12, 2008, from: http://www.un.org/esa/population/publications/2007_PopDevt/2007_PopDevt_Urban.htm#top

Owusu-Ansah, J. K., & O'Connor, K.: Transportation and Physical Development around Kumasi, Ghana. International Journal of Human and Social Sciences , 2006, 1 (1), 1-6.

Afrane, S.: Urban Planning and Public Health in Ghana, Accra, Daily Graphic, Febraury 13, 2006. 7 &17.

Bartone, C., Bernstein, J., Leitmann, J., & Eigen, J.: Toward Environmental Strategies for Cities: Policy Considerations for Urban Environmental Management in Developing Countries, Washington, D.C., The World Bank, 1994.

UN-HABITAT. An Urbanizing World: Global Report on Human Settlements. Research, Oxford University Press, 1996.

Wikipedia: Awutu Senya District, 2014, Retrieved June 13, 2014 from:. http://en.wikipedia.org/wiki/Awutu_Senya_District#mediaviewer/File:Central_Ghana_districts.png

Srinagar – Impact of Urbanisation on the Environment & Recommendations through Spatial Planning for Sustainable Development

Xerxes Rao
SAI Consulting Engineers Pvt. Ltd., India
SAI House, Satyam Corporate Square, Behind Rajpath Club, Bodakdev, Ahmedabad – 380 059, India
xerxesrao@yahoo.com, xerxesrao@gmail.com

Abstract
With fast pace of urbanisation, it is vital to understand interlinkage between various components of urbanization and environment in order to achieve sustainable development. The future development can be planned accordingly. Often improper development is responsible for various forms of environmental degradation. Thereby it is essential to know natural characteristics, quality, productivity, suitability and limitations for sustainable utilization of land ecosystems.
Srinagar city and its surroundings is bestowed with ample natural resources viz. reserved and protected forests, national sanctuaries, migratory corridors, saffron fields, ramsar site, numerous water bodies, wetlands & lakes, orchards, hills & snow clad mountain ranges. However, these natural resources are under tremendous stress due to rapid urbanization, encroachment and uncontrolled development. With increasing urbanization, gravity of environmental problems is intensifying. The city lies under multi hazard prone region with natural disasters like earthquakes, floods, landslides, etc. Understanding interactions between various developments and their consequences is vital. Especially in case of Srinagar, it is experiencing rapid change and the cumulative impacts of development if realized too late shall lead to mitigation measures only. By adopting a curative approach, environmental damage, caused due to urbanization, can be averted to a sizeable extent & natural resources can be protected.

Key Words
Environment, Srinagar, natural resources, forest, urbanization, water bodies, sustainable development, biodiversity, economic development, master plan

1 Introduction

India is one of the fastest growing economies in the world with nearly 700 million rural populations directly depending on climate sensitive sectors (like agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Climate change is likely to impact all ecosystems as well as socio-economic systems as per the National Communications Report of India to the UNFCCC. In fact, countries like India

are facing the dual burden of climate change and globalization. (Climate change mitigation in India, Development Alternatives)

When cities grow, it requires more land and resources to support the growth. This leads to change in land use causing environmental problems such as air and water pollution, loss of open space and biodiversity, heat island effects, disasters and so on. This continuation of urbanization pattern will increase land and resource consumption, and exacerbate the environmental problems which have already posed threats to our planet and cost billions of dollars to our economy. Therefore, planners, governments, planning agencies and others should acknowledge these problems immediately and put environmental perspective into land use planning and decision making process effectively and promptly. The resources are scarce and precious hence every concern should be incorporated to protect and conserve them.

2 Need and Relevance

Changing drivers, such as population growth, economic activities and consumption patterns, have placed increasing pressure on the environment. In the past 20 years, there has been limited integration of environment into development decision making. (D. Martino and Z. Zommers, 2007)

The urbanization process has resulted in land pressure viz. occupancy of unsafe land: alongside major rivers, construct unsafe houses or work in unsafe environments (Havlick: 1986). Forests, grasslands, wetlands and croplands get encroached upon under the influence of expanding cities. Such development often incurs greater risks from natural hazards such as flood and landslide as a result of having to live in very closely built structures.

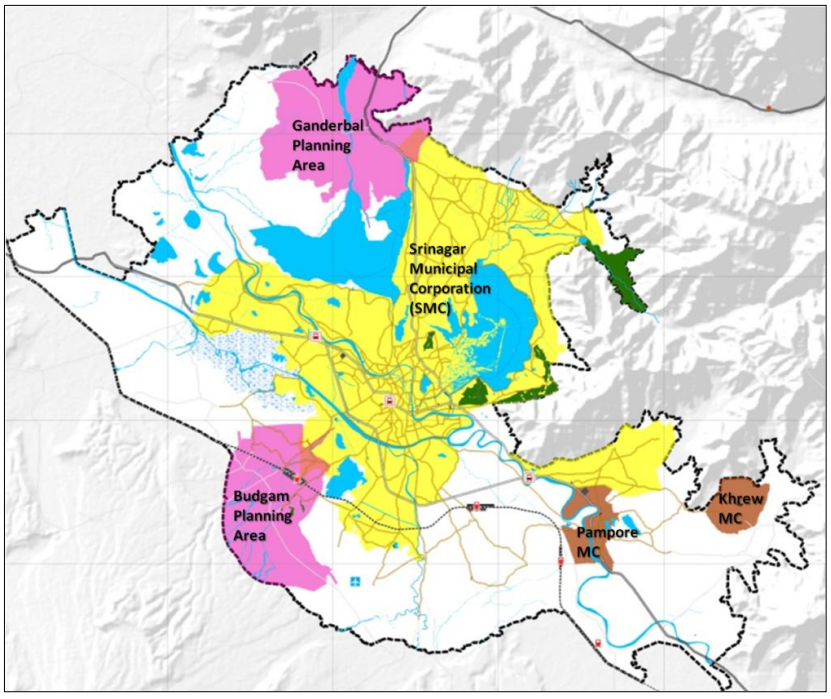
Many governments continue to create policies concerned with environmental, economic and social matters as single issues. There is a continued failure to link environment and development in decision-making (Dernbach 2002). As a result, development strategies often ignore the need to maintain the very ecosystem services on which long-term development goals.

3 Study Area

The area within the jurisdiction of the Srinagar Development Authority is 757 km^2 which will be the Master Plan area. It includes urban local bodies of Srinagar Municipal Corporation, Ganderbal Municipal Committee, Budgam Municipal Committee, Khrew Municipal Committee and Pampore Municipal Committee. Its mountains, scenic spots, beautiful valleys, rivers with ice-cold water, attractive lakes and springs and ever-green fields, dense forests and beautiful health resorts, enhance its grandeur and are a source of great attraction for tourists. It is also widely known for its different kinds of agricultural products, fruit, vegetables, walnut trees, walnut wood for woodcarving, saffron, minerals, precious stones handicrafts like woollen carpets, shawls and finest kind of embroidery. However, with increase in urbanization these environmental resources are getting affected and scarce. Some of the problems being faced are:

- Area under agriculture and orchards are reducing
- Shrinking wetlands, excessive weed infestation, heavy siltation and eutrophication within the lakes
- Pollution of river and lakes due to lack of sewage treatment facilities
- Recurrent flooding of low lying areas
- Reducing area under saffron cultivation due to pollution from nearby cement factories
- Reclamation of wetlands for urban development, excessive growth of floating gardens and houseboats in Dal and Nigeen lakes
- Cutting of Hills for urban expansion & quarrying
- Soil erosion

The rapid growth of population has brought about extensive urbanization in Srinagar, mainly through the extension of utilization of cultivated land and large-scale deforestation. The irrational land transformation process has not only disrupted the ecological balance of Srinagar watersheds through reduced groundwater, increased surface run-off and soil erosion, but has also adversely affected the ecology of the adjoining areas by frequent floods and landslides. Increased mining and stone quarrying by cement industries is causing high dust pollution which is affecting the production and quality of saffron in Khrew-Pampore belt. Indiscriminate Mining of river beds for sand and gravel, would lead to extreme soil erosion, landslides, and flash floods of unmanageable magnitude. Actual time period for snowfall has also undergone a change. Quantity of snowfall in Kashmir has clearly reduced over the last few decades. In areas prone to seismic hazards, the large number of building of variable quality, many of which poorly constructed or badly maintained, will pose high risk to lives.



Map 1 Showing the Srinagar Local Planning Area with urban local bodies

4 Urbanisation and Environmental Degradation

4.1 Understanding Environmental Resources

Environmental Resources of ecosystem and their services to humans are infinite and precious. Some of the resources that are fundamental to the natural balance of the ecosystem are forest, wetlands, water bodies, Saffron, hills, orchards, plantation, etc. Environmental damage of urban growth can be averted by protecting environmental resources of our ecosystem. Therefore, it is very important to acquire local environmental information of the place in order to identify important environmental resources of that place. Such information could then be used in land use planning and decision making process. Local environment information includes information about topography, geology, hydrology, vegetation and wildlife of that area. Each of these features may have certain characteristics based on their aesthetic values, conservation levels, ecological functions, economical values, and public health and safety issues.

4.2 Understanding Urbanization

Urbanization is the concentration of population due to the process of movement and redistribution (Geruson & McGrath, 1977, p. 3). Here movement and redistribution refers to the spatial location and relocation of human population, resources, and industries in a landscape.

Most major metropolitan areas face the growing problems of urban sprawl, loss of natural vegetation and open space and a general decline in the extent and connectivity of wetlands and wildlife habitat. The public identifies with these problems when they see development replacing undeveloped land around them. Urban growth rates show no signs of slowing, especially when viewed at the global scale, since these problems can be generally attributed to increasing population.

"The 'environment' is where we live; and Development is what we all do in attempting to improve our lot within that abode. The two are inseparable" - UNEP, 2007

5 Master Plan Preparation for Srinagar & its Surroundings

5.1 Context of the Project

Owing to location advantage of centrality and its scenic beauty, Srinagar is an important tourist destination in Kashmir valley. It is the summer capital of Jammu & Kashmir State and has rich architectural & cultural heritage. The city also has world famous parks & gardens, water bodies, unique agro and horticulture products. In absence of industrial activities, the economy is thriving on famous traditional local art and craft, wooden furniture, woollen articles, intricate embroidery and tourism activities. Owing to this concentration of economic activities in Srinagar which is the main hub that acts as centripetal force to its surrounding areas, the vast hinterland remains undeveloped.

The physical character of the city itself explains the natural barriers such as surrounding hills in Northeast, meandering Jhelum River bisecting the city, wetlands like Anchar, Hokersar in west and south-west, Dal lake right in middle and valley in the south. All these, limit the growth of city in certain directions. The current Road pattern is primarily radial and organic.

Box 1: Statutory provision for the preparation of Master Plan in state of Jammu & Kashmir, India

Under the provision of J&K Development Act, Local Area was delineated for Master Plan 1971-91 under SRO Notification 43 dated 2/2/1971 under Section 3 of the J&K Development Act for purposes of land development up to 1991, which included 62 villages. This Local Area was further expanded by accreditation of additional 126 villages, for preparation of sanctioned Master Plan 2000-2021.

Local area for the Proposed Master Plan for year 2032 was further extended for an additional area of 340 Sq. Km. to include urban local bodies of Ganderbal, Budgam & additional 160 rural settlements; owing to growth and development that may take place along the proposed motorway alignment and additional areas to be conserved.

5.2 Study of Existing situation for Srinagar Local Area

5.2.1 Previous Master Plans for Srinagar Development Authority[1]

Preparation of First Master Plan for SDA was in year 1971 was the first planning initiative for development of the city. The first Master Plan was prepared for an area of 236 km^2, under J&K Development Act, 1970. This Master Plan could not be revised due to certain administrative reasons. No Zonal Plans could be prepared. Therefore, the life of First Master Plan 1971-91 was extended from time to time by the Government.

Second Master Plan for Srinagar Metropolitan Area was formulated for a plan period of 20 years (2000 –2021) and was approved by the cabinet in year 2003. This master plan was prepared for 416 km^2; which incorporated the areas of Srinagar Municipal Corporation, Khrew Municipality, Pampore Municipality and Badami Baug Cantonment with clear objective of flexible landuse and efficient transportation network. The Master Plan 2000-2021 could not control the problems of urban development as it could not provide long term perspective and policy. SDA is the highest planning authority yet development works of other government departments are carried without SDA's notice/ approval and not as per landuse plan. There is no accurate base map, cadastral map and updated revenue record and hence it is difficult to implement Master Plan proposals.

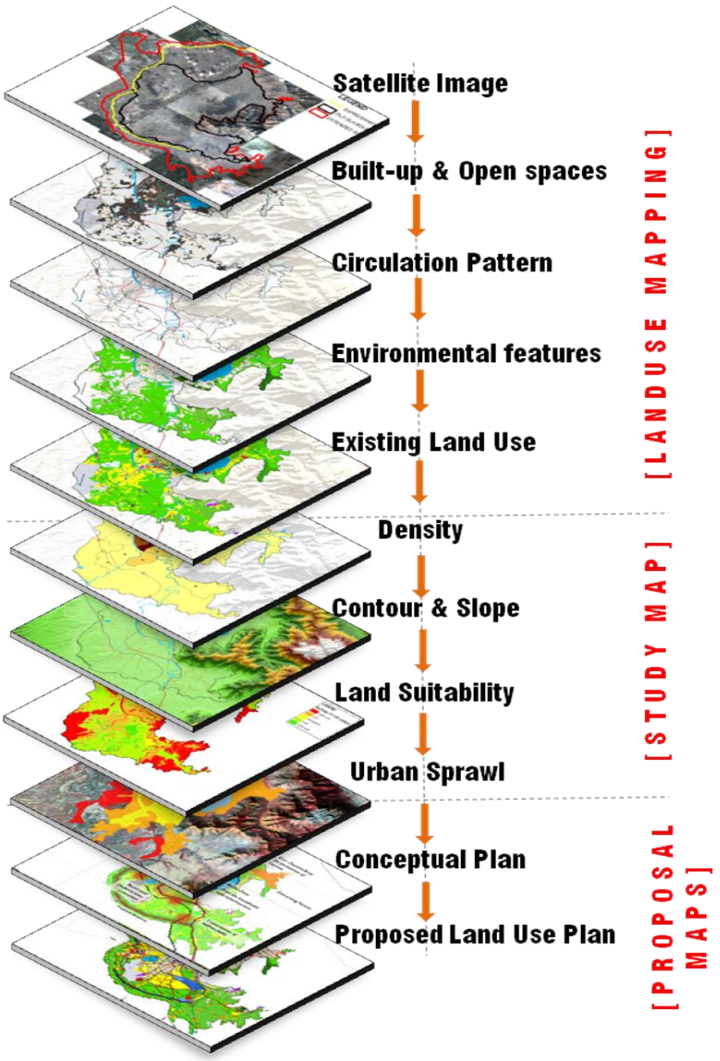
5.2.2 Use of GIS Mapping and Satellite Imagery

The existing Master Plan did not have an accurate Base Map prepared and hence SDA was finding it difficult to show the existing conditions on the ground which affected the success of implementation of the Master Plan. Hence it was imperative for SDA to have an updated Master Plan which would have an accurate Base Map and Existing Land use Map. Hence the preparation of an accurate Base Map using the latest satellite imagery was the main task of the review of the Master Plan for Srinagar.

[1] The state government constituted an Urban Development Authority for the planned development of the Region under the aegis of the J&K Development Act, 1971 known as the Srinagar Development Authority

High resolution Quick Bird satellite imagery was used for the preparation of the Base Map. This satellite imagery was of year 2007 in True Colour Composite. The high resolution image enables to identify various objects, manmade, topographical & geological features on the ground. These features are then used in formulating a Master Plan.

A Base Map is a multi-layered compilation of geographic data, which includes all existing features on the surface such as roads, water bodies, streams/rivers, buildings, utility features, administrative units etc. with a geographic reference. The geo-referenced satellite image data was considered as base for preparation of Base Map and Existing Land use map of SLA. The methodology for preparation of the Landuse Maps for the project is shown below:

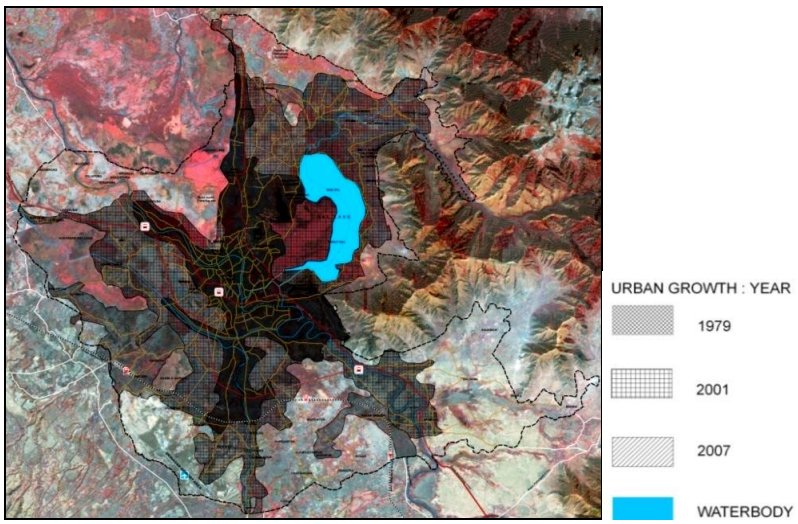


5.3 Existing Landuse Plan

It is always imperative and pertinent to analyze the land use pattern of a city. It shows the human activities carried out by the people. Analysis of existing land use and its configuration across spatial and temporal scale is indispensable and is the most important step for efficient planning.

5.3.1 Development Pattern

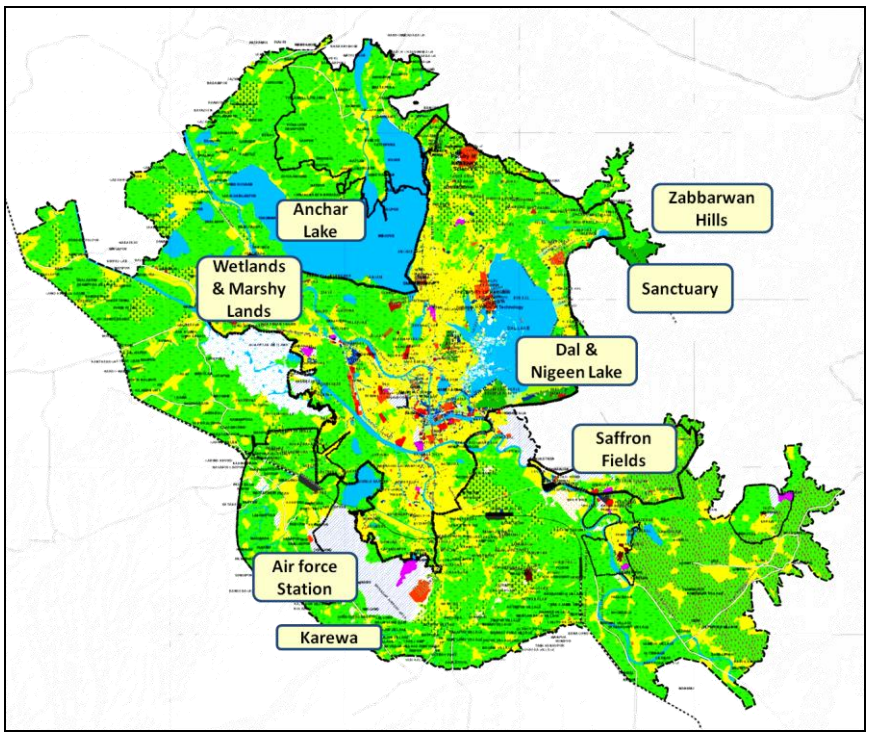
The temporal growth of the city is shown in map. Till year 1979, the city grew primarily on the banks of River Jhelum along major corridors and was limited to eastern part of Dal Lake. By year 2001, the city expanded in northeast and southwest directions, on the either sides of the Dal Lake and reached Zabarwan Mountains. Then, by year 2007, spatial growth was observed in north towards Baramulla, in southeast and southwest directions.



Map 2 Spatial Growth of Srinagar City

The city has developed along river Jhelum which passes through heart of the city. The core city consists of areas like Khanyar, Nowhatta, and Shaheedgunj which have developed along the river. The development also came up around Nishat-Laam-Brein and Shalimar-Harwan areas behind Mughal Gardens- Nishat and Shalimar. It also came up in Pampore along NH 1A. With the construction of NH 1A by-pass in south of Jhelum, the development got impetus and spread to the areas like Kashmir University, Bagh-e-Ali Mardan Khan Industrial Estate, SKIMS, etc. and already existing Hazratbal Shrine the areas, majorly in the form of residences. There are some planned colonies in these areas like Sanat Nagar, Bemina, Jawahar Nagar, etc. The development can also be seen in pockets in Humhama because of Airport, in Zainakote because of HMT Factory (which is not functioning presently), along Ganderbal Road (NH-1D) ahead of SKIMS, Soura. The development also came up in peripheral areas like Khunmoh because of Industrial Estate and in Khrew because of Cement Factory.

The advantages of geographical location coupled with the status of capital city and the largest urban settlement of state has made Srinagar a fast growing city. Besides natural growth, there has been high level of immigration.



Map 3 Showing physical barriers for Spatial Growth

5.3.2 Landuse Analysis

Srinagar being situated in a border state has number of defence establishments. Hence, there is significant chunk of land under Restricted Land Use. SLA has sizeable area under water bodies i.e. 9.0% of SLA. Due to fertile land, large stretches of area is under agriculture. Since tourism is the mainstay of Srinagar's economy, the area under industrial development is less. The investment in industrial sector and other commercial sector is less.

In addition, the terrain, climatic condition and the regional connectivity does not support sustainable and profitable economic development. Due to narrow 'Right of Way' within the privately owned colonies, area under traffic & transportation is less i.e. 2.5 % only. This is the main reason why Srinagar city & its adjoining region faces traffic related problems. Although Srinagar is a seat of administration, the area under public purpose, semi public purpose and community spaces is only 1.6 % of SLA. There are few patches of reserved forest within SLA.

5.3.3 Landuse Analysis

Peculiar geophysical setting and geomorphic feature in and around the city are impediments and have influenced the spatial growth. The implications on growth are:

- Zabarwan Mountains form the edge of Municipal Boundary in north and east.
- Wetlands have restricted the growth largely in west.
- Water bodies like Anchar Lake in north-west part of SLA[2] do not permit growth.
- Valley areas after Airport, Air Force Station and Karewas[3] in south restrict development.
- There are Karewas; large stretches of saffron fields near Pampore and Khunmoh in south-eastern part of SLA do not permit growth.

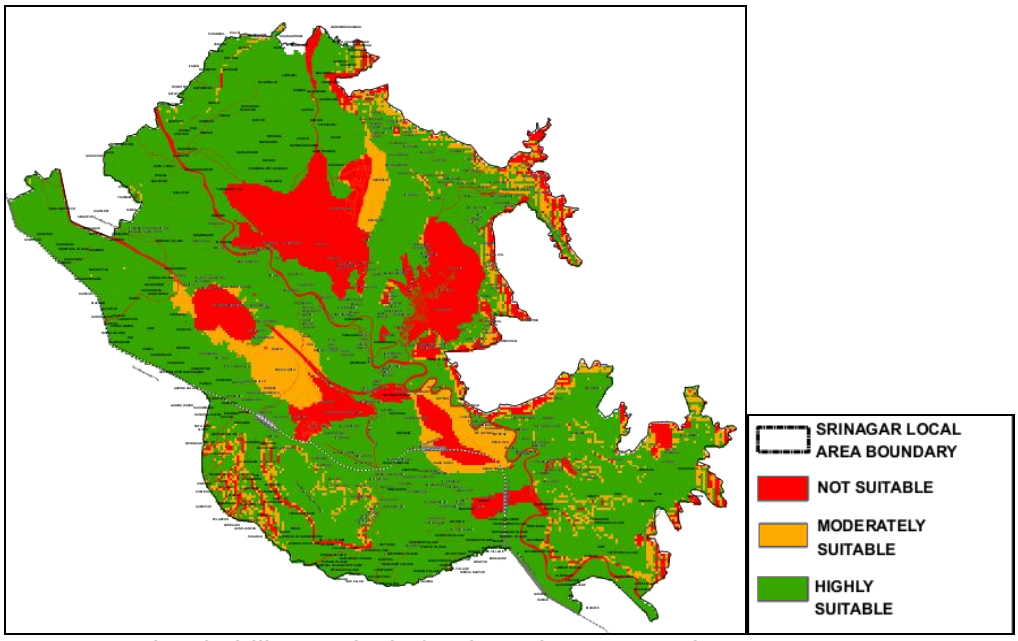
[2] Srinagar Local Area is the total area for which the Master Plan is to be prepared
[3] Karewas are elevated tableland in Kashmiri language.

Other factors within city that act as constraint for development are as follows:

- A sizeable portion of the city is flood prone and low-lying. These areas are not suitable for development as they experienced widespread residential expansion and now are facing problems of frequent occurrence of floods.
- Restricted zone around the protected monuments affect the development.
- Areas near graveyards and large institutional areas
- Defence areas in core city

5.4 Land Suitability Analysis

For the preparation of Draft Master Plan various parameters were studied & based on which a set of maps were prepared. These were based on topography, flood prone area, drainage maps, slope, landuse and land cover. This analysis involves wide ranges of criteria including environmental factors. One of the most important was the land use suitability mapping and analysis. An urban model was prepared to find out site suitability**.** Various thematic maps were prepared by use of GIS. Different weightage according to their importance was given, but due to unavailability of data for various parameters, limited parameters with equal weightage were considered.



Map 4 Land Suitability Analysis for the Srinagar Local Area

6 Analysing the Impact of Urbanisation on Environment, Natural Resources and Water Bodies

Srinagar city along with its surrounding region is bestowed with ample natural resources. It is famous for its natural beauty, landscape and water bodies provided by Dal Lake, Nigeen Lake, Anchar Lake, Jhelum River and Zabarwan Mountains with deep forest. This is located in juxtaposition to these water bodies.

Environment is very important aspect which needs to be considered while planning the development proposals. There are about seven wetlands in the local area and is surrounded by forest, rich flora and fauna and important mineral like limestone.

Pampore-Khrew belt is famous for saffron cultivation. Orchards plantation, mulberry trees, paddy cultivation & step-farming are some of important aspects from environment view point which needs to be conserved and promoted. However, in the recent times because of unregulated human activities, these natural features are reducing and facing large problems of getting polluted. Main environmental problems seen in the local area are Eutrophication of Lakes and Wet Lands, Denudation of Forests, Derelict Land because of brick kilns, industrial pollution, water pollution, air pollution, land-slides, stone-blasting and quarrying.

In the sanctioned master plan of year 2021, there were no provisions or proposals for the preservation of important environmental features. Large residential areas were proposed on saffron and paddy fields.

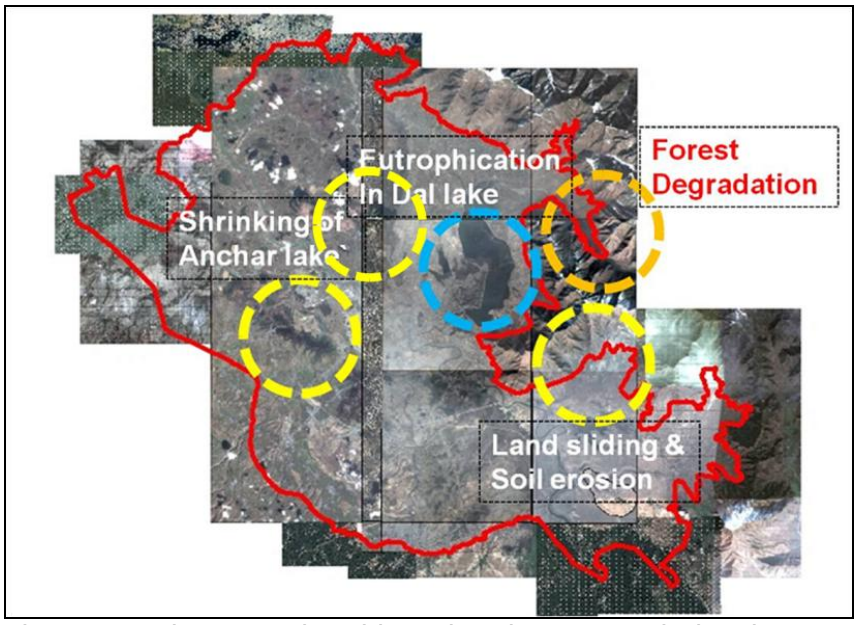


Figure 1 Environmental Problems in Srinagar Local Planning Area

6.1 Lakes and Water Bodies

Owing to reduction of plant cover in catchment areas and deforestation, the rainwater brings sediments to the water bodies. It is the main reason for increased siltation. In addition, encroachments are resulting in conversion of open water bodies. It is done by filling the lake and changing it into floating gardens and even into residential areas. The activities like sewage, drainage, garbage disposal, siltation due to soil erosion and agricultural run-off in and around the water bodies have resulted in rapid undergrowth of weeds in all the lakes in Srinagar city. All this has increased the process of eutrophication of the lakes and has affected the very existence of these water bodies. There is also a danger and cause damage to the ecosystem of the lake (flora and fauna).

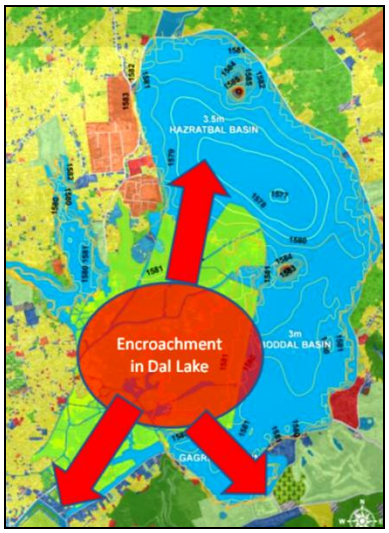


Figure 2 Encroachment in Dal Lake

Dal Lake has reduced in size from 75 km^2 to 25 km^2 (1980) and to 24 km^2 (2011) and its depth has reduced from 13.5 m to 2.5 m. The total catchment area of Dal Lake is about 316 km^2, which includes the areas of Dachigam, Tailbal, lake, hillside,

Srinagar City, etc. The depth of water varies from 2.50 m to 6.50 m. A few years back the depth was 13.0 m but due to heavy silting the depth is drastically reduced.

6.2 Wetlands

The wetlands are reclaimed to put it to agricultural use. The marshes are also used for cultivation of willow. These activities have considerably reduced the area under wetlands at an alarming rate. Eutrophication, increase in level of nitrogen and phosphorus is a matter of great concern since shrinking of wetlands leads to disturbance in pattern of migratory birds. Another reason for degradation is heavy siltation through Doodhganga nallah.

6.3 Air Quality

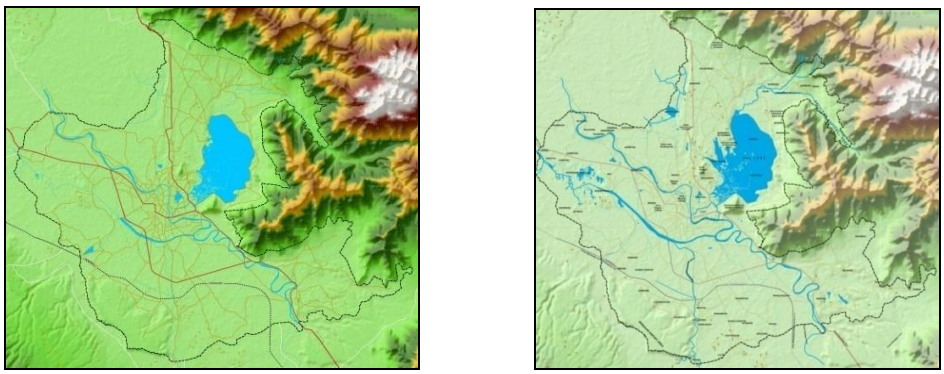
The cement factories at Khunmoh and Khrew are causing air pollution which severely affects the Saffron cultivation. These factories are already classified under 'Red' category by state pollution control board. At present, the total capacity of factories at Khrew is 5540 MT/d and Khunmoh is 1600 MT/d. It is evident from the study of land use over a period of time that the saffron production has been suffering due to dust from these cement factories.

6.4 Stone Quarrying

The illegal mining of mountains for extraction of stones and limestone across the valley has drastically affected the fragile environment and endangered wildlife of the valley. The mining particularly for extraction of stones, gypsum and limestone poses a major threat to the environment and wildlife. Mining of lime stone and the harmful emissions of over a dozen cement factories in the fragile zone has affected the human population and wildlife besides saffron and almond production. The extensive mining in the eco fragile belt of the Khrew-Khunmoh directly contributes to air, noise and water pollution, threatening the wild animals in the Dachigam National Park.

6.5 Topography

Srinagar city is located at an average elevation of 5,400 meters above mean sea level and it spreads over in the heart of the oval shaped Valley of Kashmir. The city as well as its hinterland is bounded by natural wall of mountains. In the east direction, the city is bounded by Zabarwan Mountains environed by the shallow and swampy lakes of Dal and Nigeen. The hillocks of Takth-i-Suliman in the east and Hari Parbat in the centre add to the beauty of the city and make surroundings invigorating.



Map 5 Topography of Srinagar and surrounding area

6.6 Issues

- Over the last four decades, the expansion of Srinagar city and land transformation has severely affected the environment & ecology. It has not only damaged the beauty of mountains, but has also deteriorated the fragile ecosystem.
- The change due to deforestation and sprawl of urban growth is devouring the scenic beauty, reducing the forest cover, resulting in excessive soil erosion in catchment area of Harwan and Telbal nallahs and siltation in Dal Lake.
- The physical grandeur of the water bodies has deteriorated with the agglomeration of residences and other urban activities in the immediate vicinity and growth of houseboats.
- In the absence of appropriate drainage and sewerage disposal system, city's effluents are directly or indirectly drained into various water bodies. Discharge/flow has been choked and quality of water has been polluted.
- The problems have further worsened by the encroachment and siltation in the catchment area. This is threatening the very existence of these water bodies because of high dose of pollution, algae growth, and reduction in area through eutrophication, encroachments and siltation.

7 Participatory Approach

Urban planning is a very complex subject which involves preparation of Master Plans. These plans are prepared for the people. Therefore, it is imperative to involve them in the planning process. Various stakeholder consultations, interactive sessions, group discussions, interviews and one-to-one discussion with the key personnel for the review/ update of the Master Plan was done.

8 Use of Master Plan as tool for Sustainable Urban Development

8.1 Planning Concept

Considering basic creativity of Kashmiri entrepreneurship, their art and culture / quality craftsmanship, availability of large natural and manmade heritage in the shape of lakes, gardens, snow clad mountains, invigorating climate and ever fresh air coupled with availability of high order of technical and professional institutions in the city, Srinagar has high degree of potential to emerge as global tourist destination, centre for national and international conventions, hub of information technology and information technology enabled services, provider of quality healthcare and educational services, provided required level of policy options and support systems for promoting rational and planned development, quality infrastructure, user friendly policy options, state of art developmental and institutional mechanisms are put in place.

Primarily four principles formed the base for preparation of conceptual framework for the Master Plan. These were Decentralization, Conservation & Preservation, Planning Intervention and Conservative Surgery

8.2 Planning Intervention

A detailed comparative analysis of Sanctioned Master Plan 2000-2021 and exisitng land use 2012 is carried out to check the compliance and deviation against proposed land use. The areas of mismatch were then identified; probable reasons for non

compliance were also reviewed. This exercise also helped in identifying the land which could be made available for future development. Based on this analysis, the viable proposals of Master Plan 2000-2021 were retained with necessary modifications. Planning intervention was made for different areas to promote rational development. The preliminary zoning was done based on above study.

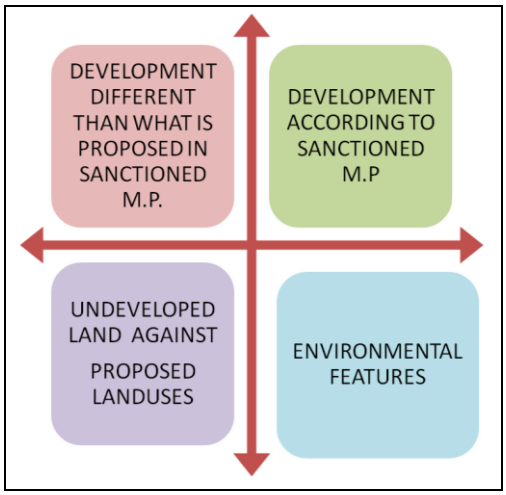


Figure 3 Output from planning intervention

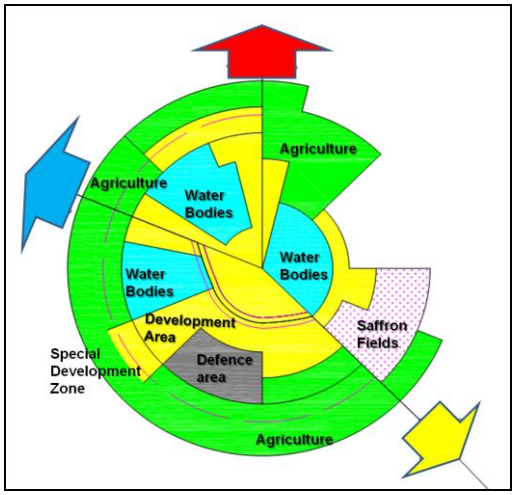


Figure 4 Proposed Concept – Hoyts Model

8.3 Planning Proposals

Defining a rational and realistic agenda for an implementable and sustainable Master Plan would require in-depth knowledge of existing ground realities, detailed studies and analysis made of the inherent basic strengths, existing weaknesses, available opportunities and emerging threats. It also requires crystallizing the perception of citizens, communities and others stakeholders based on high degree of interaction besides the road map for the future growth and development.

In order to achieve the defined objectives and goals for the Master Plan the vision statement, mission statements for various focused areas were detailed out. These focus areas were studied in depth and proposals were prepared based on these guidelines. The focus areas included:

- Growth Management Plan
- Urban Environment and Water Bodies
- Urban Infrastructure Services
- Heritage and Tourism
- Social Infrastructure

For the purpose of this paper only the studies and proposals related to the Urban Environment and Water Bodies is discussed. A brief description of the land uses was also discussed to show how the integration between various land uses is essential for a sustainable Master plan.

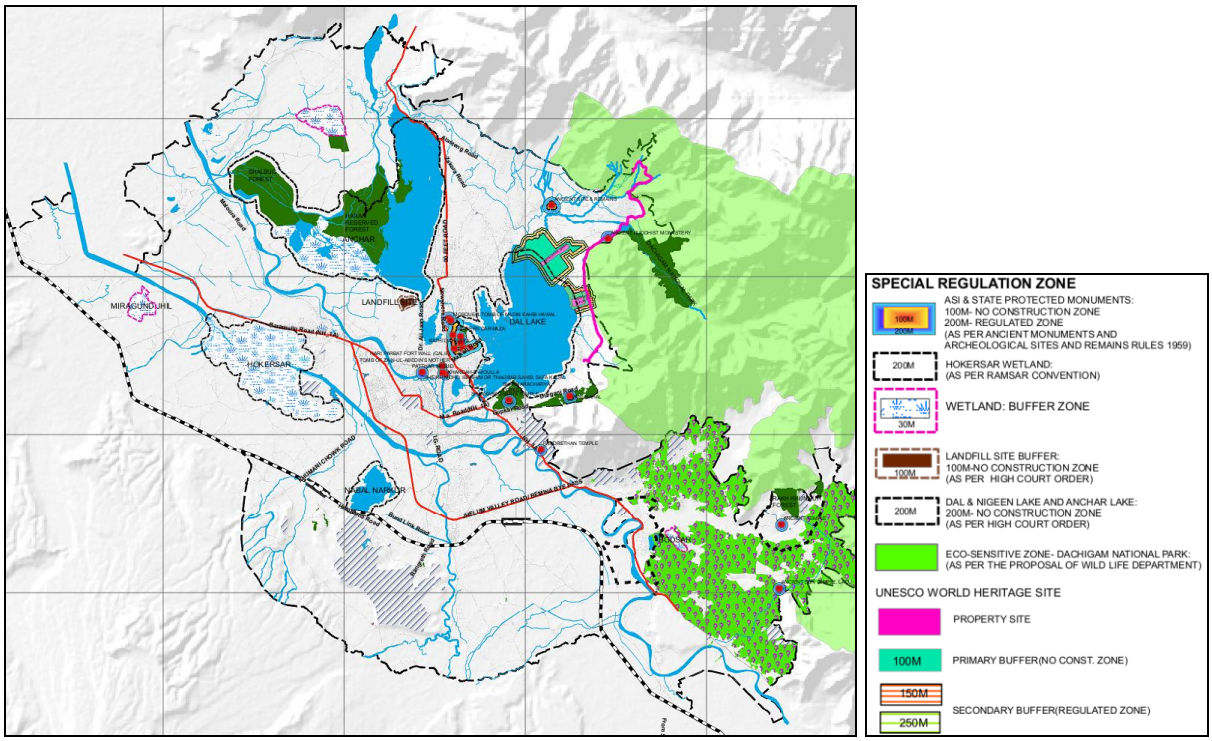
8.3.1 Landuse and Land cover

Srinagar has different type of agricultural activities. It has saffron field, Walnut & apple orchards and very fertile paddy fields. These are important elements of nation's economy. These areas are now disappearing due to urban development. In the

interest of rare agricultural productions, such agricultural areas need strong protection from unwanted development. Secondly it is also observed that few industrial activities have come up in the vicinity of these agriculturally rich areas jeopardizing the crop production. As a part of land use and land cover, best areas which are the part of urban economy and where there are rare species like saffron and paddy, attempt is made to avoid any kind of further development in these areas so as to boost economy of the city.

There are dense forest areas on the periphery of Srinagar with wild life. There are also many orchards with very tall well grown trees. Such areas are marked as most unsuitable for urban development.

Due to several water bodies, accumulation of rainy water, and ages old water bodies which are tourist attraction, wet areas and water bodies are delineated and marked as unsuitable for any building activities. These wet areas, also, show very high ground water table. If any urban development takes place, it will contaminate the ground water. Such areas with high water table, wet lands and water bodies are conserved in this master plan. Wet areas which are not injurious were selected as second priority wherein development can come up with certain improvement measures.



Map 6 Areas of special regulation and protection zone

8.4 Landuse for Special Areas

Existing environmental resources and sensitive zones of Srinagar Local Area were mapped. Physical features like Water bodies, Forests, Hills, and Orchards in Srinagar are important fragile areas that need to be conserved. To save these areas from any kind of degradation and pollution hazards master plan has proposed few strategies.

8.4.1 Lakes

- Utmost importance is to curb sediment deposition that is taking place in all the water bodies. There is a need for watershed management. All the lakes are drying due to siltation and encroachment. The water intake is reducing which adversely affect the shrinking of lakes and results in to reduction of tourists.
- There should a constant supply of fresh water in all these water bodies. Water may be released from the River Jhelum and dam on River Sindh to recharge Lakes, to maintain water level of these lakes.
- For desilting the lakes, it is proposed to allow people to take away soil from these water bodies as this is good manure for agriculture fields. Eutrophication is another challenge that can be removed by continuous flow of water, fountains, boat movement, stopping garbage disposal etc.

8.4.2 Wetlands

- Thousands of migratory birds come from Siberia and other regions come to Anchar and Hokersar wetlands in the winter season. By increasing water table, spread and places for hatching these wetlands can be promoted as an important place for tourism. Planning & maintenance can protect environment and ecology of Srinagar.
- Besides Hokersar wetland, Srinagar Local area also has small wetlands like Shalbag Wetland, Nambal Narkur Wetlands which are eco-fragile area and hence are Protected and conserved.
- Hokarsar Wetland is Ramsar Site. According to MoEF[4] draft regulatory framework for Wetland Conservation' 2010, a 200 m buffer will be delineated as "No Development Zone".

8.4.3 Rivers

River Jhelum, Sindh and Doodhganga flow from Srinagar Planning area. These rivers and their flood spill channels are under environmental protection concern. There are not as such rules for protection of these rivers from pollution. Draft master plan proposes 30m buffer both side as no development zone along rivers. This buffer can be developed under River Front Development or as Recreation area.

8.4.4 Forests

Reserved Forest is an area mass of land duly notified under the provisions of India Forest Act or the State Forest Acts having full degree of protection. In Reserved Forests, all activities are prohibited unless permitted. Reserved Forest is notified under section 20 of the Indian Forest Act, 1927 [Act 16 of 1927]. There are reserved forests in SLA which is preserved. These locations were transferred on map with the help of Forest Department & Topography sheets.

Protected Forest is an area or mass of land notified under the provisions of India Forest Act or the State Forest Acts having limited degree of protection. In Protected Forests, all activities are permitted unless prohibited.

[4] Ministry of Environment & Forest

Dachigam National Park - Dachigam National Park can be promoted for wildlife Tourism and sanctuaries. A special tourism zone of 11 Sq. Km. areas is demarcated in the Dachigam National Park so that tourism activities do not have adverse impact on Natural Habitat.

8.5 Agricultural Land

Agriculture is predominant sector in the economy. Another important sector of economy relates to horticulture produce which includes apples, apricots, cherries, pears, plums, almonds and walnuts. Kashmiri saffron is very famous in international market.

The total area under agriculture and allied activities is 331.11 km^2. In the Master Plan, effort has been made to preserve agricultural land. The agriculture zone in local area is defined to include area which is primarily and essentially required to be retained as such and is not to be urbanized. The care is taken that no development which will cause harm to agricultural produce will come up on and around agriculture area. The land falling under agriculture zone will be saved from any commercial/ residential development.

8.6 Land under Saffron Farming

As known widely, Saffron from Kashmir valley is worlds' darkest and having strong flavour and aroma. This saffron is rare and difficult to obtain for consumer as it is only produce in Kashmir valley.

Cement industries in Khrew and Khunmoh, sparse development in Khrew-Pampore region, are causing adverse effect on saffron production. There are cases of converting land under saffron to other agriculture use or non-agriculture use. To stop this practice, area under saffron is remarketed in draft master plan and proposed to reserved and retained as it is. Existing total area under Saffron is 60.17 km^2 which is 8% of total SLA. Saffron fields are conserved in east area as "No Development Zone".

8.7 Development Control Regulations[5]

In order of secure planned development of Srinagar Local Area, it will be important that proposals defined in the Srinagar Master Plan are implemented on the ground in letter and spirit. There were no regulations for heritage precincts, building line controls or proposed road widths. The regulations for parking, physically handicapped persons, residential and non residential development, fire protection and natural disaster mitigation were missing within the previous DCR. There was a serious need to redefine the land use zoning and incorporate various provisions within the existing DCR.

The Development Control Regulations are defined as a policy document to implement the Master Plan for a planned and equitable development of Srinagar. A new set of Development Control Regulations were proposed. DCR was tailored to meet the needs keeping in mind the character and essence of Srinagar.

[5] Development Control Regulations

8.8 Urban Design Guidelines

The urban design guidelines for certain important areas viz. core area of city, areas with environmental significance, special heritage areas etc were prepared for the physical development toward a desired scale and character that is consistent with the social, economic and aesthetic values of the City. These guidelines will direct the process of revitalization, planning, design and management of such areas.

9 Conclusions

The agenda defined in the Master Plan for securing rational development shall not be achieved unless it is adequately supported through a well defined mechanism for ensuring its proper implementation. In order of secure planned development of Srinagar local area, it will be important that proposals defined in the Srinagar master Plan are implemented on the ground in letter and spirit. The agenda defined in the master Plan for securing rational development shall not be achieved unless it is adequately supported through a well-defined mechanism for ensuring its proper implementation.

However, more studies need to be focused on different issues of environment and pollution, which integrates the quantitative measure to spatial growth and environmental threshold. The components of urbanization in context to city should be developed based on standard parameters of environmental impacts which shall be identified for preparation of study of impacts. In addition, there is no study carried out in India for integrating these correlation studies with spatial land use planning of city. The focus should be to try to find out environmental threshold levels beyond which any development may have negative effect on environment.

In last few years urbanization have become so intensive and predominant that we can see their impacts in forms of deteriorating environmental quality, loss of prime agricultural lands, destruction of wetlands, and loss of fish and wildlife habitats, intense floods, landslides, etc. To address such a problem detailed information and sound knowledge about changes in urbanization over a time & their impact on Environmental Resources & carrying capacity of environment for future growth is important for legislators, planners and State & local governmental officials.

References

1. Data Base and Analysis Report for Master Plan report for Srinagar Local Area 2012-2032; 2013
2. Draft Master Plan report for Srinagar Local Area 2012-2032; 2013
3. Impact of Urban Land Transformation on Water Bodies in Srinagar City, India (Shahab Fazal, Arshad Amin, 2011) (scientific research Journal)
4. Saffron Cultivation in Kashmir: Practices & Problems (Amjad Masood Husaini, Badrul Hassan, Muzzaffar, Jaime, Nayar, 2010) (Global science books)
5. Report on climate change and its impact on Kashmir (Arjimand Hussain Talib)(Actionaid)
6. Land Use Land Cover Change Detection Using Remote Sensing Data and GIS Tools : A

Case Study of Delhi State, 2011
7. Forecasting land use change and its environmental impact at a watershed scale (Z. Tang, B.A. Engel, B.C. Pijanowski, K.J. Lim, 2005) (Journal of Environmental Management)

Application of Climate Science to Perform Risk Assessment to Improve Resiliency of Critical Infrastructure to Potential Climate Change

[1]Rajat Chakraborti, [1]Jagjit Kaur, [2]Armin Munévar, [3]James Marchese, [4]Homayoun R. Moghaddam, [5]Dave Jones, [6]Shahrouzeh Saneie

[1]CH2MHILL
325 E. Hillcrest Drive, Suite 125
Thousand Oaks, CA 91360, USA
Chakraborti_Rajat@yahoo.com; Rajat.Chakraborti@ch2m.com
Jagjit_Ub@yahoo.com; Jagjit.Kaur@ch2m.com

[2]Global Technology Leader – Integrated Water Resource Management, CH2MHILL
402 West Broadway, Suite 1450
San Diego, CA 92101, USA
Armin.Munevar@ch2m.com

[3]City of Los Angeles Bureau of Sanitation
Assistant Division Manager
Regulatory Affairs Division
City of Los Angeles, Dept. Public Works
Bureau of Sanitation, CA, USA
Jim.Marchese@lacity.org

[4]Director, Regulatory Affairs Division
City of Los Angeles, Bureau of Sanitation
1149 So. Broadway Ave., Suite 10018
Los Angeles, CA 90015, USA
Omar.Moghaddam@lacity.org

[5]CH2M HILL
1000 Wilshire Bl, Suite 2100,
Los Angeles, CA 90017, USA
Dave.Jones@ch2m.com

[6]Assistant Division Manager
City of Los Angeles, Bureau of Sanitation, Regulatory Affairs Division
12000 Vista Del Mar
Playa Del Rey, CA 90293, USA
Shahrouzeh.Saneie@lacity.org

Abstract

The SimCLIM integrated modeling system was used to assess the potential threats of climate change in terms of projected changes in future rainfall and sea level rise for infrastructure facilities of the City of Los Angeles, California, USA. The assessments were performed using an ensemble of general circulation model (GCM) from the Coupled Model Intercomparison Project (CMIP3) (archive located at the Lawrence Livermore National Laboratory that reflect the range in projected future precipitation characteristics for the years 2025, 2050, and 2090. The results were used to quantify climate change impacts on the facilities' hydraulic characteristics through the year 2090 using the City's existing design and one modified by projected changes storm precipitation. For the City's stormwater and sewer system assessment, the SimCLIM extreme event analysis was used to develop updated precipitation intensity, duration and frequency (IDF) curves for the project areas from a user-selected range of future greenhouse gas emission scenarios and GCM projections. The results from the model indicate larger sewer and storm drainage flows, predicting an increase in the frequency of sanitary sewer overflows (spills) from the sewer system and flooding from the storm drainage system for storms under selected climate change scenarios.

This strategic system-wide comprehensive study included preparation of climate adaptive plans for the critical facilities based on their vulnerability and overall system risk. Potential climate effects, including both extreme precipitation and sea level changes, on the operation of critical facilities were explored for the development of projects within the capital improvement program that provide for improved climate resilient infrastructure. The risk assessment process included identification of infrastructure facilities most at risk and potential preliminary adaptation strategies to increase the resiliency of these facilities under extreme climate events.

The SimCLIM application provided a customizable climate risk and resilience process that provided planners and decision-makers with a range of results based on the Intergovernmental Panel on Climate Change (IPCC) GCM results in a format that supports management planning and appropriate adaptation solutions for developing climate resilient infrastructure.

Key words: Climate change, sea level rise, precipitation, stormwater, adaptation strategy, risk assessment

1 Introduction

Climate change poses new challenges for cities in terms of design, planning, and operation of new and existing facilities. Climate change effects, including higher extreme precipitation amounts, higher temperatures, and sea level rise (SLR), coupled

with storm surge, are projected to result in increased flooding, sewer overflows, and regulatory uncertainty in management of infrastructure facilities. This paper will explain how climate change model results were applied to assess infrastructure facilities for vulnerability to climate change effects providing a basis for identification of adaptation strategies to reduce risk.

Based on recently published reports (Melillo etal., 2014), the southwestern United States is likely to experience more extreme climate events such as intense rainfall and higher temperatures causing additional stress to the City of Los Angeles' (City's) wastewater, stormwater and solids resources systems and operations. The risk of increased flooding due to extreme rainfall is compounded by projected increases in sea level and storm surge for coastal facilities, also potentially driven by extreme climate. One measure of climate change is how much of the annual precipitation at a location comes from days with precipitation exceeding two inches (Karl and Knight, 1998).

An analysis of projected changes in precipitation intensity, duration and frequency (IDF), as well as sea level rise, was conducted for the City's stormwater and wastewater infrastructure facilities based on climate change projections. Hydraulic modeling by the City was then used to predict potential sanitary sewer overflows at the Venice Pumping Plant and storm drainage flooding of the San Pedro storm drainage network due to extreme climate events.

To determine the potential risk of extreme climate conditions on the City's infrastructure facilities, the Los Angeles Bureau of Sanitation (BOS) is conducting a strategic system-wide vulnerability assessment to prioritize critical systems and infrastructure that of greatest risk to climate variability and change based on a risk-based screening level approach. Using this approach, the City will be able to prioritize critical facilities and infrastructure that are at greatest risk due to climate variability and change.

2 Climate Change Impacts on Infrastructure Facilities

The City evaluated the possible effects of climate change on two of its most vulnerable wastewater collection and storm drain networks using the City of Los Angeles Design Storm Hyetographs (back loaded). The City uses these hyetographs as input to their hydraulic model (MIKE URBAN) to estimate projected sewer flows into the Venice Pumping Plant and storm drainage flows within the San Pedro subshed. SimCLIM provided projected changes in 24-hour IDF amounts at the target years for three National Weather Service precipitation stations in the project area. The results were averaged and used as input to modify the City's Design Storm Hyetographs.

2.1 Climate Change Assessment Tool

SimCLIM (Warrick, 2005, 2007) is a PC-based application that seamlessly integrates observed data, SRES greenhouse gas emission scenarios and results from 12 daily general circulation models available from the CMIP3 database as illustrated in Figure 1.

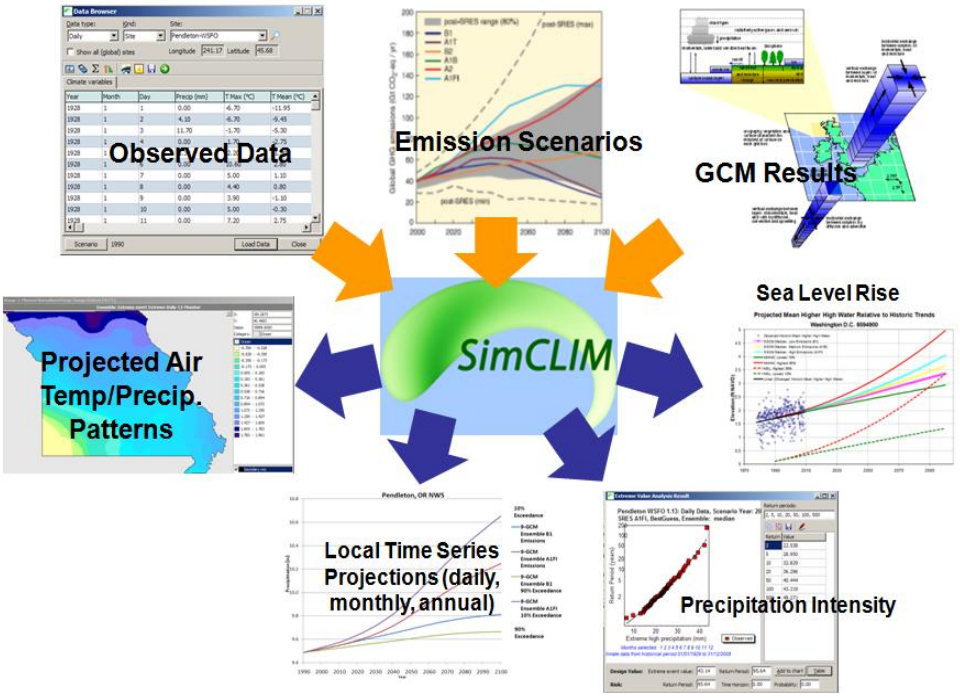


Figure 1: SimCLIM application functional input and output.

The Los Angeles project used the IDF feature available from SimCLIM to calculate historical and projected changes in IDF daily precipitation values. SimCLIM uses the generalized extreme value (GEV) method to determine precipitation return periods and corresponding amounts from historical annual daily maximum precipitation values. The GEV analysis (Jenkinson, 1955) is widely used for modeling extremes of natural phenomena, and is of considerable importance in hydrology (Natural Environment Research Council, 1975).

GCM results are produced at a coarse resolution (200 kilometer grid) and must be downscaled to capture the effects of local climate characteristics. Statistical downscaling is a two-step process basically consisting of development of statistical relationships between local climate variables (for example, surface air temperature, and precipitation) and large-scale predictors, and application of such relationships to the output of GCM to simulate local climate characteristics. The SimCLIM application uses a statistical pattern scaling method developed by Santer et al. (1990) to create downscaled precipitation patterns at a 65 kilometer (i.e., 35 mile grid) resolution.

2.2 Climate Change Impact on the City's Stormwater and Wastewater Facilities

Historical precipitation IDF values from three long-term and active National Weather Service climate stations in the City were analyzed using the SimCLIM computer model's generalized extreme value (GEV) statistical distribution. The historical analysis provided the baseline for determining projected changes in precipitation intensity, duration, and frequency derived from 12 daily GCMs and the SRES B1 (low) and A1FI (high) greenhouse gas emissions scenarios (IPCC, 2000) for the years 2025, 2050, and 2090.

The location of the Venice Pumping Plant and a portion of the San Pedro area storm drainage system sites are shown in Figure 2.

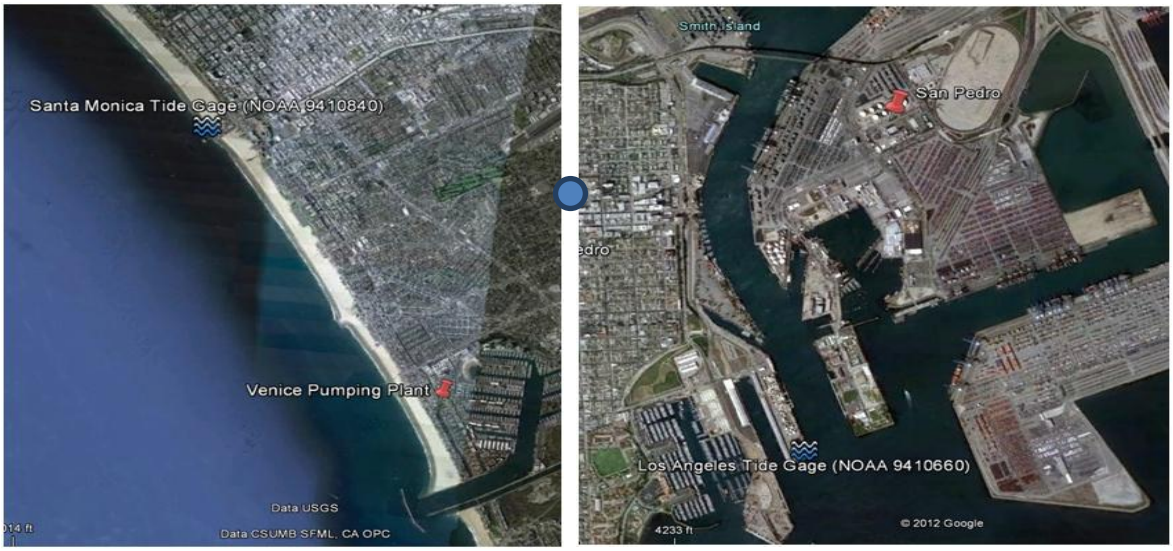


Figure 2: Climate change impacts to two critical City facilities were evaluated with respect to precipitation and sea level rise (tide gauge and rain gauge locations are shown, Source: Google Earth, NOAA).

For the year 2025, an examination of SimCLIM results indicates very little change in projected hourly precipitation amounts compared to the historical design hyetograph, except for the 100-year storm event. For the year 2050, however, an examination of SimCLIM low emission (B1) results indicates a trend to higher precipitation amounts when compared to the historical design hyetograph, however all changes are within 0.10 inches including the peak hour-21. The high emission (A1FI) results for all hours are higher than the design hyetograph and approximately 0.17 inches higher for the peak hour-21. An examination of low emission (B1) results for 2090 indicates a trend to higher amounts when compared to the design hyetograph, however all changes are less than 0.18 inches. The high emission (A1FI) precipitation amounts for all hours are higher than the design hyetograph and approximately 0.43 inches higher for hour-21.

The modeling results for the current design storm and modified (climate change adjusted) storm for the year 2090 were analyzed to obtain an adequate level of contrast on the effect of the climate change on the sanitary sewer system connected to the

Venice Pumping Plant and on the San Pedro storm drain network using the City's MIKE URBAN hydrodynamic models. Wet weather flows were generated in the model using the Unit Hydrograph Method routines for the 2010, 2025, 2050 and 2090 design storms. Flooding and flow rates were analyzed to quantify the climate change effect on the hydraulics of storm drain network. Figure 3 shows the results of the modified 10 Year-24 hour design storm for 2090 from an ensemble of 12 daily GCMs in the San Pedro area. The "original" storm indicates the rainfall intensity without climate change assessment, while the "modified" peak precipitation includes climate change effects.

Flow rates and spills were predicted for the San Pedro storm drain system for the City's ultimate planning year of 2090 for the 10-year design storm. Figure 4 shows the impact of climate change on the San Pedro storm drain system. A comparison between the design storm and modified design storm conditions predict considerable increases in the number of spills under the modified storm, especially along the northern branch of the storm drain network which shows little spilling with the design storm.

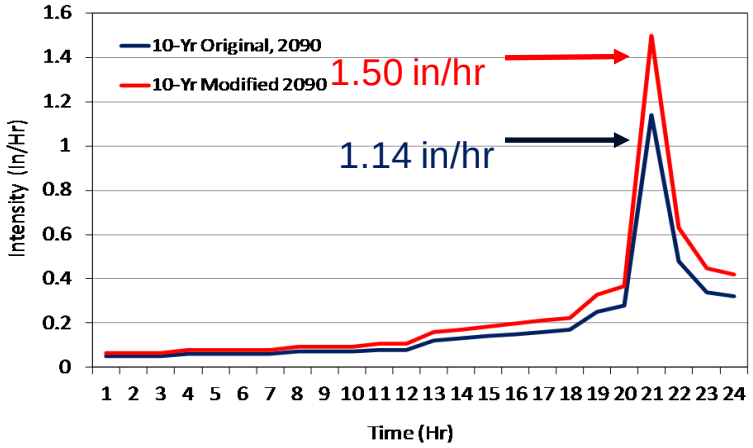


Figure 3: Modified 10 Year- 24 hour design storm for 2090 from an ensemble of 12 daily GCMs

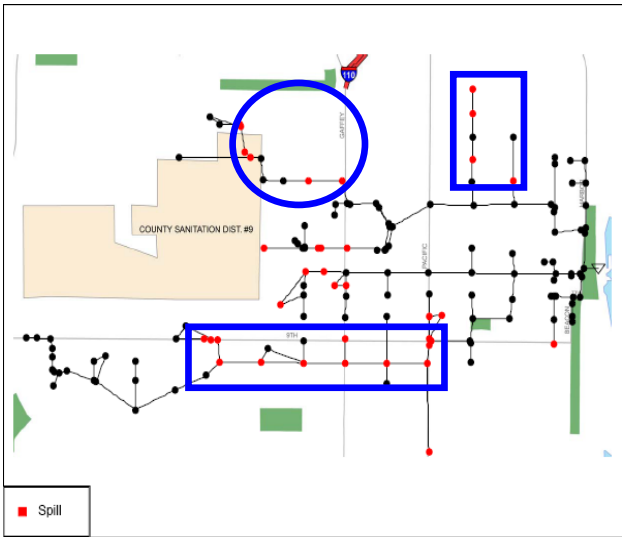


Figure 4: Flow rates and spills for the San Pedro storm drain system

An 11.7 percent increase to 70 cfs is predicted at the outfall's peak discharge flow rate due to climate change. Additionally, a one-foot sea level rise in year 2090 introduces a slight backwater condition at the outfall. The peak flow rate due to the effect of climate change at the Venice pumping plant area predicts a 3 cfs (1.9 %) increase by year 2090. This flow rate could cause wastewater spills from the coastal interceptor sewer facility based on the present capacity of the sewer network.

Similar analyses for other locations may identify potential of flooding/storm due to rainfall and sea level rise or areas vulnerable to climate change will help the City prepare climate based adaptation planning and develop capital improvement plans. Currently, the City is working on identifying critical assets which are vulnerable and sensitive to climate change effects and to develop adaptation planning to those critical/sensitive assets vulnerable for climate change.

2.3 Climate Change Impact of Projected Sea Level Rise on the Facilities

Sea level at a particular place can be higher or lower than the global mean due to regional effects. This is due to global sea-level rise, thermal expansion, atmosphere-ocean circulation patterns in the Pacific (e.g., El Niño); which affect ocean levels, melting of modern and Ice Age glaciers and ice sheets, which affect ocean and land levels, and tectonics (land uplift or subsidence) and fluid withdrawal/recharge, which affect land levels (Cayan and Dalrymple, 2012).

Global projections are based on oceanic-atmospheric climate models (AOGCMs) which are based on (i) knowledge of physical processes and underestimate land ice contribution; (ii) Semi-empirical methods (Vermeer and Rahmstorf, 2009) which is based on the observation that sea level rises faster as the Earth gets warmer and reproduce past sea-level rise, but ice behavior is changing; and (iii) combination of

climate models and extrapolations of observed trends in ice loss rates and accounts for rapid changes in ice sheets and glaciers (ice dynamics) (Cayan and Dalrymple, 2012; Cayan et al., 2009).

Global sea level rise can be estimated from tide gauge data by subtracting the land elevation change component. Thus, tide gauges are important observational instruments for measuring sea level change and trends. However, because variations in climate and ocean circulation can cause fluctuations over 10-year periods, the most reliable sea level data are from tide gauges having records 50 years or longer and for which the rates have been adjusted using a global isostatic adjustment model (Douglas, 2001).

The SimCLIM application (Warrick, 2005) provides a workbench to assess the impacts of climate on the environment. SimCLIM merges historical climate information with global climate change projections to provide users with the ability to conduct sensitivity analysis and examine climate change impacts on infrastructure facilities.

The SimCLIM Sea Level Scenario Generator used output from 13 GCMs available from the Assessment Report 4 (AR4) CMIP3 database. The Sea Level Scenario Generator was run using a low (B1) and high (A1FI) emission scenarios to generate projected changes in mean sea level (MSL). A relationship between MSL and mean higher high water (MHHW) was developed for the National Oceanic and Atmospheric Administration (NOAA) Los Angeles and Santa Monica tide gages in the Los Angeles basin area through the year 2090. Based on recent research focused on ice sheet melt contribution to sea level rise, the SimCLIM model was to include median AR4 ice sheet contributions of 0.85 mm/year for the B1 emissions scenario and 1.9 mm/year for the A1FI (IPCC, 2007a).

The North American Vertical Datum (NAVD) MSL values for Los Angeles for the year 2100 using 13 AR4 GCMs with and without ice sheet flow, two greenhouse gas scenarios (low [B1] and high [A1FI]) and Vermeer and Rahmstorf (2009) study range from 3.5 feet to 4.3 feet for AR4, 3.9 feet to 4.9 feet for AR4 using ice sheet flow, and 6.0 feet to 7.3 feet from Vermeer and Rahmstorf (2009) as shown in Figure 5.

The corresponding NAVD MHHW values for Los Angeles for the year 2100 using 13 AR4 GCMs with and without ice sheet flow, two greenhouse gas scenarios (low [B1] and high [A1FI]) and Vermeer and Rahmstorf (2009) study range from 6.2 feet to 6.9 feet for AR4, 6.5 feet to 7.7 feet for AR4 using ice sheet flow, and 8.6 feet to 9.8 feet from Vermeer and Rahmstorf (2009).

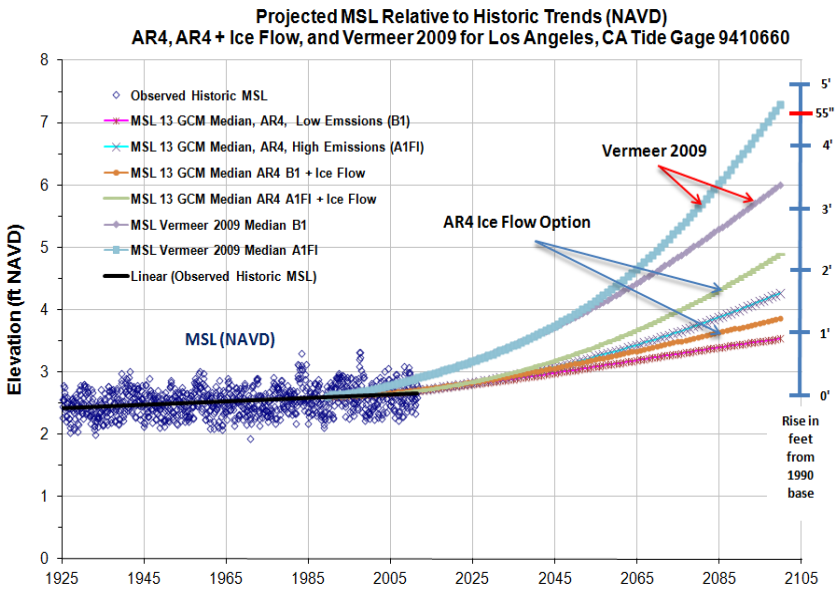


Figure 5: Range of Projected Change in MSL Relative to Historical Trends for Los Angeles, CA Tide Gage – Results from SimCLIM and Vermeer and Rahmsdorf (2009).

The effect of sea level rise and surge impacts to the Venice Pumping Plant area for the year 2100 is shown in Figure 6.

Figure 6: Sea Level Rise and Surge Impacts to the Venice Pumping Plant area in 2100 (Source: Google Earth and NOAA).

3 Strategic System-wide Vulnerability Assessment to Prioritize Critical Infrastructure based on Potential Climate Change Impacts

Various infrastructural facilities of the City would be affected by climate change activities. Also, the climate change impact on water resources and various assets would be variable. The short-term and long term asset vulnerability and risk assessment would assist development of an adaptation strategy which eventually helps reduce risk and cost for civil work in the future (USCOE, 2012).

This risk and asset vulnerability assessment was conducted because it (i) provides information about the nature of the problem, (ii) identifies assets affected by climate change impacts, (iii) narrows focus by identifying locations or parts of the system that are most vulnerable, (iv) provides information about the relationships between vulnerabilities of different systems, (v) helps to develop effective, targeted policy, and (vi) helps with prioritization of adaptation responses. Using a risk-based screening-level approach, currently the City is prioritizing critical infrastructure facilities.

Climate change effects, including increased extreme precipitation, temperature, and sea level rise coupled with storm surge, are expected to result in increased flooding, sewer overflows, and regulatory uncertainty in management of infrastructure facilities. Climate change poses new challenges for cities in terms of design, planning, and operation of new and existing facilities. It is important to understand the impact of climate change on the two areas studied in the City of Los Angeles, followed by development of a roadmap to identify infrastructure facilities vulnerable to climate change and identification of adaptation strategies to protect against the potential impacts of climate change.

This climate change risk assessment process focused on the potential impacts of extreme climate (i.e., intense rainfall, sea level rise, storm surge, etc.) on the selected BOS systems and infrastructure. The objective of a risk assessment process is to identify infrastructure most at risk and to identify potential preliminary adaptation strategies to increase the resiliency of these facilities under extreme climate events. The process follows a six-step framework including (i) framing the problem, (ii) identifying and ranking major assets vulnerable to climate change effects, (iii) developing potential adaptation measures, (iv) linking adaptation strategies to current processes, (v) implementing adaptation measures, and (vi) monitoring adaptation strategies and reassessing the plan.

The vulnerability assessment of BOS assets includes wastewater treatment plants, wastewater pumping plants, overflow retention structures, interceptor and trunk sewers, force mains, and air treatment facilities in the City's wastewater system; the Los Angeles River, Ballona Creek, Dominguez Channel, and Santa Monica Bay Beaches watersheds and stormwater quality improvement projects in the City's stormwater system; and recycling, refuse, hazardous waste, landfills and collection systems in the City's solids resources management system.

A strategic system-wide comprehensive study will include preparation of climate adaptive plans for the critical facilities based on their vulnerability and overall system risk. Potential climate effects, including both extreme precipitation and sea level changes, on the operation of critical facilities are to be explored for the development of projects within the capital improvement program that provide for improved climate resilient infrastructure. The goals of the asset vulnerability assessment are:

- Improve the resilience of the BOS's Wastewater, Watershed Protection, and Solid Resources program areas, infrastructure, programs, and systems to climate change effects;
- Decrease long-term risks and costs by identifying early actions to increase resilience; and
- Coordinate current and future efforts with other City activities and organizations involved in work to improve resource efficiencies.

A strategic vulnerability assessment workshop was held with City officials including division managers, planners, superintendents and system operators to achieve the desired outcomes, including:

- Agreement on critical infrastructure, including relative priority of criticality based on desired level of service
- Agreement on sensitivity of climate change on facilities (e.g., vulnerability and potential impact of extreme climate events)
- Identification of the linkages between wastewater, stormwater, and solids resources facilities (e.g., inter-related operations)
- Developing a greater understanding of how extreme weather events and climate variability may impact the City's infrastructure facilities and rank accordingly

Six major climate-related threats were discussed:

1. increasing temperature
2. increasing extreme precipitation
3. increasing sea level and storm surge
4. increasing drought severity
5. increasing wildfire risk
6. increasing extreme winds

For ease of conducting the vulnerability assessment, each of the BOS program areas has been organized into systems (e.g., wastewater, watershed protection, and solid resources), planning areas (e.g., wastewater treatment plants, pump stations, and landfills), and components (e.g., Hyperion Wastewater Treatment Plant, Venice Pumping Plant, Lopez Canyon Landfill). Scenarios of climate changes associated with each of the six climate-related threats have been developed based on the most recent climate assessments for the region.

The BOS Climate Vulnerability Assessment Team is initiating the development of an asset and climate vulnerability matrix. This matrix will identify the major assets associated with each of the BOS program areas, and characterize the relative climate vulnerability associated with the assets within each program area.

Goals of the climate vulnerability matrix include:

1. Identify the planning areas and components that best reflect how the program area is managed and for which vulnerability can be assessed.
2. Provide initial evaluations of the sensitivity, adaptive capacity, and vulnerability for each system component.

4 Future Plan: Potential Adaptation Planning for Critical Assets

Based on a screening level evaluation of the BOS systems, the next task would be to evaluate system risk to extreme climate events, and to identify areas needing in-depth comprehensive study. The comprehensive study would include preparation of climate adaptive plans for the critical facilities that identify critical system thresholds, system sensitivity, and adaptive capacity derived vulnerabilities. Cost-effective and environmentally sustainable adaptation solutions will be considered among potential mitigation options or alternatives. Potential climate effects on the operation of critical facilities will be used in the design of capital improvement projects including options that provide resilience against current and potential future sea-level and storm surge risks, and/or for preparing and implementing emergency response plans.

References

[1] Cayan, D and Dalrymple, R.A. (2012). Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future—NRC Committee findings, 7th Biennial Bay Delta Science Conference, October 16, 2012.

[2] Cayan, D., Tyree, M., Dettinger, M., Hidalgo, H., Das, T., Maurer, E., Bromirski, P., Graham, N., and Flick, R. 2009. Climate Change Scenarios and Sea Level Rise Estimates for the California 2008 Climate Change Scenarios Assessment.

[3] City of Los Angeles (City), 1990. Clean Water Program Advanced Planning Report. Technical Memorandum No. 6B: Infiltration/Inflow Allowance for Design of the sanitary Sewer System, Wastewater Program Management Division.

[4] City of Los Angeles (City), 2012. Climate Change Effect on City of Los Angeles' Wastewater Collection and Storm Drain System, Wastewater Program Management Division.

[5] Douglas, B.C. 2001. Sea Level Change in the Era of the Recording Tide Gauges. In: Sea Level Rise: History and Consequences. Douglas, B.C., M.S. Kearney, and S.P. Leatherman (eds.). International geophysics series v. 75. Academic Press, San Diego, CA, pp. 37-64.

[6] Intergovernmental Panel on Climate Change (IPCC). 2000: Special Report on Emissions Scenarios. Cambridge: Cambridge University Press. http://www.grida.no/publications/other/ipcc%5Fsr/?src=/climate/ipcc/emission/.

[7] IPCC (U.S. Intergovernmental Panel on Climate Change) 2007a. 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, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Chapter 10.6.5 Projections of Global Average Sea Level Change for the 21st Century, Table 10.7. Cambridge University Press, Cambridge, U.K. and NY, USA. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-6-5.html#table-10-7

[8] Jenkinson, A. F. 1955. The Frequency Distribution of the Annual Maximum (or Minimum) Values of Meteorological Elements. Quarterly Journal of the Royal Meteorological Society. 81(348): 158–71.

[9] Karl, T. R., and R. W. Knight. 1998. Secular Trends of Precipitation Amount, Frequency, and Intensity in the United States. Bulletin of the American Meteorological Society. 79(2): 231–41

[10] Lawrence Livermore National Laboratory. 2010. http://wwwpcmdi.llnl.gov/new_users.php. Retrieved November 2009 from Program for Climate Model Diagnosis and Intercomparison.

Natural Environment Research Council. 1975. Flood Studies Report, Volume II: Meteorological Studies. London, UK.

[11] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, USGCRP, 148 pp.

[12] PCMDI (Program for Climate Model Diagnosis and Intercomparison). 2009. Lawrence Livermore National Laboratory. https://esg.llnl.gov:8443/index.jsp

[13] Rahmstorf, S., A. Cazenave, J.A. Church, J.E. Hansen, R.F. Keeling, D.E. Parker, and R.C.J. Somerville. 2007. Recent Climate Observations Compared to Projections. Science, 316(5825), 709.

[14] Santer, B. D., T. M. L. Wigley, M. E. Schlesinger, and J. F. B. Mitchell. 1990. Developing Climate Scenarios from Equilibrium GCM Results. Report No. 47. Max-Planck-Institut-für-Meteorologie. Hamburg.

[15] Semenov, V. A., and L. Bengtsson. 2002: Secular Trends in Daily Precipitation Characteristics: Greenhouse Gas Simulation with a Coupled AOGCM. Climate Dynamics, 19(2): 123–40.

[16] USCOE, 2012, Reducing Civil Works Vulnerability Comprehensive Evaluation of Projects with Respect to Sea-Level Change, http://corpsclimate.us/rcwvceslcurves.cfm

[17] Vermeer, M., Rahmstorf, S. 2009. Global Sea Level Linked to Global Temperature. Proceedings of the National Academy of Sciences 106 (51): 21527–21532.

[18] Warrick, R. 2005. Climate Proofing: A Risk-based Approach to Adaptation. Asian Development Bank. http://www.adb.org/Documents/Reports/Climate-Proofing/climate-proofing.pdf.

[19] Warrick, R. A. 2007. SimCLIM: Recent Developments of an Integrated Model for Multi-Scale, Risk-based Assessments of Climate Change Impacts and Adaptation. Proceedings of the 2007 ANZSEE Conference on Re-inventing Sustainability: A Climate for Change. Noosaville,

Queensland, Australia.
http://www.anzsee.org/anzsee2007papers/Abstracts/Warrick.Richard.pdf

Strategy for Climate Change Management of the Water Supply of Quito - Ecuador

Fausto Alarcón Leoro
Empresa Pública Metropolitana de Agua Potable y Saneamiento
Av. Mariana de Jesús entre Alemania e Italia, Edificio Matriz B, 4to. Piso
Postcode: 170515; Quito – Ecuador
Fausto.Alarcon@aguaquito.gob.ec / fauxal@gmail.com

Abstract: The system that provides water to the city of Quito is likely to be challenged not only because of future increases on water demand and other anthropogenic pressures, but also because of changes in water availability at the intakes due to the impacts of climate change, such as: the Antisana's glacier retreat, paramo's degradation, longer and more severe droughts, among others. This paper aims to describe the Strategy for Climate Change Management for the Quito's Public Water and Sanitation Utility –EPMAPS that includes both Adaptation and Mitigation Programs to Climate Change.

The Adaptation Program is based on the evaluation and discussion of the major findings of studies that have been developed for EPMAPS. The results show an estimated average potential loss in water availability of 12% for all of Quito's water supply systems due to climate change. More pessimistic climate estimates resulted in reductions around 34%. Additionally, a future scenario of socio-environmental conflicts due to water scarcity has been analysed.

This paper aims to highlight a number of actions and good practices to shape a comprehensive strategy that includes the implementation of both structural and non-structural measures to ensure adaptation to climate change, focusing not only to maintain or increase the water supply of the systems, but also to decrease the demand by optimizing water use. To overcome the uncertainties of the analysis, a set of non-regret measures has been used to mainstream climate change adaptation into the Infrastructure Master Plan.

The Mitigation Program is based on a set of indicators of the Ecological Footprint calculated for EPMAPS. Total direct and indirect emissions reached 119.947 tCO2eq during 2012. Some measures for reductions of GHG emissions that include some good practices on the wise use of resources and energy within EPMAPS will briefly be mentioned.

Key Words: Water supply, adaptation to climate change, climate change scenarios, non-regret measures, mitigation to climate change, paramo.

1 Context

The "Empresa Pública Metropolitana de Agua Potable y Saneamiento" -EPMAPS is the Public Utility Company of Water and Sanitation of the Metropolitan District of Quito that provides water and sanitation to around 2.4 million people. The total coverage of the services within the District is around 97.18% for water supply and 91.14% for

the sewage system. No waste water treatment process is currently in place in Quito. The unaccounted-for water is 27.75% and the average domestic water consumption is 159.79 l/cap/day. Water quality fulfills all national and international requirements [3].

In order to cope with the greater water demand in the city due to both population growth and greater per capita consumption, several projects have been developed since 1957, farther every time, including a number of interbasin water transfers. The EPMAPS's Infrastructure Master Plan foresees the need of a new infrastructure expansion in the coming years, including a "Rios Orientales" Project that would provide 17m^3/sec. [4].

Year	System	Flow (lt/sec)	%	Distance (Km.)	Reservoirs.	Catchments	Status
1957	El Placer	620	8.61	24	-	Paramo / Aquifer	Non protected
1974	Pita-Puengasí	1,800	25.00	40	-	Paramo / Glacier	Non protected
1990	Papallacta (I)	1,500	20.83	51	-	Paramo	Protected / National Park
1998	Mica- Quito Sur	1,500	20.83	45	1	Paramo / Glacier	Protected / Reserve
2001	Papallacta (II)	1,500	20.83	73	3	Paramo / Glacier	Protected / National Park
	Well, creeks	280	3.89	-	-	Aquifer	Non protected
TOTAL		7,200	100.00		4		
FUTURE	"Ríos Orientales" Project	17,000		120	-	Paramo / Glacier	Protected / National Park

Table 1: Water Supply Systems of EPMAPS. Modified from Ref. 4

At present most catchments are dominated by ecosystems known as paramo (high elevation wetlands), and to a smaller degree by the glaciers residing on the highest peaks. There is a growing concern that increased temperatures due to global warming may become a threat to the paramo which, from a water harvesting point of view, constitutes an almost ideal combination of vegetation and soils with very large water retaining capacity, good erosion protection and low evaporative losses. The paramo seem to be a fragile ecosystem as both deforestation and grazing have been found that they reduce the paramo's water retaining capacity significantly [2]. Glacier retreat is very well documented in the area. This retreat will also have a negative effect on the yields of the intake catchments, although to a smaller extent [Ref. 6]. This situation among other anthropogenic pressures (population growth, deforestation, the expansion of the agricultural and cattle herding frontiers, forest fires, water overdraft, etc.) will surely bring a scenario of water stress that EPMAPS will have to manage.

2 Climate Change

As the latest IPCC's Assessment Report -AR5 confirms, changes in the hydrological cycle due to climate change can lead to diverse impacts and risks, and they are conditioned by and interact with non-climatic drivers of change and water-management responses. There are *medium level of agreements* and *medium level evidences* that climate change is likely to increase the frequency of meteorological droughts (less rainfall), agricultural droughts (less soil moisture) as well as short hydrological droughts (less surface water and groundwater) [7].

Even though water moves through the hydrological cycle, it is a locally variable resource, and vulnerabilities to water-related hazards such as floods and droughts differ between regions. Therefore, it is necessary to assess the particular conditions and the climate change impacts of the area of influence of EPMAPS´s water supply systems.

2.1 Climate Change Signals

The National Institute of Meteorology and Hydrology -INAMHI points out an increase in the mean, maximum, and minimum annual temperature throughout Ecuador. Taking into account the data of the 39 stations considered, between 1960 and 2006, the mean annual temperature rose by 0.8 °C, the absolute maximum temperature by 1.4 °C and the absolute minimum temperature by 1.0°C. The rainfall amount, frequency, and intensity have varied considerably in the country, particularly in the last few years, with significant geographic and season differences [10]. A research conducted by INAMHI at the Quito Observatory detected a growing trend towards an increase in temperatures between 1891 and 2012 and a certain downward trend in precipitation [11].

Regarding the climate behavior within the catchment areas of the water supply systems, the "Vulnerability to Climate Change of the Pita-Puengasí water system" study shows that there is not enough hydro-meteorological information (very small time series and data quality concerns) to conclude any climate change trend with statistical significance in most meteorological stations in the region, that is why the analysis has been performed only with a reduced number of stations. That fact shows the limitation and the *high degree of uncertainty* of any hydro-meteorological analysis within the region. The study concludes with a *medium level of certainty* trends of rising temperatures and precipitation reduction in certain months in the catchment areas [11].

People's perceptions about how the climate has changed during last years confirm the idea that temperature has been rising, the number of extreme events has increased and the seasonal rainfall has changed [9]; [13].

2.2 Climate Change Scenarios

An analysis of climate change indicators using the statistical tool ClimDex indicates that, in general, in terms of temperature, it was found that the minimum and maximum temperatures are rising at a rate of between 0 and 0.5 °C / decade for entire study area. This result is consistent with the downward trends for the percentage of

days with cold nights and cold days, and trends of increase in the percentage of nights and warm days [12].

As for precipitation, the results show a clear sign of increasing total rainfall for catchment areas. Extreme rainfall is also increasing in the study area, while very extreme precipitation evidence slight increase in the valleys. The number of consecutive dry days is also increasing throughout the study area, indicating that days with precipitation are becoming less common in the study area, but when it rains it tends to be more extreme [12].

As far as climate change scenarios from global models, Ecuador relies on national climate change scenarios that resulted from the PRECIS, TL959 and ETA models. Such results have been subject to validation and consensus under a joint initiative among INAMHI and the Ministry of Environment. In general, the results of the studies performed on national geographic spaces and pilot spaces, show no consensus [10]. This fact shows the great deal of *uncertainty* while dealing with these scenarios.

Particularly to the catchment area of Quito's water supply systems, INAMHI has proposed a climate change scenario using the TL959 model. The results of this study are shown in the Fig. 1. However, the use of these kind of models have limitations regarding the proper scale, consistency of the models as well as the capacity to model non hydrostatic events such as the precipitation in the tropical highlands [1]

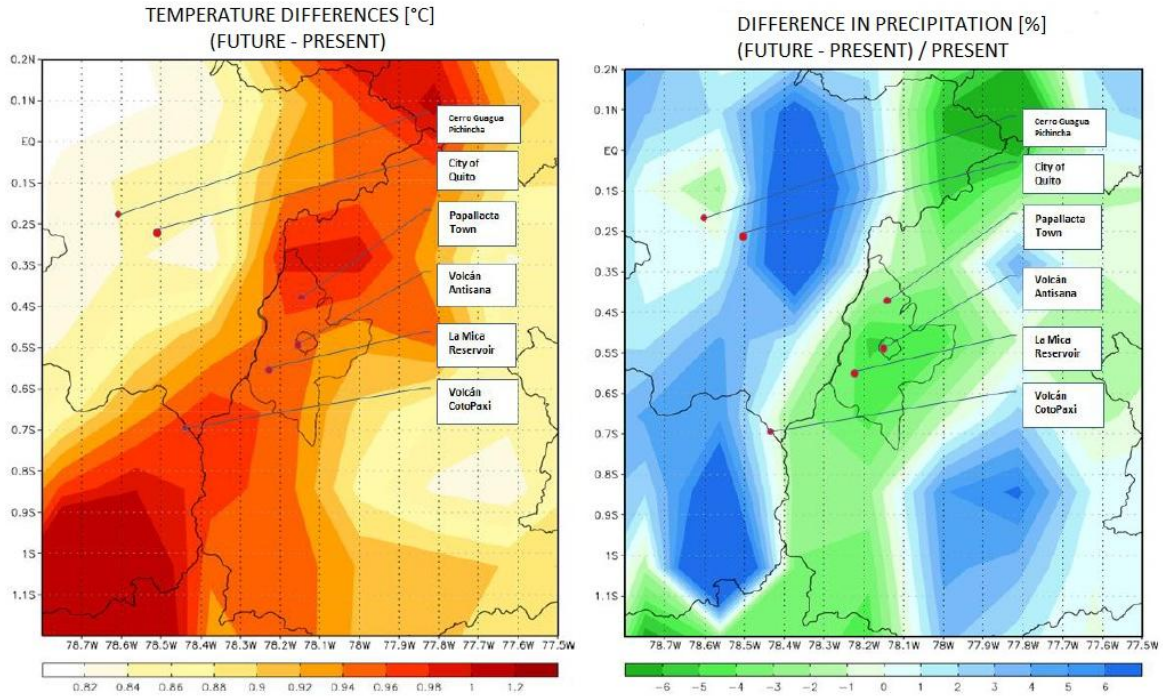


Fig. 1: Average change of temperature and precipitation from the present (1979-2003) to the near future (2015-2039) in the Quito area. TL959 Model. Source. Ref.1

As illustrated in Fig. 1 the model simulation suggests temperatures in the near future (2015-2039) would be rising all over the area. The simulated changes for the mountain areas are between 0.9 and 1 deg. C. The study suggests an average decrease in precipitation of 3-4 % for the important intake catchment around Antisana. The large spatial variation is noted where particularly the valley areas are expected to receive more precipitation than in the present situation.

Although INAMHI [1] highlights *the uncertainty* of presented figures and suggests using the tendency rather than the exact numbers, these changes on precipitation and temperatures have been assumed in another study [8] to model the impacts in the near future over EPMAPS' intake catchments.

2.3 Impacts of Climate Change

The aforementioned analysis describes a trend of higher temperatures and increasing precipitation but with greater seasonal and spatial differences in the territory. A qualitative impact analysis of the climate change scenarios forecast that higher temperatures would lead to an increase of water demand for all uses, higher evapotranspiration rates as well as lower water retention capacity of both glacier and paramo ecosystems. Changes in the precipitation as the scenario described, would lead to a higher number of extreme events, less rainfall during dry seasons (potential droughts) and higher rainfall intensity in wet season (potential floods and landslides) [13].

The paramo ecosystem is of great concern due to its large extension in the intake catchments and its ideal characteristics from a water yielding point of view (good water regulation and low evaporation). The paramo is under threat from anthropogenic pressure (the limiting upper level for feasible cultivation will increase with the temperature) and from nature as the upper level of the tree line will also increase. Therefore, it is important to take into account the climate change impacts over the paramo in order to assess the impacts over the future water availability within the Quito's water supply systems.

A study conducted by the DHI [8], assesses the climate change impacts on the glacier retreat and the mountain hydrology and its implications over the Quito's water supply. This study uses the TL-959' outputs and assuming a "Best Estimate Scenario" (rise of 1°C) and a "Pessimistic Scenario" (rise of 2°C).

The projection so called "Best Estimate" is based on the predictions of climate change for the 2015-2035 period using the meteorological model TL-959 [1]. The total change in flow availability using this projection is estimated at 12% decrease. The largest contribution (6%) originate from the assessed general change in runoff due to the smaller amounts of precipitation and larger evapotranspiration, while the potential changes from degradation of paramo could be almost of the same magnitude (5%). Glacial retreat contributes only marginally to the decreases due to its small contribution to the Quito's water supply systems [8]

For the more pessimistic scenario (+2 °C), the loss of paramo could be substantially contributing with 18% of the total 34% flow loss. These impacts are assumed to be related to the possible degradation of the paramo for various reasons.

The combined impacts on the water availability at EPMAPS' intakes from the considered changes in paramo, glacier areas and runoff, due to changes in the precipitation regime and rising temperature, are illustrated in Fig. 2

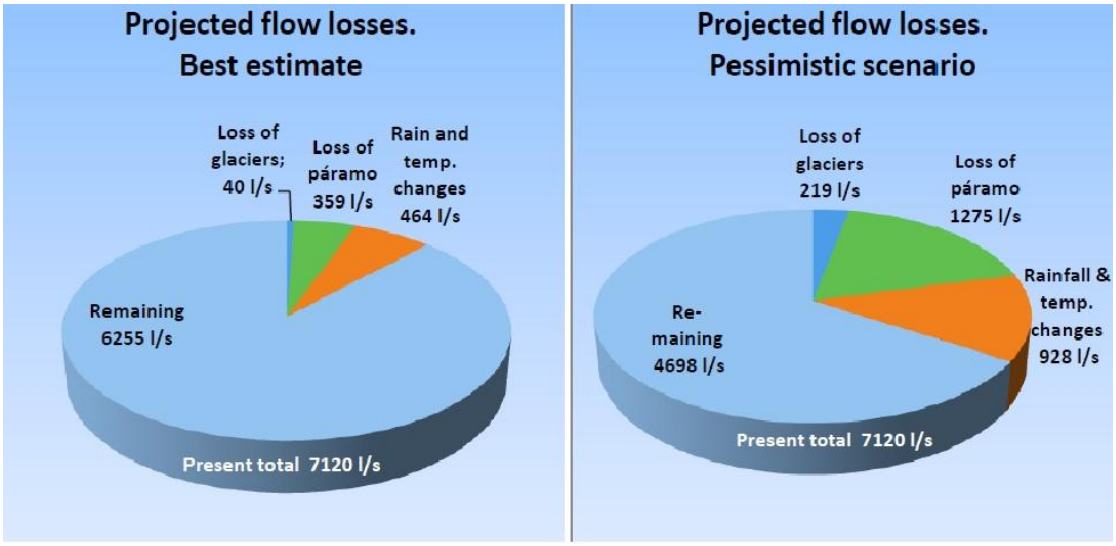


Fig. 2: Projected flow losses within EPMAPS' water intakes due to climate change. Source. Ref.8

It has to be emphasized that these results have a great deal of uncertainty that has been introduced in the analyses through a number of aspects such as: lack of consistent hydrological information, a number of assumptions while modeling impacts, and the already mentioned uncertainties of future climate scenarios.

Another study conducted by the SEI [13], assesses also the vulnerability to climate change of the Quito's water supply systems. This study includes the outputs of multiple Global Circulation Models, downscaled and assembled into a series of dataset future projections (2050) ready for analysis. 5 scenarios have been formulated through the combinations of factors such as: population, temperature, drought periods and paramo's retreat.

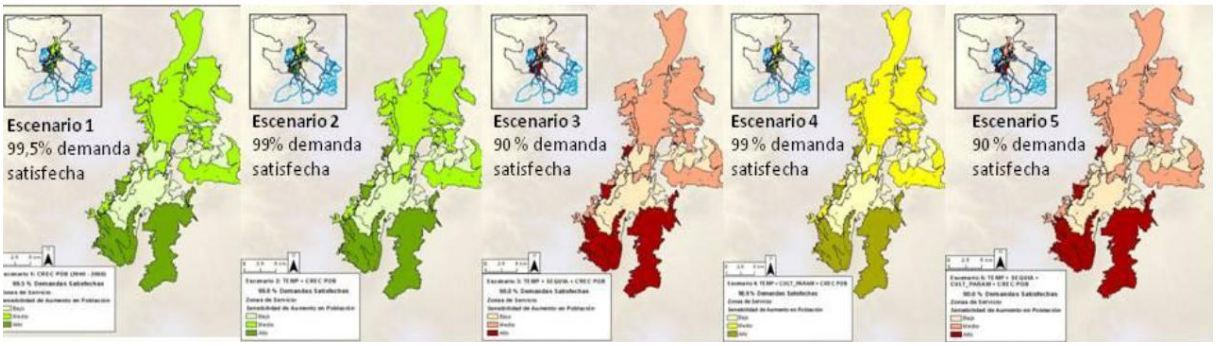


Fig. 3: Projected level of satisfaction of water demand in the MDQ. Source: Ref.13

The Fig. 3 shows the projected level of satisfaction of water demand in Quito of the 5 scenarios that analyze: 1) Population growth; 2) Scenario 1 + higher temperature; 3) Scenario 2 + drought periods 4) Scenario 2 + paramo's retreat; 5) Scenario 4 + drought periods. According to these results (Scenarios 3 and 5), only 90% of Quito's population could be satisfied with water supply by 2050 [13]

Besides all physical impacts of climate change over the water availability, a scenario of future socio-environmental conflicts has been described for the Pita-Puengasí water supply system. Water shortage within the watershed would have special impacts

over farmers, increasing a competition over the scarce water resources during droughts [9]

3 Adaptation to Climate Change Program

Planning the future water supply of the city, demands assessing the trends of population growth, demand per capita, many anthropogenic factors as well as institutional and regulatory issues that would influence over the total water demand of DMQ. In order to meet future water demands, EPMAPS has developed an Infrastructure Master Plan proposing a number of actions and new infrastructure projects. However, due to the lack of consistent evidence of climate change from the statistical point of view and high uncertainties of future climate scenarios, no specific action has been formulated regarding adaptation to climate change in the Master Plan [9], [4].

Nevertheless, the consequences of climate change over the availability and the future water demand in Quito, analyzed in recent studies, show the increasing necessity to establish a strategy to cope with the possible impacts of climate change, despite the fact of high level of uncertainty.

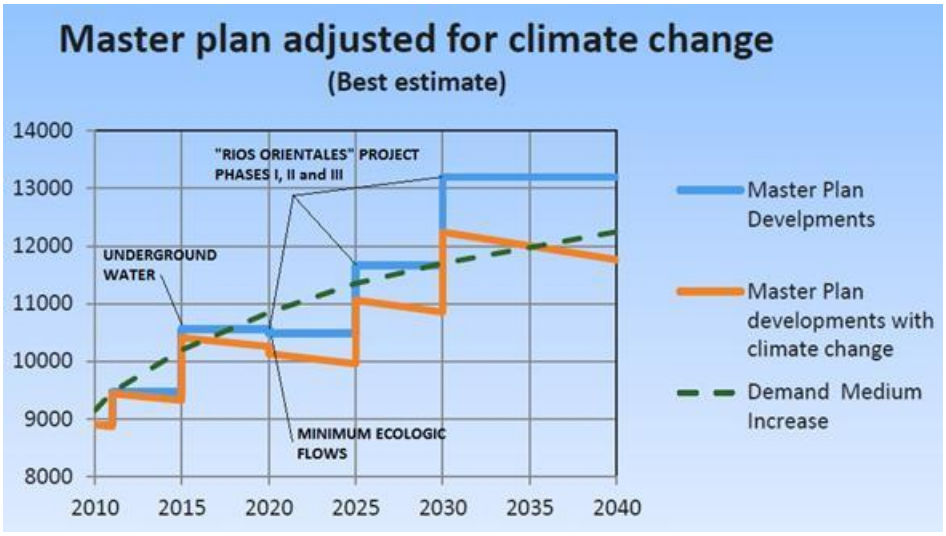


Fig. 4: Planned developments and the water availability of these projects adjusted for climate change impacts Source. Ref.8

The Fig. 4 shows the results of the impact analysis of climate change over the Quito's water availability by 2040. It can be noticed that climate change could affect the effectiveness of future infrastructure projects ("Rios Orientales" projects, phases I, II and III) to meet future water demand [8]. This situation raises a question: Should EPMAPS invest in the development more infrastructure projects to cope with the effects of climate change, despite the uncertainties?

As precautionary principle, a screening process of EPMAPS's activities currently in place has been made in order to find non-regret adaptation measures. The term "Non-regret measures" refers to all those activities that contribute to adaptation and are useful in any case (with or without climate change). In this way, it is possible to prioritize those actions (both structural / non-structural projects) that would contribute to adaptation. Those projects wouldn't constitute oversized infrastructure and could easily be included within the Master Plan framework. The Table 2 shows a number of activities that are currently being implemented and have strong potential to contribute

to the EPMAPS's adaptation capacity. As result of the analysis, a set of recommended measures has been added to the list to enhance the adaptation strategy.

	Structural Measures	Non Structural Measures	Crosscutting Issues
Demand Side	-"Friend Plumber " Program	- Improvement of subsidies program	- Institutional Strengthening
	- Micrometering (control of losses)	- Reduction of unaccounted-for water	- Strategic Planning (Mission & Vision)
	- Promotion of low water consumption devices *	- "Yaku" Water Museum	- EPMAPS Master Plan
		- Edu-communication (Awareness campaigns) *	- Corporative Risk Management
		- Tariffs management	- Disaster risk management *
Supply Side	- "Rios Orientales" project. Phase I. Chalpi river	- Hydro-meteorological Monitoring & Forecast	- Institutional Networking *
	- "Rios Orientales" project. Phase II. Quijos river	- Water Quality Control (4 stages)	- Strengthening community relationships *
	- "Rios Orientales" project. Phase III. Quijos river	- Land acquisition for conservation (Mudadero, Contadero and Antisana Ranches) *	- Further research in key areas *
	- "Rios Orientales" project. Phase IV. East Antisana intakes	- Protection of strategic paramo areas to maintain ecological services (Management Plans) *	- Promoting efficient irrigation systems to strategic farmers *
	- Improvement of Aquifer exploitation	- Research on paramo restoration techniques	- Special water distribution agreements during droughts *
	- Macrometering and pressures control	- Watershed modeling *	
	- Further interconnection of main water tanks (distribution redundancy) *	-Scientific Research Center *	
		- Watershed monitoring *	- Promoting integrated watershed management *
		- Restoration of paramo's degradated areas *	

Table 2: Climate Change Adaptation Program of EPMAPS.

The projects marked in white are all adaptation measures that are already being implemented or their implementation is already projected in the Master Plan. The activities marked by light grey are measures that are also currently being implemented but there is a need either to be strengthened or to be prioritized. Those measures marked in dark grey are the additional recommended adaptation activities proposed by the current analysis. The projects marked with (*) represent those measures where climate change criteria have been introduced during their formulation.

Among all these adaptation measures, it is worth to mention the importance of those activities linked to the protection of paramo's ecosystem. As the impact assessment revealed, both paramo's degradation and the expansion of the agricultural and cattle herding frontiers due to climate change will have an important impact over Quito's future water availability. The Fig. 5 shows the projected results of paramo's protection over the future water availability.

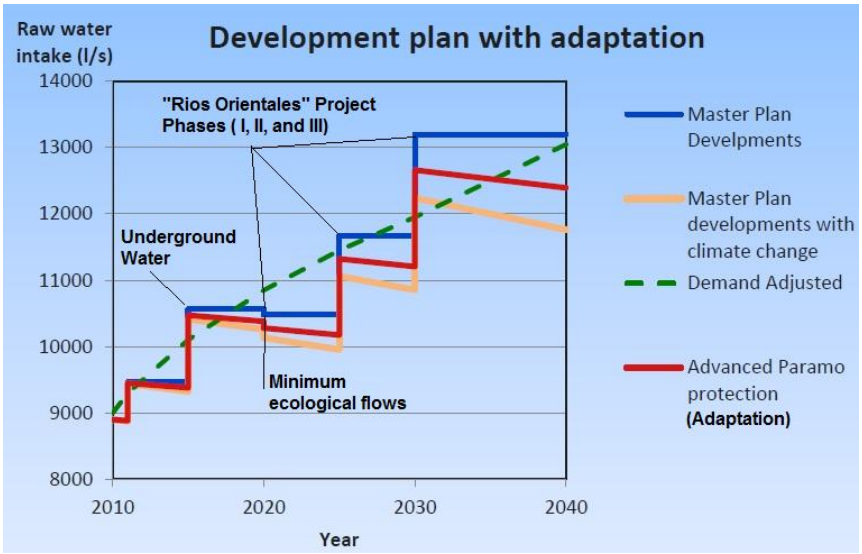


Fig. 5: Impact of adaptation measures (paramo's protection) over water availability. Source: Ref.8

4 Mitigation to Climate Change Program

In 2012, EPMAPS generated 119,947.5 tonnes of carbon dioxide (tCO_2e), of which only 2.68% were emissions under the direct control of the company. 74.83% of EPMAPS's total Greenhouse Gases emissions are from construction materials used in new infrastructure projects and another 8.98% of the total GHG emissions are due to energy acquisition [5]

The Eco-efficiency Plan of EPMAPS aims at reducing the intensity of consumption of materials of construction, electricity, fuel and water in the activities of the company. The Plan also includes the promotion of a culture of sustainable consumption within the company (capacity building). It has been recommended, further specific assessments on energy consumption on pumping stations and further requirements regarding the implementation of good environmental practices to contractors.

Among the proposed measures to mitigate climate change, it can be highlighted, the exploitation of the hydroelectric potential of water supply systems through the use of micro-power plants, as well as, the carbon sequestration through the protection and preservation of the paramo.

5 Conclusions

In order to mainstream climate change into the EPMAPS's Master Plan, a comprehensive set of measures has been formulated, covering both structural and non-structural projects, aiming either to maintain or increase water supply or to decrease its demand. The introduction of the "non-regret" criterion within the analysis, in one hand, has helped to manage the uncertainties involved during the assessment of climate change, and in the other hand, it has allowed the results to be less controversial to the main decision makers. It is important to mention that the EPMAPS's Adaptation Program must be continuously be monitored, assessed and re-evaluated in order to guaranty that the set of measures proposed in the program are proper enough to cope with the negative effects of climate change.

As it is the case to mitigation, the adaptation to climate change of EPMAPS alone has no sense without the establishment of an institutional network to cover those aspects that the company cannot solve, as well as the people's awareness and involvement in the process of reducing water demand and protecting strategic ecosystems such as paramos.

In order to improve the current analysis, further research on the relationship and interaction of -glacier, paramo, superficial run-off and underground water- has been recommended. It is also important to strengthen the hydro-meteorological monitoring of the watershed areas of EPMAPS's main water intakes.

References

[1] Chimborazo,O. Guerra, S: Escenarios de Cambio Climático con las Salidas del Modelo TL-959.Antisana. INAMHI –MAE. 2010.

[2] Crespo, P., et. Al: Land use change impacts on the hydrology of wet Andean paramo ecosystems, Universidad de Cuenca - IAHS Press. 2009

[3] EPMAPS: Memoria de Sostenibilidad 2012, pp. 50-87.

[4] EPMAPS: Resumen Ejecutivo-Plan Maestro de Abastecimiento de Agua. Elaborated by Hazen and Sawyer P. C. 2011.

[5] EPMAPS: Línea base, Evaluación y Formulación de indicadores y Planes de uso ecoeficiente de recursos de la EPMAPS, Prepared by La Ceiba – Deuman, 2013

[6] INAMHI: Glaciares del Ecuador: Antisana 15 y 12, Carihuayrazo, Balance de Masa, Topografía, Pluviometría, Meteorología & Hidrología. Informes 2008, 2009.

[7] IPCC Working Group II: Assessment Report 5, Chapter 3: Freshwater resources, 2014, pp. 1-26

[8] Jensen, R.: Climate Change Impacts on Glacier Retreat and Mountain Hydrology and its Implications for Quito Water Supply, IADB – DHI, 2013.

[9] MAE – SGCAN –PRAA: Estudio de vulnerabilidad y adaptación al cambio climático del sistema de agua potable Pita – Puengasí y sus cuencas abastecedoras, Prepared by INTERCOOPERATION, 2013.

[10] Ministerio del Ambiente: Segunda Comunicación Nacional de Cambio Climático del Ecuador, 2011, pp. 59-64, Quito -Ecuador

[11] Municipality of the Metropolitan District of Quito, Secretariat of the Environment: Climate Change Strategy of Quito, 2009. 36 pp.

[12] Muñoz, A.: Análisis estadístico con Climdex de índice climáticos para las provincias de Pichincha y Napo, MAE-PRAA, 2014.

[13] Secretaría de Ambiente – MDMQ: Estudio de Vulnerabilidad al Cambio Climático DMQ. Prepared by Stockolm Environmental Institute – SEI, 2014.

Adapting Rural Water Infrastructure Projects to Climate Change: Chilean Norms and Practices

Jimenez-Cavieres, Fernando
Boreal Research and Consulting Ltda.
Av. Cristobal Colon 5444 Depto 1004
758-0214, Las Condes, Santiago
Chile
fjimenez@borealconsultores.cl

Abstract: According to the latest ND-GAIN Index, Chile is the best ranked country in Latin America and the 25th in the world for adaptation to climate change and global climate challenges. However, adaptation challenges still exist in the infrastructure sector, particularly in rural water infrastructure investments where adaptation approach has been not incorporated so far.

After an ex-post evaluation carried out to nine cases studies in two southern regions, it has been evidenced that Chilean climate change adaptation criteria norms and standards have not reached rural water supply projects.

This paper explores the contrast between norms and standards with the practices occurred all throughout the project cycle, from the feasibility to the actual implementation and operation. It is suggested that institutional changes as well as information and appropriate monitoring system are key tasks in the near future.

Key Words: rural infrastructure, rural water supply, Chile, Chilean, climate change adaptation criteria, norms and standards, information & monitoring systems

1 Climate change and national agenda

Official figures indicate that Chilean contribution to greenhouse emissions is estimated at 0.2%, what is not only considered low but also means that Chile is not forced to take any measures. Nevertheless, the country is committed towards both steps on adaptation actions and to actively participate on international initiatives such as the Intergovernmental Panel on Climate Change (IPCC).

Since 2000, Chile is submitting *National Communications* to IPCC, keeping updated information about its internal situation and agenda. Within this frame, Chile is considered highly vulnerable to extreme events related to water resources, which have important impacts on energy generation and water supply.

Water cycle perturbation is an evident signal of climate change everywhere. In Chile, altered rainfall patterns, decreasing snow storage capacity, glaciers retreat, chronic droughts and desertification processes, are part of the effects which caused a severe reduction on water obtainability in many regions of the country, as well as over storming rain and flooding that follow droughts.

Besides these typical effects of climate change on agriculture and water supply, there are also evidences from the health sector about serious increases in outbreaks of pulmonary syndrome caused by Hanta virus. There are also studies which suggest that atmospheric pollution is worsening as a result of increasing motorization rate. Climate change is also behind augmenting probabilities of forest fires. All this diverse type of impacts show evidences of the broadness and intertwined effects of climate change.

According to the *United Nations Framework Convention on Climate Change*, Chile is among the most vulnerable countries because it holds seven out of the nine characteristics which define a risky territory (fragile ecosystems; arid and semiarid territories; prone to natural disasters, to drought and to desertification; low lying coastal areas; economy based mainly on row materials exploitation).

Already in 1999, a national study elaborated by CONAMA -the Chilean governmental commission for environment- predicted major temperature changes through the country, with decreases close to 2° in the warm north and increases up to 3° in central and southern colder regions. These variants affect the water cycle modifying rainfall patterns. While central regions will experiment a reduction, what means increasing desertification, the extreme southern regions –from Chiloe Island to extreme Patagonia- will increase.

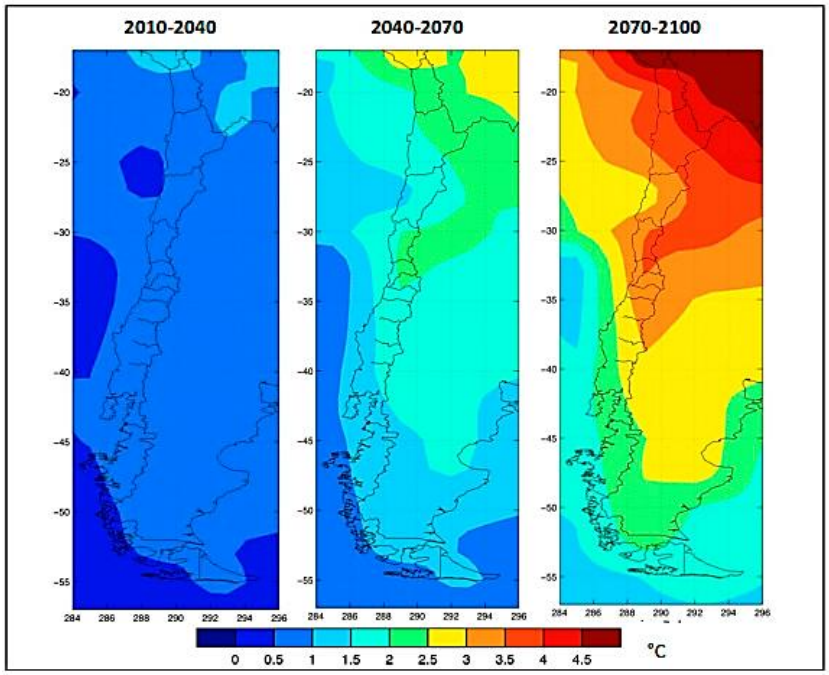


Fig. 1 Eventual temperature scenarios in Celsius grades (Source: United Nations Economic Commission for Latin American and Caribbean countries, ECLAC, 2012 [1])

Behind these tendencies is possible two find two opposite but interrelated climatic phenomena: *el Niño and la Niña* (the Boy and the Girl). While the first (el Niño) is considered the warmer phase of the phenomenon, characterized by rainfalls and increasing ocean surface temperatures that affect fishing stock as well as infrastructure such as roads, bridges and ports, the later (la Niña) shows a decrease in rainfall up to 79% of normal precipitation, which cause drought and impact on hydroelectric generation, agriculture, livestock and mining production, among others.

Taking into account all this evidences and its impact on many interrelated social, economic, cultural and environmental sectors the Chilean government have been developing an action agenda which derived in a first *National Climate Change Plan* 2008-2012 [2]. This plan contains several strategic considerations for public policies and regulations, including mitigation and adaptation measures to be implemented both by private and public sector.

1.1 Technical and social adaptation criteria

Among the measures considered by the National Plan mentioned above, there are both norms and recommendations that slowly have been considered in high impact projects such as energy plants, transportation systems and huge infrastructure such as dams, bridges and ports.

It is evident that instable weather conditions change the frequency, intensity, timing and exposure of climatic phenomena. However, weather is not the single factor behind all the damage resulting after natural disasters. Many of the impacts of climate change can be prevented or mitigated by proper technical, political, economic and even cultural decisions. In other words, we may possibly adapt our decisions to climate change evident alterations.

As a matter of fact, according to IPCC [3] "*adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts".* That means to incorporate climate change criteria in the process of decision-making related to actions, projects and policies which may affect or be affected by meteorological conditions, considering both challenges and possible opportunities.

Adaptation is being considered as an appropriate approach to face climate change, particularly since there is enough evidence of human responsibility in part of the alterations and the fact that some impacts can at least be mitigated.

According to the report *"Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation"* (SREX, IPCC, 2012) there is insufficient research about the impacts of climate change on infrastructure, even though there is enough awareness of potential risks. More detailed analysis about climate change-related consequences is required and only few countries are doing it, indicates the report. Even so, there is certain international consensus that incorporation of measures to adapt infrastructure to climate change must be comprehensively incorporated form the very beginning of any project and taking into account its whole cycle

The main objective of the Chilean National Adaptation Plan is to address country's vulnerability and future climate risks, setting forth adaptation and mitigation policies according to the areas and specific objectives shown in following table:

Table 1. National Climate Change Strategy (Source: National Climate Change Plan)

Area	*Objectives*
Adaptation to the Impacts of Climate Change	*1. Evaluate environmental and socioeconomic impacts of climate change in Chile.* *2. Define adaptation measures.* *3. Implement and follow-up on adaptation measures*
Mitigation of Greenhouse Gas Emissions	*1. Analyze alternatives for mitigating greenhouse gas emissions in Chile.* *2. Define mitigation measures.* *3. Implement and follow-up on mitigation measures*
Creation and Promotion of Capacities in the Area of	*1. Promote public information and awareness about climate change.* *2. Encourage education and research on climate change.* *3. Improve systematic climate observation.* *4. Generate high-quality, accessible information for decision-making.* *5. Build institutional capacities for mitigation and adaptation.* *6. Develop and transfer technologies for mitigation and adaptation.* *7. Regularly review and update Chile's national greenhouse gas inventory.* *8. Actively participate in the international climate change agenda.* *9. Support international cooperation on climate change.* *10. Establish synergies with other global conventions being implemented.*

This National Plan proposed the development of sectorial adaptation plans, which have being since then in charge of special sectorial commissions that combined academics scholars, private and public organizations. Every commission should propose specific actions to be taken by each sector to mitigate climate change and adapt to its effects.

The infrastructure sector involves different commissions and ministries such as Ministry of works, Ministry of transport and telecommunications, Ministry of Housing and Urbanism and the Ministry of Energy. Regarding the water sector, the main responsible is the Ministry of works through its Directorate of Hydraulic Works (*Direccion de Obras Hidraulicas or DOH*).

The Chilean Ministry of works *(Ministerio de Obras Publicas or MOP*) is the institution in charge of planning, prospecting and analysing, building, maintaining and supervising conservation and exploitation of public work infrastructure and facilities. In this role, the last years the MOP has advanced important steps on the definition of adaptation measures for the infrastructure sector. As a matter of fact, the MOP have been developing a preventive strategic focus on standing infrastructure certainly in risk of being affected, as well on the incorporation of adaptation measures in the whole project cycle in the case of new investments.

After the analysis of predicable effects and scope of climate change on infrastructure, the MOP elaborated a methodological proposal to define adaptation measures which incorporate the following criteria:

- Adaptation should be considered as a process rather than a result. Monitoring and evaluation are key elements for continuous learning.
- Adaptation should be understand comprehensive and complementary to both risks prevention and post disasters reactive management.

- Adaptation should take into account citizens' involvement through appropriate information and decision-making framework.

In last years, concrete criteria and measures have been implemented within the development of specific pilot projects such as irrigation reservoirs, ports and bridges in charge of the MOP, but this experience has not be yet extended to other types of projects. In addition to basic logical relevance studies and pertinent cost-benefit analysis, the projects are evaluated in terms of their exposure to climatic alterations and risk as well as examined in relation to eventual effects of the project on other activities.

This type of analysis starts from the planning stage analyzing predictable weather scenarios in the project location. It includes a sensibility analysis which revises eventual graduations of temperature and precipitations in order to have many different scenarios to evaluate. As far as every projects depends on location, specific studies are carried case by case.

In the case of projects related to water resources, the MOP has utilized the Water and Evaluation Planning system or WEAP, which is a software and methodology for integrated water resources management and policy analysis. Using this methodology, the MOP collects specific information about water resources (demand and supply) in a locality and revises predictable scenarios for analysis and decision-making process.

As far as any infrastructure project is meant to be developed for human well-being, they have to be evaluated as well in relation to their social impacts. Nevertheless, social impacts are as broad as technical ones, due to the fact that they include direct health and security effects derived from floods, droughts or higher temperatures but also by increasing costs of food or fuel, just to mention some.

In the Chilean case, every infrastructure public investments should be approved by the Ministry of Social Development [4], which is in charge of the evaluation of social cost and benefit analyses as well as social profitability. In the cases of water and electricity supply is normal to find subsidies that ensure affordability, particularly for low-income families. This subsidies are part of the social considerations embedded in the whole project cycle and include indigenous and gender issues.

Methodologies to include beneficiaries' participation both in the development and maintenance of infrastructure projects have been also implemented by the Ministry of Public Works or MOP. However, most of the social and environmental principles which might be applied in adapting projects to climate change are concentrated either on big infrastructure projects or in urban ones, where involved population have a "stronger" weight which can even enforce the withdrawal of some initiatives such as, i.e.: carbon generating plants, huge water dams, and so on. In spite of the fact that there is not enough information, small and dispersed or isolated rural areas are still not considered in such deep, question that will be exposed later in this paper.

In short, Chile have begun to include adaptation criteria to develop infrastructure projects but still they are just focus on high scale ones, such as dams, ports and bridges and it is not taking attention to smaller infrastructure projects which have a direct im-

pact on social conditions and quality of life for many vulnerable people, especially those living in rural areas.

2 Rural Water Supply and Climate Change: evidence from nine case studies

The evidence captured within the frame of an ex-post evaluation carried out by the author´s consulting firm shows that rural water supply projects are not considering any adaptation criteria. Moreover, it seems that even normal social and economic sustainability analysis were feeble because they are not prepared to face many palpable risks such as weather alterations that both impact on energy plants and on water capitation sources that supply rural water installations. This assertions will be presented more in detail later and after a brief backdrop about the Chilean rural water sector and the specific program focus on this areas.

2.1 Water governmental sector and rural supply

The Chilean government had made a significant commitment to increasing rural infrastructure services as a mean to address poverty and income inequality, which is highly concentrated in rural areas. Although a recent IPCC [5] report recognizes that Chile has made considerable progress on water supply systems, access to water in rural areas remains incomplete or unreliable as a result of either scarcity problems or due to population dispersion. In addition, water supply systems are also threated by future unreliability of energy supply due to the predominance of hydroelectric plants which concurred for water and are affected by these shortages as well.

It is pertinent to clarify in advance that water in Chile is almost fully privatized, both water rights to take the resource from waterways and its later use for irrigation or drinking water supply is actually in private hands. Nevertheless, in the case of rural water supply, where no market interest exists due to low profit chances, is the government who provides the infrastructure and left the community the responsibility to run the administration of water installations in a sort of cooperative organization.

The Chilean rural drinking water program or *Programa de Agua Drinking Rural* (APR as acronym) dates from 1965, times where agrarian reform was in vogue, is still the governmental instrument to provide safe and secure water for rural areas with low density, disperse or isolated settlements. While in urban areas water supply reaches 99% of the inhabitants since 30 years ago, in rural areas it has been a process of augmenting from 48% in the year 1990 to close 75% by 2010, all by the intervention of the APR program.

The APR work in rural dispersed or isolated areas but its priority is focus on concentrated settlements with populations in a range between 150 and 3,000 inhabitants, considering a minimum of 15 dwellings per km of distribution pipelines. Nevertheless, since 2004 the APR is also attending semi concentrated rural areas with at least 80 households and a minimum of 8 dwelling per each km of distribution pipes. This benchmarks are justified by the Ministerial Directorate of Hydraulic Works (DOH) as the result of social and economic profitability analysis. By 2011, local water coopera-

tives and water committees provide drinking water to almost 1.7 million of rural inhabitants, what means almost 10% of Chilean population.

2.2 Case studies ex-post evaluation: some results and conclusions

Within the frame of an ex-post evaluation of nine APR projects in the southern regions of *La Araucania* and *Los Lagos* (900 to 1,200 km away from the Capital Santiago), many sides of the projects cycle were analysed. In spite of the fact that no part of the terms of reference involve indicators related to climate change adaptation, simple observation and data analysis provided elements to disclose and to criticize its inexistence, because this absence puts operation and reliability of the projects in risk both in middle and in the long run, particularly where uncertainty about future water availability and concurred use exist.

Since 1994, projects for rural drinking water systems are led by the Directorate of Hydraulic Works (DOH). Respective DOH Regional office identifies demand of rural settlers, which are organized around a water committees or cooperatives, and makes bids for tender bot for feasibility studies and following design and construction of the system. These project cycle stages might be implemented for different consulting firms or private water and sanitary companies.

Fig. 2 Storage tank, Well pump and Treatment in Putemún, Castro (Photos by the author ®)

An overall first finding of the study is that rural water provision system is weak in institutional terms, because, among others, it lacks of a specific legislation: they are neither part of the National Sanitary Law that sets up the structure and framework for all privately run water supply systems, nor within the control umbrella of the governmental Superintendence of Water and Sanitation Services (SISS as acronym). The SISS, which is the agency in charge of setting rates periodically and to define and enforce service standards for private concessioned companies, has no authority over rural water committees or cooperatives management, neither to influence rates or quality of the service.

In relation to design of the systems, the fact that feasibility studies and design projects might be developed for different professionals, divergences between diagnosis and actual designs built are common. Even though DOH guidelines for feasibility studies includes geological, hydraulic and precipitation analysis, there is no scenarios evaluation. Consulting firms provides a mere description current facts such as water availability, geomorphological situation and precipitation statistics. Studies include socio-economic description of the inhabitants due to the fact that governmental financed projects are meant to attend just low-income rural families.

In the field study was possible to find problems related to different stages of the projects, from deficient designs to weak administrative running of rural water cooperatives or committees.

The most common design failure is related to energy supply, particularly considering frequent blackouts on the countryside systems; electricity supply is not reliable. Nevertheless, all water plants depends on electricity to operate sophisticated automatized control panel boards, which also use expensive and not easy to find relays without considering any breaker system nor an emergency diesel –or other- generator system to supply energy in between.

This dependence on electrical energy entails various climate change related problems to be considered. On one hand, in some places there is a tough concurrence to obtain privatized water rights, especially in the case of scarcity. On the other hand, when energy is produced by fossil fuels, emissions are usually neglected by small infrastructure planners.

In the case of systems that depends on groundwater sources, there is no reliable information about actual availability, what is a critical aspects for sustainability. Better data and monitoring systems seems unavoidable. In the case of system relaying on superficial water, the main weakness is around catchment dams or tanks which need to be protected from storms that derived in washed off contaminants into the streams. This type of prevention and adaptation measures are mostly not considered in these APR projects.

Fig. 3 Catchment dam in Putique, Quinchao Island (Photo by the author ®)

As it was mentioned, administration of APR projects are in charge of the organized community through water committees or cooperatives, they are responsible for managing, operating and maintaining the systems and for replacing equipment and also, when possible, for performing small-scale reinvestment and maintenance tasks. They also have to contract systems operators, accountants and administrative secretaries or manager.

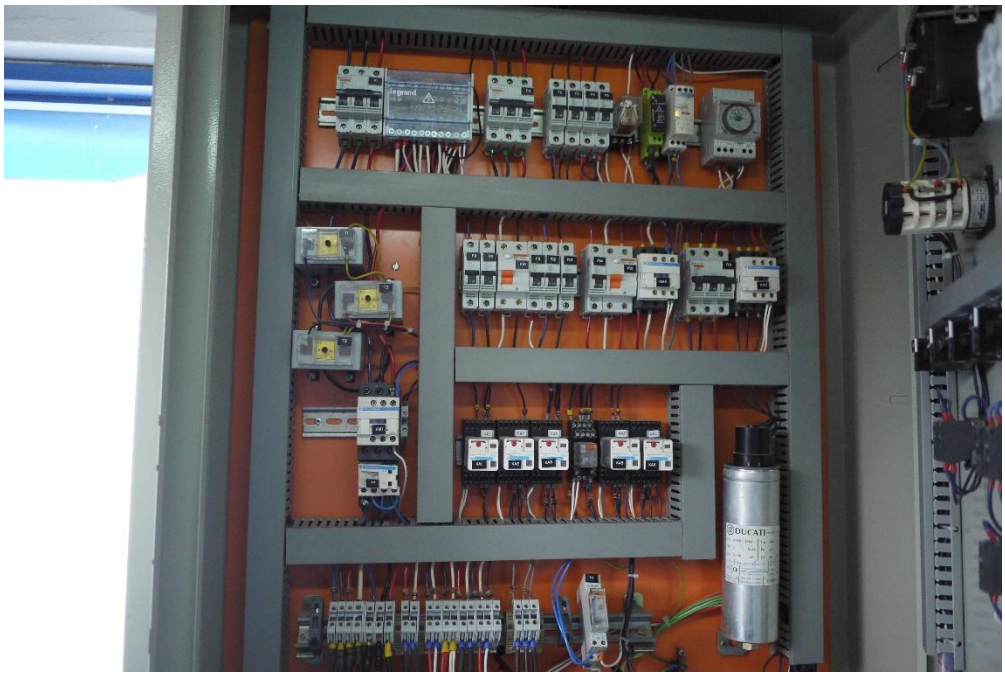


Fig. 4 Automatized control panel board (Photo by the author ®)

However, many times they do not have enough financial resources to pay three people and they contract one-in-all person. As a result, most of these committees present administrative and technical difficulties. Financial constrains derives from non-payers and unexpected investments to repair system failures such as relays replacements or storms caused damages. Many of the beneficiaries received even a subsidy to pay water bills, which goes directly to the committee.

The ministerial DOH provides technical assistance either directly or through subcontracted sanitary companies –usually those water firms which serves urban areas-. These technical assistance consist in a threefold on field advice: accountability advice to maintain proper book and rates definition; social advice to manage and require subsidies for lower income families in the settlement; technical assistance to maintain the water plant and all its equipment. Pumps that quite working, blocked filter systems and electrical failures are the three most common emergencies.

In an attempt to solve some of these problems, there is draft law in the Congress which pursues to include both a better financial backstopping to the committees and proposing an improvement on technical quality requirements. The main concerns under this draft law is sustainability.

In this direction, the ministerial DOH is working to develop performance indicators that help defining standards and quality services benchmarks which should be incorporated into the whole projects cycle, from feasibility and design to construction and later operation of the infrastructure.

3 Conclusions

To conclude, social and economic effects and impacts of small water supply projects should also include climate change criteria and tools, such as WASP and other types of predictive methods within the ex-ante evaluation process and the prefeasibility studies of rural water supply infrastructure projects. This is a critical tasks in these areas where there is a combination of territorial isolation, low-density and low-income settlers and at lack of reliable water. Moreover, the State should enforce a fast track for the draft law meant to regulate rural water services, particularly taking into account current water rights conflicts with other uses such as agriculture, forest or hydroelectric plants. Better information and appropriate monitoring system seems to be key challenges in the future.

References

[1] CEPAL, La Economía del Cambio Climático en Chile, 2012, Naciones Unidas y Gobierno de Chile (ECLAC: Economic Commission for Latin America & Caribbean countries)
[2] Ministry of Environment, National Climate Action Plan, 2008-2012
[3] IPCC, Working Group II: Impacts, adaptation and Vulnerability, 2001. Available in: http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=643
[4] Ministerio de Desarrollo Social, Metodologías de evaluación de proyectos, 2012. Available in: http://sni.ministeriodesarrollosocial.gob.cl/index.php?option=com_content&task=view&id=4&Itemid=9
[5] IPCC, "Climate Change 2014: Mitigation of Climate Change", 2014. Available in: http://mitigation2014.org/report/final-draft

Literature revised

[5] DGF-CONAMA, Estudio de la variabilidad climática en Chile para el siglo XXI. 2007 http://www.dgf.uchile.cl/PRECIS/ Last access July, 2010.
[6] Solomon, S. et al. (eds) Climate Change, 2007: The Physical Science Basis, 2007, Cambridge University Press for the Intergovernmental Panel on Climate Change.
[7] Events and Disasters to Advance Climate Change Adaptation, A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, UK, and New York, NY, USA, 2012, 582 pp.

Panama Canal Authority facing the Climate Change Challenges

Luis Alberto Moral Miranda
Panama Canal Authority
Bldg. 732 Corozal Oeste, Panama city
LAMoral@pancanal.com, luismoral05@hotmail.com

Abstract: Panama as a developing country, faces the impacts of a fast growing economy on the environment, above all in recent years with the economy growing near 10%, the highest impact of this growth it is found in the energy requirements to support it, in the consumption of the natural resources and the deforestation of vast areas in the country. The Panama Canal Authority has in its vision the statement of being leader in sustainable development for the conservation of the Panama Canal watershed and at same time cornerstone of the global transportation system and driving force for the progress, development and growth of Panama. To describe and analyze the strategies, policies and tools used by the Canal Authority to achieve its goals, in line with the country and global policies regarding environment and climate change, this document is prepared. The Panama Canal Authority has developed its own policies, which are aligned or exceed the requirements determined by the national policies and it is referent to them. It has the office of Environmental Evaluation in charge of coordinating and implementing these policies. It currently has ongoing projects as the carbon sequestration to protect the channel watershed, the implementation of a green building policy for all building projects since 2012, and the government has pointed out the Expansion Program of the Panama Canal as a possible NAMA (National Appropriate Mitigation Action) initiative. This document will analyze the coordination and framework guiding these initiatives, with information of the Environmental Evaluation, how is the planning and implementation as well as the results obtained.

This document is prepared by Luis Alberto Moral Miranda, source of the information is public documentation about the projects and the company, coordinated through the Environmental Evaluation Section of the Panama Canal Authority, point of contact Lisbeth Karina Vergara (LKVergara@pancanal.com).

Key Words: sustainable development, deforestation, policies, strategy, carbon sequestration, canal expansion, green building.

1 Introduction

Panama is considered a small country, because of its size, 78,200 km^2. In its territory was found the narrowest point for the construction of a channel to communicate Pacific and Atlantic Ocean. The Panama Canal construction was started by a French company in 1881 and finalized by the US government 100 years ago. Panama as country receive this important asset by the end of year 1999, national agreements before the occurrence of this event allowed to create a legal framework to blind the institution from political issues and to include its revenues as part of the government

budget and imposed a commitment in the institution to maximize the benefit for the whole nation.

Panama´s economy structure has an 80% percent share for the service sector, and this has been built due to the Panama Canal. Panamanian administration of the Canal and the expansion program has influenced the last 10 years of steady and high economic growth experienced in the country, which has led to double the Gross domestic Product per capita for the country in these last 10 years. According to the World Bank, for year 2014 Panama's GDP was 42.6 milliards US$ dollars, equivalent to $7,740 per capita[1].

A high economic growth has produced negative environmental effects, in first place a higher energy demand in the country, part of it, mainly for peak hour generation, is supplied by fossil fuel energy generation with the consequent greenhouse gasses emissions to the atmosphere. Secondly, it has also produced an increment in the tropical forest deforestation, due to higher demands for land. These two effects have been classified as the main anthropogenic contributors to climate change. The Panama Canal has experienced both effects in its current expansion program and it has taken some measures to mitigate its impacts.

2 Climate Change Impacts

In order to understand climate changes, it is important to know the climatic indicators for the country, their average values and the drivers of its variability, the projections for the future and the climate change impacts experienced by country, and the Panama Canal.

2.1 Climate Baseline

Panama has tropical climate, with high humidity and hot temperatures. It has a long rainy season from May to December and a short dry season from January to May. Average annual temperature for the country is 27°C and average total rainfall is 1900 mm annually. Maximum mean temperatures across the country oscillate between 31.1°C and 34.5°C. Minimum temperature ranges from 20.1°C and 22.4°C. [2]

Climate variability in Panama is driven mainly by the ENSO (El Niño/La Niña Southern Oscillation), tropical cyclones, and sea surface temperatures.

2.2 Climate Future

Using Global Climate Models (GCMs), the climate change conditions changes has been projected for the whole Central American region, a Regional Climate model (RCM) has been used to produce specific results for the country which are in general [3]:

- Increase of variability and intensity of extreme events
- Increase of dry season temperatures
- Decrease in dry season rainfall

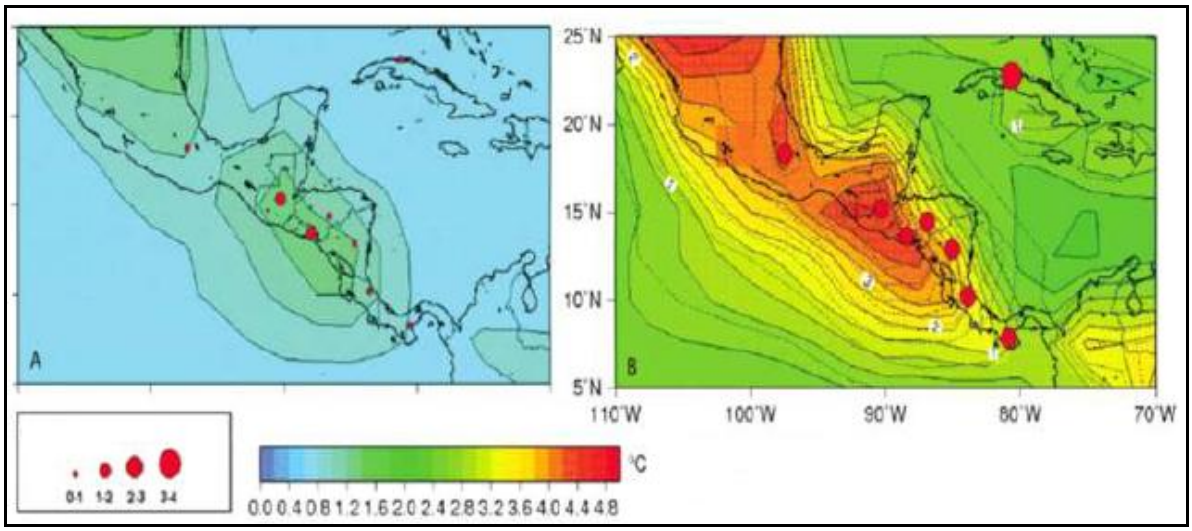


Fig.1 Projected mean temperature across Central America using the PRECIS Regional climate model. A - Year 2020, B – year 2080

2.3 Recent years Impacts

The occurrence of climate-related disasters in Latin America has already increased by a factor of 2.4 since 1970[4]. Panama has experienced a series of extreme weather events including intense rainfalls, windstorms, floods, droughts, wildfires, earthquakes, landslides, tropical cyclones, tsunamis, and ENSO/El Niño-La Niña events.

Between 1982 and 2008, Panama was struck by 32 natural disaster events, with economic damages totalling an estimated US $86 million[5], the share of each of the causes are shown in figure 1. From all the disaster numbered, droughts, floods and storms are related to the weather, from them drought is the one with the highest economic impact. See figure 2.

If the foreseen impacts modelled occur, a dry season rainfall decrease could increase the frequency of droughts in Panama, and the increase in variability and intensity of extreme event would be related with the number of floods and storms and their consequential economic and social impact.

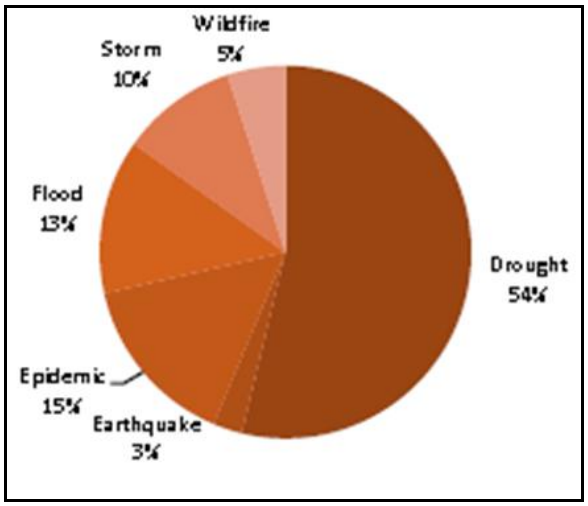


Fig.2 Average distribution of major natural hazards in Panama. Source: EM-DAT: The OFDA/ CRED International Disaster Database, Université Catholique de Louvain.

The Panama Canal has experienced the impact of both phenomena, being also droughts the one that produces the most negative economic impact. During year 1997-1998 the Canal experienced the most recent long drought period due to the El Niño, the operating level of the Gatun Lake was below the normal levels for an extended period of 17 months, and 109 days below the critical level for operations. The Canal operated with draft restrictions during this period impacting the client's carrying capacity while using the infrastructure. Other example is the extreme climatic event in December 2010 named "La Purisima". It was extreme rainfall within the Panama Canal watershed; which produced the highest levels in Gatun Lake since the start of canal operations, and high speed on the contributory river currents, endangering the navigation on the channel, therefore the Canal was closed for vessel transit for one day period impacting its most valuable indicator for the maritime sector which is the reliability.

3 Governance

The Panama Canal is an autonomous public institution within Panama governmental organization. It was trespassed the administration to Panama on December 1999, after a transition period of more than 20 years. Previous to this transfer, the country's legal framework was modified to include this new asset, in the country´s development and defining rules to assure the continuity of operations. Panama's Constitution was amended with a new title, exclusive for the Canal in year 1994. In year 1997, a law for the organization was created, most of it based in the existing framework. The environmental legal framework is oriented to the protection of the Gatun Lake watershed and its natural resources.

In addition to its internal legal framework, the Canal works under the National Environmental Law from 1998, which creates a National Authority for Environmental issues. National policies and the implementation of international agreements are coordinated by this institution. Related to climate changes there is a National Committee for climate change (CONACCP), with 27 institutions, including the Canal to coordinate national actions.

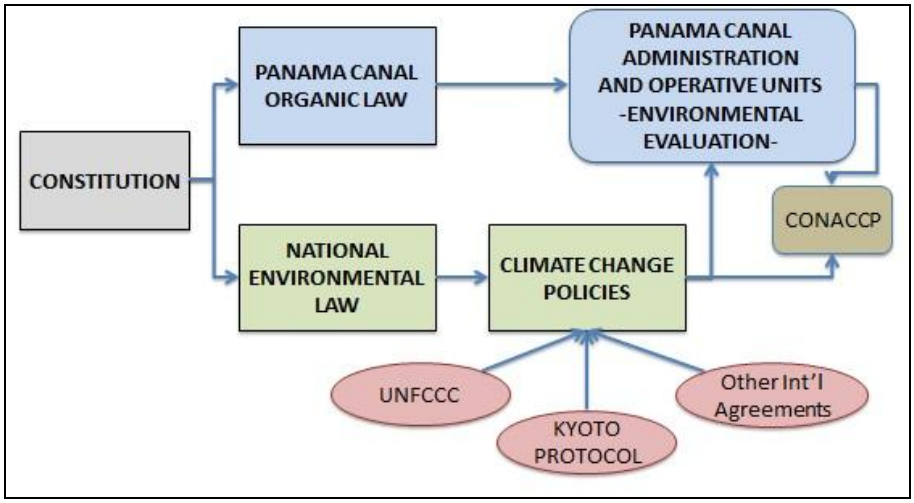


Fig. 3 Legal Framework and Institutions involved with Climate Change Policies for the Panama Canal

As a company the Canal defined its vision, mission and values, to be followed by each of the employees and the administration in its decision making process. It considers equally important the sustainability of the watershed and the economic growth in the country.

4 Responses and Strategy

The Panama Canal has taken indirect measures that constitute adaptations and mitigations to the climate changes, since it is part of the company's vision, "being leader in sustainable development". Some examples of adaptation measures are:

- New Locks structures: Allows the use of the route for bigger vessels, decreasing the unit cost in the cargo transportation, due to a scale economy. The indirect effect is the decrease in the use of fossil fuels and is adaptation to the search of more efficient ways of transport in the global economy.
- Water Saving Basins: The new canal infrastructure includes for each lock chamber a set of basins to store part of the water needed for a lockage. Currently in the existing locks a lockage uses 200 million liters of water from Gatun Lake. The use of water saving basins allows the reuse of approximately a 60% of the water required for a lockage, and even with bigger dimensions, the operation with water saving basins allows using 7% less water for each lockage than the existing locks. This measure is an adaptation to climate change, since a higher water demand because of the infrastructure dimensions and the possibility of less rainfall would hazard the canal operation, and reusing the water reduces this impact.
- Lake and channel deepening: This is an adaptation of the existing infrastructure to allow bigger vessel, and helps preventing draft restrictions because of droughts in the future.
- Reforestation works: Any time forest is impacted by deforestation in the execution of a construction project within the Panama Canal watershed, it is part of the environmental measures required, to mitigate the impact by reforestation in selected areas. Reforestation required is greater than the deforestation incurred, therefore for the future the reduction by carbon sequestration is expected to be higher.

4.1 Green Route Strategy

Since year 2009 the Panama Canal developed and it is implementing a strategy to achieve the environmental objectives of the company's vision, the name of this strategy is the Green Route, since the canal is a route servicing the worldwide trade, to be considered "green" by year 2020 is an added value, and environmental friendly policies and actions are part of this strategy. It is being considered with the ANAM to include this strategy as NAMA initiative for the country.

The objectives of this strategy are:

- To establish the Panama Canal as a low carbon company, integrating the Gatun Lake watershed communities in the initiatives.

- Implement actions of continuous improvement in the environmental management for the Canal operations.
- Comply with the socio environmental role for the sustainable management of the Gatun Lake watershed.
- Contribute with the worldwide initiatives to reduce Greenhouse gasses from the maritime industry.

Currently it has three different lines of action interlinked, at different stages in its implementation each of them, these are: Socio environmental management, emission mitigations and low carbon operation.

4.1.1 Socio Environmental Management

As part of the Canal strategic vision for environmental sustainability, a Socio Environmental Program within the Panama Canal watershed was developed together with the existing communities, known as PIEA (Environmental Economic Incentive Program) with its own funds, before the conception of the Green Route strategy and the connection with climate change policies.

The canal as institution has the information of the whole watershed and coordinates with other governmental agencies the approval of any project. The watershed has an extension of 3,39 square kilometers and a population of approximately 183 000 a inhabitants. Around 46% of the area is primary or secondary forest, and there are extensive areas as grasslands that can be forested. A high percentage of the population is rural and live in poverty conditions, which in many cases produces the effect of forest degradation for production of cash crops (bananas and coffee).

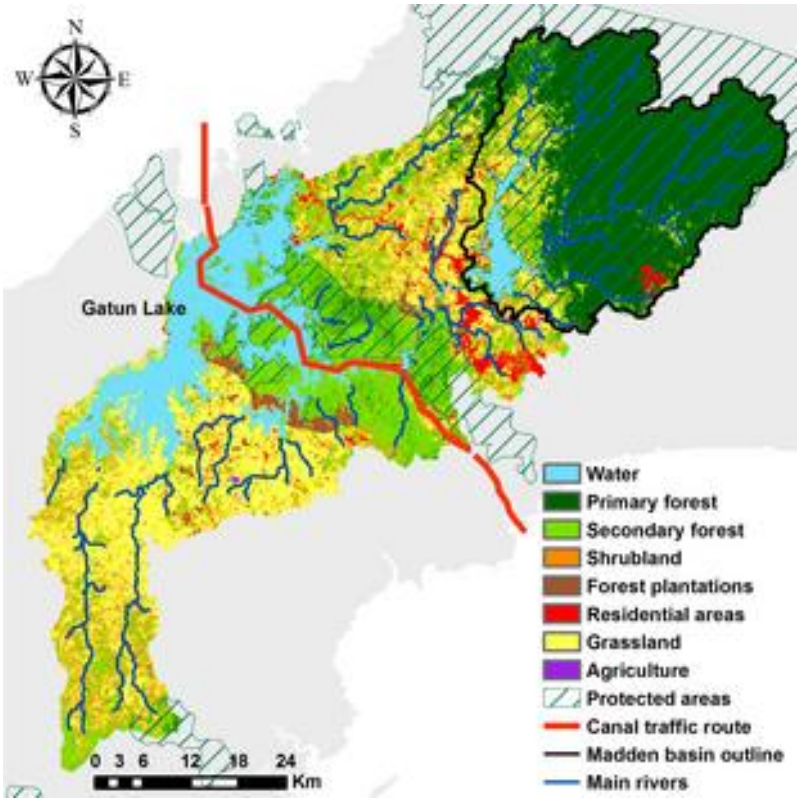


Fig. 4 Panama Canal Watershed. Different land uses.
https://asunews.asu.edu/20130523_Panamacanalwatershed

From this Program, a project named “Sustainable Forest Cover Establishment Project” was selected as part of the Green Route Strategy to explore the possibility to become eligible for carbon sequestration under the category AFOLU (Agriculture forestry and other land use) in the international carbon market.

The project started in year 2007 with a target to recover 10 000 hectares of degraded areas (formerly pasture grassland). The target set up at beginning of the project was the reforestation with commercial and native species (3 445 ha), the establishment of agroforestry systems (4 147 ha) and silvo-pastoral system (2 408 ha). [6]

Since year 2011 the Canal counts with the technical cooperation of GIZ through the Regional Program REDD/CCAD-GIZ, to explore compensation mechanisms making use of the existing international multilateral and market instruments, together with Panama’s National Environmental Agency (ANAM).

It was considered the carbon market for emissions according to the Kyoto Protocol, but the cost of this option was too expensive compared to the investment. It was also considered the possibility to certify the projects for the voluntary market, and finally it was decided to follow this path.

For the voluntary market, it was necessary to certify the project, so it was decided to get the certification under the Climate, Community and Biodiversity Standard (CCB), through the company Environmental Services Inc. in March 2012, and then under the Carbon Fix Standard on December 2013 through the company Rainforest Alliance. Certifications from Carbon Fix are now validated by the Gold Standard. [7] These certifications need a renewal every 5 years. For this certification it was important that the project simultaneously address climate change by CO_2 sequestration, support local communities and conserve or improve the biodiversity conditions.

It was estimated that the forestry activities in this project will lead to the removal of 292,717 tCO_2e emissions through the course of the project lifetime of 30 years, of which 87,815 tCO_2e are allocated in a buffer account, resulting in 204,902 tCO_2e that could be commercialized as Verified Emissions Reductions (VERs). [8]

Currently the Panama Canal is offering 50,000 VERs for potential buyers interested in high value social and environmental carbon credits, to compensate or mitigate their Greenhouse gasses emissions. These VERs can be found in the financial services portal Markit.

This line of action is also considering other type of socio-environmental projects within the watershed, to be worked with the indigenous population under the REDD program (Reduction of Emission by Deforestation and forest Degradation) and consist in the avoidance of changes of land use for forest areas, in order to keep amount of the existing forest. Currently the baseline is being updated with the technical cooperation of GIZ and coordination with ANAM.

4.1.2 Emission Mitigation

Emission mitigation is oriented to promote in the canal clients the practice of the best environmental management practices oriented to reduce the emissions produced. Indirectly new routes and existing routes that decide to use bigger ships to transport their cargo through the expanded canal would be reducing its emissions per unit,

since it is a shorter route than the existing alternative routes and it offers a scale economy.

The use of best environmental practices would be recognized for the canal clients, and support could be provided for the use of the existing mechanism to compensate these reductions.

The socio environmental projects are also included on this line of action, since the emissions produced by the canal clients which are around 1 000 000 tCO_2 could be mitigated through these type of projects.

4.1.3 Low Carbon Operation

This line of action consists of an optimization of the operation and daily functions in the Panama Canal in order to reduce emissions. The first action taken is the mapping of the existing conditions (carbon footprint) to set up a baseline. This is being worked together with the technical cooperation of the multilateral CAF (Development Bank of Latin America).

Currently is being implemented a directive from the Canal Administration, to implement Green Building requirements for all new buildings and improvements. These measures are oriented to decrease the energy demand and consumption on buildings. As a tropical country most of the energy consumption in buildings is produced by air conditioning and lighting. New buildings will have controls to optimize the use of air conditioning, by sensors, will be built with improved isolation measures and optimized alignment. Lighting will be more efficient by making use of more natural light wherever is possible and changing to LED technology.

Other future measures considered is to introduce the use of renewable energy for some operations, the use more energy efficient equipment and the possibility to substitute the use of fossil fuel for power generation for a more efficient fuel as natural gas.

5 Conclusion

It is a fact that the climate change is ongoing and the infrastructure planned for the future should take into account adapting to its impacts. In tropical countries reforestation and avoiding deforestation is a mitigation measure recognized and which can be financed by international instruments.

The Panama Canal is implementing measures to both, adapt and mitigate its impacts, facing this reality and adding value to its operation and services, and at the same time achieving the objective defined in the company vision of by being leader in sustainability for the country and the industry.

In order to measure the strategy results, with efficacy and the achievement of the objective, is necessary a thorough mapping to create baselines and benchmarks.

Thinking in energetic efficiency and renewable energy it is at the level of the individual, each person consciousness provides the biggest contribution to mitigate impacts, decrease the anthropogenic impacts and take the adequate actions to adapt to the changes related to the climate.

References

[1] World Bank Data portal. Panama Available from: http://data.worldbank.org/country/panama

[2] WorldClim 1960-1990 Averages. Robert J. Humans, Susan Cameron, and Juan Parra. At Museum of Vertebrate Zoology, University of Califonia, Berkely, in collaboration with Peter Jones, and Andrew Jarvis (CIAT), and with Karen Richardon (Rainforest CRC). www.worldclim.org/current

[3] World Bank. Vulnerability, Risk Reduction, and Adaptation to Climate Change. Panama. Page 3. http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_PAN.pdf

[4] Ibid., page 6.

[5] Ibid

[6] MGM Innova. Panama Canal Authority. Sustainable Forest Cover Establishment Project. Page 5. https://s3.amazonaws.com/CCBA/Projects/Panama_Canal_Authority_Sustainable_Forest_Cover_Establishment_Project/2011-01-17_+PDD_PCA_(Final)%5B1%5D.pdf

[7] Climate Projects. ACP Sustainable Forest Cover Establishment Project http://www.climateprojects.info/PA-ACP/

[8] Markit Registry. Panama Canal Authority Sustainable Forest Cover Establishment Project. http://mer.markit.com/br-reg/PublicReport.action?getDocumentById=true&document_id=103000000040206

”Climate Change - A Global Challenge: Contributions of Infrastructure Planning”

Alejandra Cassis
Transsolar Energietechnik GmbH (Climate Engineering)
Curriestraße 2,
70563 Stuttgart
Germany
cassis@transsolar.com

Abstract:

Competent introduction of sustainable strategies in the early stages of a project can spare difficulties and energy savings in its complete life cycle. Most modern buildings are constructed independent of the outdoor climate conditions at the expense of energy consumption. The actions that we take in the present will cause repercussions for our future generations. We need to mminimize building systems and maximize passive architecture and energy efficient techniques.

Key Words: Climate Change, Energy, Sustainability, Comfort, Greenhouse Emissions

MIPALCON topics that are related to our work

- Infrastructure projects in climate change mitigation and adaptation
- Infrastructure projects to improve the living conditions in rural/urban areas
- Environmental impacts of fast growing economies
- Technical measures for the reduction of greenhouse gas emissions from infra structure projects
- Energy-efficient and sustainable building technologies

1 Energy Consumption and Climate Change

The energy supply over the past 200 years has continuously changed from renewable to non-renewable energies. Despite the fast emerging industrialization period, energy demand rushed only until half of the 20th century, with a pause in the 70´s oil crisis. Since then the consumption of energy has maintained more or less constant. With the increasingly energy consumption and depletion of our resources, there are urgent measures that need to be taken. Some of the measures that Transsolar is taking are going to be briefly mentioned in this document.

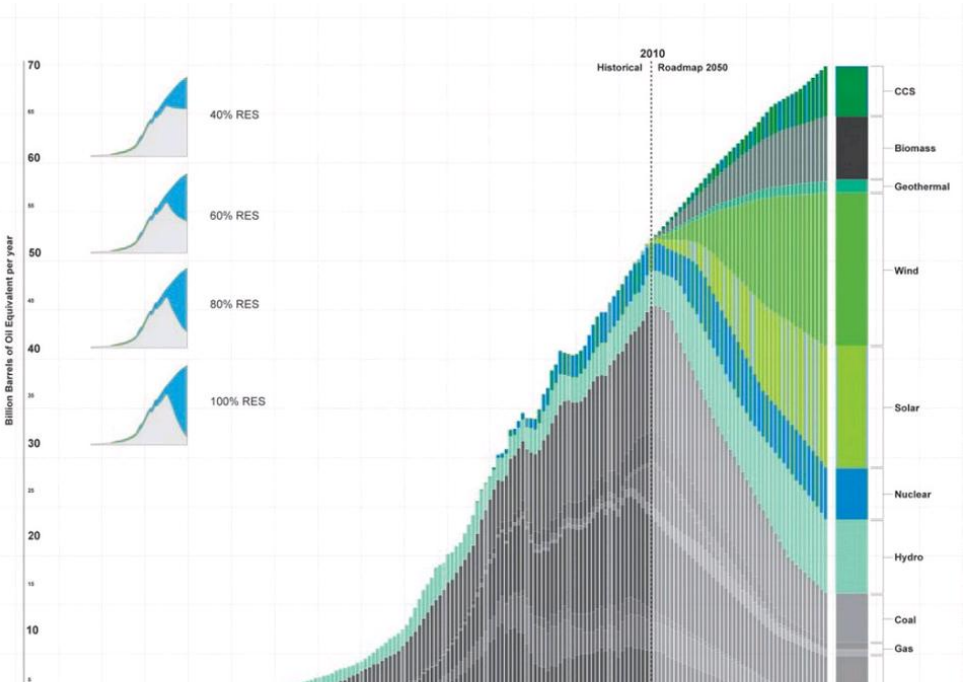


Figure 1 Energy supply in historical development and assumption for the future, related to a new approach to energy supply 1 (Roadmap 2050: a practical guide to prosperous, low carbon Europe. Brussels 2010. The European Climate Foundation - http://www.roadmap2050.eu/

We can´t ignore what is happening around us, our lifestyles have become a burden to this earth. Our planet´s resources are depleted faster than they can be renewed, incrementing our ecological footprint dramatically in the last decades. We have to change the way we generate and use energy, especially our reliance on fossil fuels. The energy used in the building sector constitutes a significant percent of our ecological footprint.

The building sector in Europe and North America is responsible for 50% of all domestic CO^2 emissions and energy use. The European Union sees this fact, as a potential for reducing our ecological impact. The EU has set ambitious goals in the building sector in the next couple of years. The buildings built after 2020 are required to achieve net zero energy, while by 2050 carbon emissions of the entire building sector must be reduced by 90%.

The decision making process in the building sector is mainly monopolized by economics and aesthetics, rather than performance and quality of space. Adding a third factor, i.e. embodied energy, grants new challenges to the problem. It is not only important to be able to control the operational efficiency but also the embodied energy in the construction sector.

To assess embodied energy in buildings is still a big challenge. Nevertheless, with developments in the field of climate engineering energy can be tracked better. There is a potential for reducing the operational energy consumption in the construction of new buildings or infrastructure projects. Some of the reduction factors are ventilation, improved technologies, passive means, improvement of insulation and heat recovery ventilation.

Our company's awareness towards the environment has increased, reinforcing our focus on strategies that help reduce global warming emissions and achieve climate neutrality.

2 What is Climate Engineering?

“Climate Engineering seeks to improve the built environment's impact on the environment while maintaining the highest indoor and outdoor comfort. Transsolar accomplishes this by developing and validating innovative climate and energy concepts.”

Transsolar works collaboratively with architects, mechanical engineers and other consultants in architectural and urban planning designs. We believe that being part of the design process in the early stages of a project is essential to generate a well-orchestrated climate control system, in which the local conditions, envelope, materials and mechanical system are integrated components and not simple ornaments.

Our work goes beyond energy conservation; we seek as well a more holistic design addressing comfort topics like daylight, natural ventilation, air quality, air temperature, acoustics and the well-being of people. We pursue to minimize the building systems and maximize passive architecture and energy efficient techniques.

There exists a necessity to create high energy performance buildings and explore new possibilities of building design. A new generation of low energy buildings is emerging, along with a float of energy efficient technologies, considered best practices. There are few examples of carbon neutral buildings, mostly found in dense urban areas. One major problem to implement these types of buildings in the “majority world”, lays on cultural barriers i.e. the budget of the projects.

3 Improve living conditions - Comfort

The requirements for comfort differ according to the typology and location of the building. The most important factors are temperature, visual comfort, hygiene, and acoustics. All of these elements need to be considered in the early steps of the design process. Comfort is relative and would be defined differently by various users. Even though these differences occur, there are suggestions regarding air movement, temperature, light intensities and humidity in the air, which can be made.

“As a basic principle, the temperature should always be determined in relation to the outside temperature”.[1] There is a greater acceptance of room temperature and interior conditions if there is flexibility in the user control system, for instance operable windows or the use of thermostats rather than having a controlled central system.

4 Design/ Integrated Design Process

Important is that all members of the design and construction team collaborate from the beginning to the end of the project to consolidate an integrated design process.

At the end, it is not only about reducing energy consumption by reducing dependence on technical systems, design itself can engage the user and improve the quality of the indoor space. User productivity can be enhanced by design-driven solutions like natural ventilation and daylight. “A design that involves the users in the operation of the building fosters a sense of ownership and responsibility for their space. This can result in reduced maintenance, reduced energy consumption and, in general, a long lasting interactive relationship between occupants and the building.”[2]

5 Energy Efficient Practices/Technologies for Sustainable Buildings (Green Buildings)

Sustainable or green infrastructure is an environmentally responsible and resource-efficient structure for its entire life cycle. Cooperation between the design team in all stages of the project is essential. According to the U.S. Environmental Protection Agency “green buildings” have the following characteristics:

-Efficient use of energy, water, and other resources

-Protect occupant’s health and improves employee productivity

-Reduce waste, pollution and environmental degradation

Low emissivity coating as a response of expensive technology (ex. triple glazing) can be applied to the interior surface of double glazing, resulting in better insulating properties.

Windows frames with good U-values are available in the European market, whereas the technology for better windows in the U.S. is very rare. Despite of the effectiveness of external shading (i.e. venetian blinds) versus the interior shade, the aesthetic acceptance is not popular in many places.

Key aspect of energy savings lies on the buildings envelope.

There are several energy efficient technologies available on the market; however this should not only be the means for energy performing buildings, integrated design is needed.

The orientation of the building can provide a variety of passive and semi-passive strategies such as passive solar heating, wind driven or stack-effect driven ventilation.

The human metabolism needs daylight. Overheating in places where the incidence of the sun is constant and direct can be avoided with window coating.

When the temperature difference between the outside and the inside desired temperature is too big active measures are inevitable. Otherwise, operational costs can be significantly reduced only with passive measures i.e. proper insulation and solar protection.

6 My tasks within Transsolar

- Development and evaluation of innovative climate and energy efficient concepts for the creation of sustainable buildings (sometimes regulated by LEED, DGNB, DIN, BREEAM, etc.)
- Evaluation and optimization of daylight through computer based simulation techniques (Radiance, Rhino_DIVA/Grasshopper)
- Development of strategies for sustainable development and low carbon planning in the built environment (ex. Master plan for São Paulo Expo 2020/ Urban remediation and civic infrastructure hub, São Paulo, Brazil Global Holcim Awards Silver 2012)
- Creation of architectural and urban planning methods as a response to climate change

References

[1] Delft University of Technology, Faculty of Architecture, Chair of Design of Constructions, Imagine 05 Energy, 2011. pp. 8-118.

[2] Lam, L., & Olsen, E., Technology, Design, Culture: Interconnected ingredients for moving beyond best practice in commercial buildings, 2014. pp.

Master Planning to Harness the Sun and Wind Energy: The Case of Shagaya Renewable Energy Master Plan Project, Kuwait

Dr. Alexander Boakye Marful
Fichtner GmbH & Co. KG, Germany
DTD 179, Hse No. AV4, SDA Community 5, Tema, Ghana
amarful@yahoo.com

Abstract: In the quest to develop and pursue urban branding and sustainable as well as liveable Cities, many of the Gulf States have undergone tremendous urbanisation and modernisation without recourse to its effect on the environment and the climate. In an attempt to reduce its gigantic carbon footprints, most of these states like the State of Kuwait have embarked on aggressive and audacious investment to harness its renewable energy resource. The latest, which is one of the largest plan projects in the world, is the Shagaya Renewable Master plan Project (SREMP) in Kuwait. SREMP is a Renewable Energy Park of 2000 Megawatts(MW) installed Capacity with a mix of Wind and Solar Energy on a 100 Km^2 land scheduled to be implemented in three phases (Phase 1: 70MW;Phase 2: 970MW; Phase 3: 1000MW). The technologies that were selected were the Photovoltaic (PV) and Concentrated Solar Power (CSP) Technology. This paper takes a look at how Infrastructure Planners could learn from SREMP strategy in master planning virgin area with the goal not for human settlement but energy production. More so, expatiation on the methodology that was followed to achieve the set out goals as well as the highlights of key planning policies that guided the master planning procedure shall be made. A general overview of the optimisation procedure and the criteria utilised for the technology clusters selection would be explained and an overview of stakeholder consultation, workshops, layout planning, visualisation and implementation strategy would looked at. Finally the resultant master plan scenarios and its fuel saving capacities and CO_2 avoidance shall be quickly highlighted and the lessons for Infrastructure Planners on such projects shall be discussed.

Key Words: Renewable Energy, Master planning, Concentrated Solar Power, Wind Energy, Power Plant

1 Introduction - Kuwait

As an organic humble Arab village, Kuwait metamorphosed into a vibrant, exploded Arab metropolis from the 1940s (Helmy,2008; p.120). Located between the Mesopotamia and the Indus river valley, Kuwait is a small country with a population of 2.7 million (2013) and growth rate of 1.7 % per annum (2013) (O'Shea & Spilling, 2010). Its GDP of US$ 165.8 billion GDP growth rate: 2.3 %/a (2013 est.) which translates into 42,100 US$ per capita (2013 est) (O'Shea & Spilling, 2010). Kuwait is bounded at the far north-western corner by the Arabian Gulf and has about 17, 800 square Km

of land. It borders on the eastern side by the Gulf, north and west by Iraq, and Saudi Arabia to the south west and South (Helmy, 2008 p.121). As a member of the Gulf Cooperation Council (GCC), Kuwait is part of the regional community with comprised of Bahrain, Oman, Qatar, Saudi Arabia and the United Arab Emirates which has a population of over 39 million residents. The GCC is one of the most urbanized areas in the world, with over 70 per cent of the population living in urban areas and with Kuwait and Qatar almost 100 per cent urbanized (UN-Habitat, 2012; p.143). Like many GCC countries, the national income of Kuwait (95 percent) overwhelmingly relies on oil and gas revenues (UN-Habitat, 2012; p.19). Unlike many of its sister GCC countries, Kuwait was not blessed with a drop of fresh water as its one of the very few countries in the world without a natural lake or water or mountains (Helmy, 2008; p.121).

1.1 Sun and Wind Energy Resource Potential

Kuwait has a desert climate which is hot and dry. Rainfall varies between 25mm-325mm annually (Alhajraf S. et al, 2010). Despite the high temperatures preliminary solar irradiation analyses based on long term satellite data yield a moderate annual Global Horizontal Irradiation (GHI) of about 2,089 kWh/m^2 and Direct Normal Irradiation (DNI) of about 1,860 kWh/m^2 (Alhajraf S. et al, 2010). Available wind analyses based on nearby ground measurements and satellite long term data feature a very strong NNW prevailing wind direction and 5.3 m/s monthly mean average (10 meters height at existing Um Omara meteorological station) (Alhajraf S. et al, 2010). The wind conditions are also characterized with a summer peak in wind speed and considerable higher wind speeds during night time due to increased shear factor. According to existing meteorological data the climatic conditions shown in Table 1 were used for planning and design purposes.

Item	Unit	Value
Irradiation (GHI)	kWh/m²-a	2,089
Irradiation (DNI)	kWh/m²-a	1,861
Maximum 3 seconds wind gust at 1 meter height	m/s	17
Reference wind speed (acc. to IEC classification)	m/s	38 m/s at 80 m 43 m/s at 100 m
Average annual rainfall	mm	196
Maximum recorded rainfall in one (1) day	mm	79

Table 1: Climatic conditions

Source: (FICHTNER GmbH & CO.KG, 2013)

1.2 Carbon Footprint and Pollution Potential

According to Wiedmann & Minx, (2008), The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product. This includes activities of individuals, populations, governments, companies, organisations, processes, as well as industry sectors. Products include goods and services. In any case, all direct (on-site, internal) and indirect emissions (off-site, external, embodied, upstream, downstream) need to be taken into account. Along with its Gulf neighbours and the

United States, Kuwait is considered among the most carbon-polluting countries in the world, partly because of its oil-producing activities but primarily because of the huge number of vehicles per capita. Low fuel cost and high level of earnings have created conditions where more than a million vehicles are on Kuwaiti roads. One vehicle for every 2.5 residents creates about 98,000 tons of carbon emissions each year (UN-Habitat, 2012; p.56). Revenues from oil have allowed GCC governments to subsidize the cost of water, electricity, oil, gas and food for decades, resulting in some of the highest per capita rates of water and energy consumption and waste generation in the world. The inefficient way of using electricity and lack of demand side management have led to the abuse of electricity generated from the oil. Electricity costs on average USD 0.12 per kWh to produce in the Gulf, but is sold for USD 0.04 per kWh (UN-Habitat, 2012; p.20). In 2007, Bahrain, Kuwait, Qatar and the UAE were the first, third, fourth and fifth-highest Carbon Mono-oxide (CO) per capita producers in the world. As a whole, the GCC produces roughly half the carbon dioxide emissions produced in the Arab world (UN-Habitat, 2012; p.172).

Oil and gas industry, electricity production, transportation, industrial heating and air-conditioning are responsible for most of the carbon emissions from the region. Qatar, Kuwait, UAE, Bahrain and Saudi Arabia figure among the world's top-10 per capita carbon emitters. The production of fresh and potable water through desalination plants for human consumption and irrigation of agricultural farms are largely dependent on fossil fuels. Consequently, Kuwait's very survival is dependent on the usage of the fossil fuel.

2 Shagaya Renewable Master Plan Project

In the framework of the State of Kuwait's 7th Strategic Plan and the Renewable Energies Program one major activity is to identify different possibilities on how to best use the available land at the Shagaya project site by means of optimizing the mix of installed renewable energy technologies with respect to a developed criteria. This activity was called the "Shagaya Renewable Energy Master Plan" (SREMP) and aims to accommodate a target renewable energy capacity of 2,000 MW up to until 2030. Kuwait Institute of Scientific Research (KISR) through its mandate selected a German consortium to undertake the process that would lead to the realisation of SREMP. In order to achieve the best results of this complex and unique flagship project, Fichtner GmbH Co & KG teamed up with the renowned solar and wind branches of the Fraunhofer Institute, Germany, Fraunhofer ISE and Fraunhofer IWES respectively, in order to capitalize on the industrial experience of Fichtner and the researching capabilities of Fraunhofer, both in the field of energy in general, and of solar and wind energy generation in particular.

2.1 SREMP Vision and Objectives

To begin the planning process a vision was co-opted from the general framework of the Strategic Plan of KISR which was in line with that of the renewable energy goals of the State of Kuwait.

a. Vision and Objectives:

The vision of the Master plan is in line with KISR long-term strategic plan for energy was outlined as: „*Maintaining secure energy future through essential bridge to sustainability by using Sun and Wind Energy Resources*" (FICHTNER GmbH & CO.KG, 2013). This specific objectives of the SREMP could be summarised as follow comprises the following aims to accommodate a target renewable energy capacity of 2,000 MW with an anticipated completion in 2030 within a defined area of 100km^2 according to the following three phases rollout:

- Phase 1: A RE Park with 70 MW of RE capacity (50 MW CSP, 10 MW PV and 10 MW Wind) including a permanent ground measurement station.
- Phase 2: Extension of the plant to a total of 1,000 MW installed RE capacity (CSP, CPV, PV and wind); and
- Phase 3: Extension of the plant to a total of 2,000 MW installed RE capacity (CSP, CPV, PV and wind).

3 Masterplanning Methodology

The Renewable Energy Park (REP) Master Plan is a dynamic "working" tool that shapes REP development, monitors change, and ensures the quality of project planning, design, and implementation (FICHTNER GmbH & CO.KG, 2013). It also act as an indicative development plan which means that the master plan was earmarked to coordinate future development ensuring that the REP develops in the right place and in the right manner (FICHTNER GmbH & CO.KG, 2013). More so, the State of Kuwait through its authorised agencies shall utilised the information shared to influence, subsidise, give grants and tax exemptions to positively affect the development process. To fulfil the charge, recommendations were outlined for REP Master Plan policies, planning principles, and the planning review process intended to make the RE Park Master Plan a continuing, and sustainable process. The methodology was based on a three-step approach, each with specific results, allowing KISR a more active role in the decisions taking process.

3.1 Concept, Policy Framework and Guidelines for The Master Planning

In other to develop a strong basis for the planning process, general policies, guidelines and principles were formulated by the team to guide them. The policies described the general and the broad framework for the planning and implementation of the basic infrastructure and engineering concepts of the SREMP. Whilst the policies gave tangible authority to the provisions of the REP Master Plan, the principles elucidated the fundamental planning concepts of the SREMP and established the basis of the engineering and infrastructural structure that is the underpinning of all future development on the SREMP. These principles are the primary framework for directing and evaluating this REP and its corresponding infrastructural development. These were supplemented with a general review of the procedures for carrying out and updating the SREMP. The policies as postulated set forth specific conceptual guidelines and recommendations necessary in the site-level execution of the master plan. These guidelines are the basic tools that the project executers and planners shall use to ensure that the various projects conform to the master plan goals as articulated in

the Planning Principles. In summary, the policies included: Policy 1 - Cost-Effective and Technically Proven; Policy 2 - Safe & Environmentally Friendly; Policy 3 - Simple, Efficient, Durable Design; Policy 4 - Accessibility, Congruency of Land Use Typology; Policy 5 - Aesthetically Harmonious Shared Facilities; Policy 6 -Water Distribution and Waste Water Treatment ; Policy 7 - Tenancy.

The General Guidelines however consisted of Sectoral Infrastructure Planning Guidelines with the following broad sections: CSP Energy Sector; Wind Energy Sector; PV Energy Sector; Operation and Maintenance Housing Community Sector; Interfaces and Shared Facilities.

3.2 Stages of the Master Planning

The methodology applied to develop this master plan was splitted into three steps. **Step one** includes the review of existing information, including previous feasibility studies, available infrastructure and meteorological and energy demand data. A technology overview of current state-of-the-art in wind, PV and CSP technologies is given and the planning principles and policies for the master plan are compiled. After the basic data that should be used in the master plan is defined, the three scenario focuses, as well as the around 14 Renewable Energy clusters (see Figure 1), have to be defined. The proposed clusters and scenario focuses were reviewed and approved by the client and when they were fixed, step one was completed. In **Step two** a techno-economic evaluation of the defined RE clusters is conducted that includes the determination of economic figures such as Capital Expenditure (CAPEX) and Operational Expenditure (OPEX), as well as performance simulation in order to generate an hourly energy output time series for each of the previously defined Renewable Energy clusters. In parallel, the scenario optimization tool is developed that uses the information from the techno-economic evaluation to optimize the shares of RE clusters according to the three defined scenario focuses. Those three optimized scenarios then presented to the client in a workshop from which the client selected one scenario. The following **step three** then includes a more detailed analysis of the selected master plan scenario. This includes a preliminary phasing and implementation plan and a network study for the selected scenario. The submission of all documentation of the master plan concludes the master plan project.

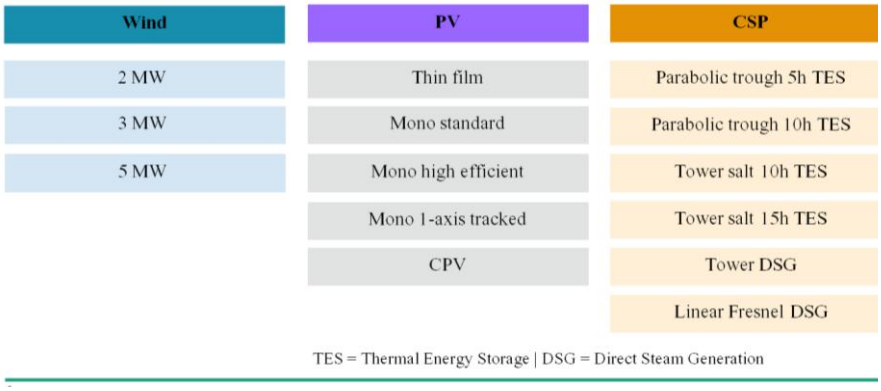


Figure 1: Renewable Energy Clusters Selected Source: (Fraunhofer Institute, Germany,& FICHTNER GmbH CO & KG 2013)

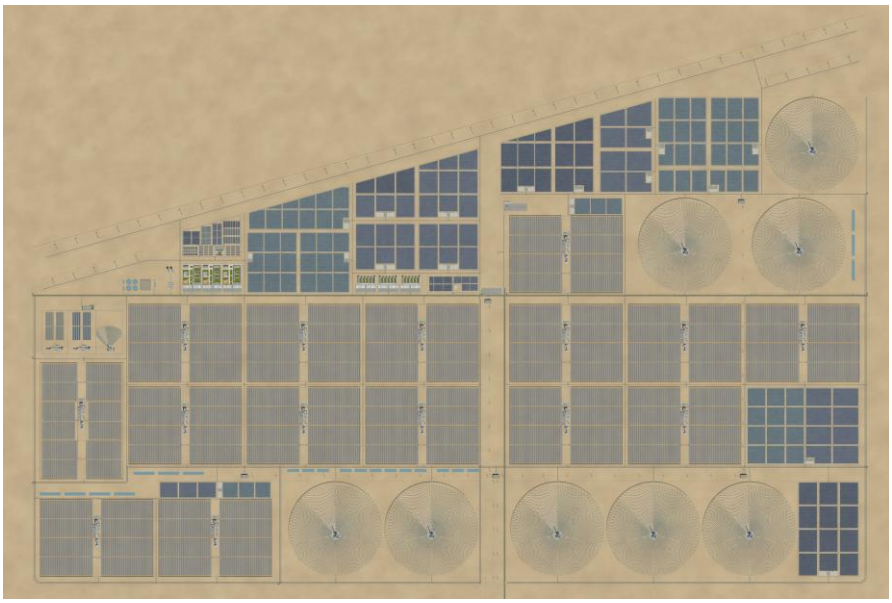
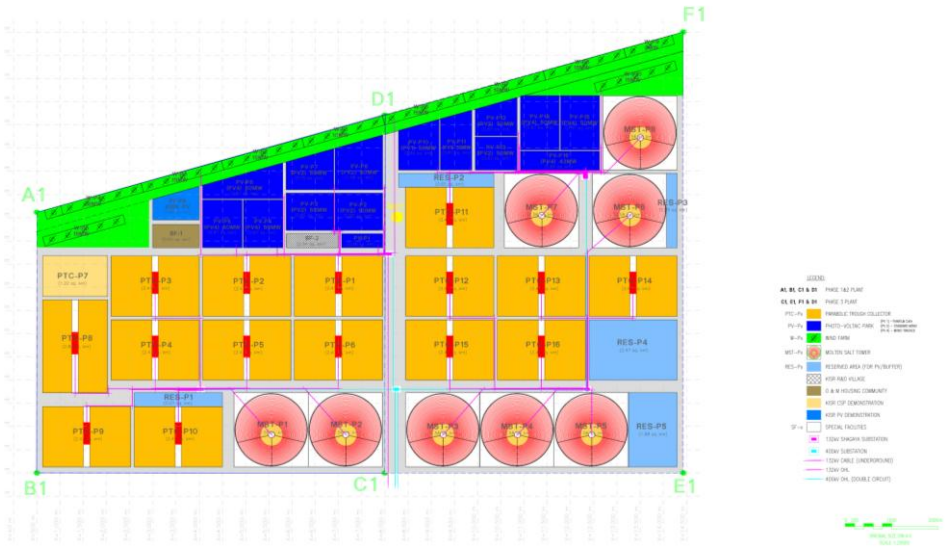


Figure 2: SREMP Land Use Plan Source: (FICHTNER GmbH & CO.KG, 2013)



3.3 Methodology for Technology Mix Optimisation

The methodological approach utilised can be split into two phases as presented in Figure 3. A first phase aimed at the selection of techno-economic characterization of viable technology options that could be considered for the park load shaving (Alhajraf, et al., 2014). A total of 3 wind, 5 PV and 6 CSP technology options were selected and a set of 8 socio- and techno-economic evaluation criteria was defined (e.g. levelized cost of electricity, job creation, full load hours per year) (Fraunhofer Institute, Germany, 2013). This phase also included the collection and definition of satellite and modelling based meteorological data and typical electricity demand profile in Kuwait, software to be used for the performance simulation and criteria to evaluate the technology options (Alhajraf, et al., 2014). Taking 2010 as the reference

year, yield simulation was performed using System Advise Model (SAM), WindPRO, Matlab and Fraunhofer in-house tools.

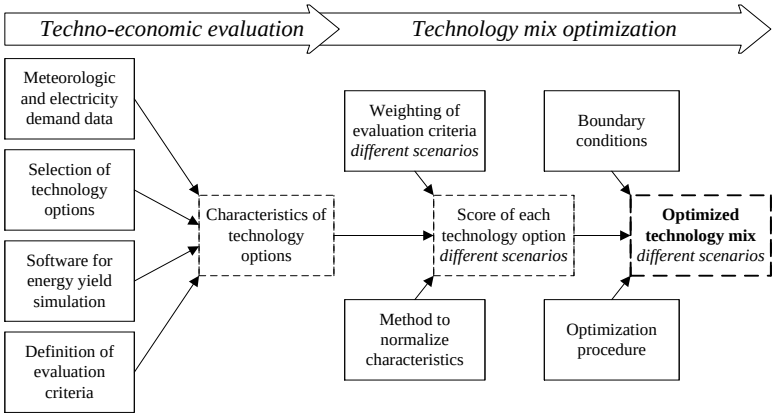


Figure 3: Methodological structure for the technology mix optimization

Source: (Fraunhofer Institute, Germany, 2013)

In the second phase of the analysis, the aim was to find the optimal technology mixes under different weightings of the evaluation criteria, i.e. the three different scenarios. For that, a method to normalize the different techno-economic characteristics determined in the first phase in order to calculate a common score of a given technology mix was developed (Alhajraf, et al., 2014). This score was then maximized in an optimization procedure under certain boundary conditions to find the optimal technology mix. For the optimization, a generalized pattern search was implemented in the software GenOpt (Lawrence Berkeley National Laboratories), which was combined with an Excel tool. Additionally, a brute force method was applied to confirm the results found by the GenOpt optimization. Three scenarios were considered in this study: (S1) *peak load shaving* is aimed to produce the maximum park capacity during the period of peak electricity demand, (S2) *high annual yield* focuses on the ability of the park to produce high kWh per year and (S3) *low levelized cost of electricity* aims at generating the cheapest kWh throughout the park. Several boundary conditions were defined for the optimization: Besides the land restriction and the total capacity to be installed in each expansion phase, a minimum capacity credit (Alhajraf, et al., 2014). had to be reached after each phase.

4 Development Frame work and Implementation Strategy

For effective development process for the SREMP, a framework that forms the basis of the implementation roll-out plan was prepared. As per this development framework, the master plan's strategic core initiatives or actions that highlights key initiatives and milestones within the master plan were identified. A strategy to deliver such initiative that describes how these shall be delivered and the implementation mechanism that is best for these actions were allocated accordingly.

4.1 Administrative Strategy for SREMP

Although there is Public Authority for Industry in Kuwait, the renewable energies department is yet to be established. It is assumed that an authority with adequate powers shall be set up as an authority for all Renewable Energy Parks (REPs) in Kuwait. The entire 2,000 MW REP shall be managed by the SREMP Authority (SREMPA) who shall act as a "landlord" to the investors that install their power plants on the various sites within the REP. The SREMPA shall provide prepared sites through its subsidiary that are supplied with the necessary utilities and services to support the investor's generating plant. The Independent Power Producers (IPPs) would build and transfer specified shared facilities and transfer them to SREMPA. The key responsibilities of the SREMPA would include portfolio management as well as issues. This power of development control and management shall be handed to an on-site subsidiary agency which shall be either full governmental agency or a shareholding company partially owned by government but acting as a private limited liability company.

4.2 Implementation Strategy

One of the first steps in translating the vision established by the Master Plan into a meaningful strategy to guide development is the identification of early 'catalyst' development opportunities which is the Shagaya Renewable Energy Park (phase 1) with installed capacity of 70 MW. This consists of 50 MW Concentrated Solar Power with the Parabolic Trough Collector technology; 10 MW Photo voltaic and a 10 MW wind park. This phase of the project is anticipated to serve as a catalyst for change and lead the way in the realisation of the master planning vision. The phase 1 would therefore set a benchmark for future developments in the Shagaya Renewable Energy Master Plan Area, particularly in terms of design character, sustainability infrastructure development and the energy output.

For the development of the substations (ST), it is recommended that the substation 1 is utilised till the end of the 8^{th} year where ST2 would have been built to support the extra 200 MW that would evacuated from the CSP plants. It is also anticipated that at the end of the first 10 years, Phases 1 and 2 would have been developed with the installed capacity of 1,000 MW. More so, an extra 530 MW would be added to this 1,000 MW making it 1530 MW by the end of the first 15 years which would culminate to 2,000MW installed capacity by the end of the 18^{th} year or by 2030 (FICHTNER GmbH & CO.KG, 2013). It is anticipated that the entire Phase 3 could be considered as the phase to be implemented in the long term. Major infrastructural development like the supply of water and fuel and gas pipelines to the site are likely to take some time before its developed or ever reach the Shagaya site under consideration.

4.3 Infrastructure Development Framework and strategy

Due to the complex nature of the infrastructure system of SREMP, a model was developed to analyse and ascertain how the various Infrastructure were interacting. Thus, the overall SREMP was broadly divided into land use sectors and the corresponding infrastructure needs identified and mapped as shown in the figure 4 below. This was use to identify which nodes and areas in the infrastructure system need attention and strategies recommended for the interface management.

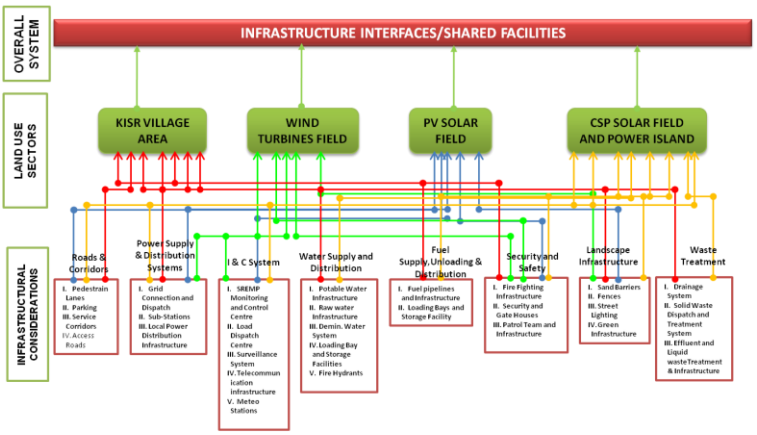


Figure 4: Infrastructure Strategy for SREMP
Source: (FICHTNER GmbH CO & KG, 2013)

5 Discussion of Master Plan Results and Conclusion

Although planning with the focus to develop an area for human occupation is quite different from that for production of energy, human being end up working and living there and hence all the principles and guidelines for liveable and sustainable communities needs to be considered. The conceptual focus of the SREMP was to utilise planning and design principles to ensure long-term success and efficiency of land use. More so, the goal of the land use plan was to create an industrial area for efficient Renewable Energy power generation. With the fore-knowledge that wind direction was North West the wind park was zoned to take the northern portion of the land area. This area also had access to east-west boundaries which served as access point for the entire site.

5.1 Scenario Selected and Optimised

After the scenario optimisation few adjustments and tweaking were done by the consultant in consultation with the client to bring the result to an acceptable level which could be utilised in the preparation of the land use. Thermal storage of CSP is important to serve the afternoon peak load whilst the high annual yield and the peak load shaving scenario show many similarities. Although PV and wind power were preferred for a low levelized cost of electricity (LCOE) inclusion of PV increases the land use efficiency. A diverse technology mix is important for a high capacity credit, but no single technology could be definitely identified as more or less important was critical since the peak load shaving for Kuwait is very important. However, diversity of the technology mix should not be neglected since it reduces dependency on a single technology. The low land use efficiency of wind is what impairs its selection into the technology mix during the optimization process. As per the client's request some few adjustments were done to the recommended scenario based on the experience of the consultants and the prediction of the market trends of the renewable energy market. Consequently, wind capacity in phases two and three was reduced so that also the wind turbines of phase one fit along the northern borderline of the Shagaya site. The Capacity of PV was increased and distributed more equally between phases two and three but the capacity of tracked PV was reduced in favour of fixed PV due to the fact of fix PV being well proven and easier to install and maintain. CSP capacity was

reduced by 100 MW and all large storage systems were reduced to medium storage systems. Additionally, more capacity was allocated to parabolic trough technology from solar tower since it was considered the more matured technology with lower risk (see Figure 2).

5.2 Fuel Saving and CO_2 Avoidance Capabilities

In other to estimate the gains made on the impact on the climate, assumptions made for the calculation of money saved due to fuel savings are a price of 90 $/barrel and a density of 7.33 bbl/toe (IEA, 2011). CO_2-savings are calculated based on the conversion factor of 870 g CO_2/kWh for the 2009 Kuwait energy mix (IEA, 2009). Consequently, the scenario selected within this master plan study estimates avoidance of CO_2 emissions by around 5.1 Million tons per year and savings of fossil fuel of around 1,710 ktoe per year (FICHTNER GmbH & CO.KG, 2013). The fossil fuel savings amount to a preliminary estimation of 1,128 Million USD per year (FICHTNER GmbH & CO.KG, 2013).

5.3 Lessons for Infrastructure Planners

As part of the lessons that could be gleaned from the above project, it was clear that basic planning process and principles needs to be understood and appreciated for its consequential application to any situation when required. From the SREMP project it was also evident that the education of infrastructure planners should include more mechanical engineers as most of the renewable energy master plans are being handled by them. Managing interfaces of Infrastructure aspects with many components requires a lot of project management skills and basic aspects of infrastructure planning. It is also necessary for infrastructure planning students and experts to consider this utilisation of optimisation procedures for their land use planning as it is critical to enhance objective planning. More so, it could be learnt that the park development framework also seeks to reinforce the set of principles that secure development which positively contributes to the enhancement and creation of distinctive and efficient industrial places (FICHTNER GmbH & CO.KG, 2013). More so, as the preferred scenario in terms of land use enhances permeability and connectivity, when planning towns and cities it is essential that mobility by for non-motorised transport system be considered to reduce the impact on the climate.

5.4 Conclusion

Suffice it to say, although optimisation tools was essential for the success of the objectivity in planning the area to meet the desired goals, the experience and expert judgement as well as the subjective intuition from the planners cannot be understated. A critical success factor for an industrial development area like SREMP is the ability to have the opportunity to open up the site and make it permeable by promoting successful accessibility to every part of the park. As the final product of a plan is most likely to fit into the dynamism of the real life situation, the inputs of experienced experts are always critical for fine tuning after software are used. Developing countries who are also endowed with renewable energy resource and oil reserves could also learn from the bold initiative of Kuwait to utilised some of the revenues from the oil to harness the sun and wind resources to better the quality of life of the people whilst also reducing the impact on the climate from the use of fossil fuels.

References

1. Alhajraf, S. et al. (2010). *Feasibility Study of Renewable Energy Technologies for Power Generation in the State of Kuwait. Final Report.* Kuwait.
2. Alhajraf, S., Lude, S., Fluri, T. P., Jülch, V., Kühn, P., Marful, A., et al. (2014). Optimization of the Technology Mix for the Shagaya 2 GW Renewable Energy Park in Kuwait. *MENASOL.* Dubai: SOLAPACES.
3. FICHTNER GmbH & CO.KG. (2013). *Shagaya Renewable Energy Master Plan Report.* Stuttgart: Fichtner.
4. Fraunhofer Institute, Germany. (2013). *Shagaya Renewable Energy Master Plan Technology Optimisation Report.* Freiburg: Fraunhofer Institute.
5. Helmy, M. (2008). *Urban Branding Strategies and the Emerging Arab Cityscapes : The Image of the Gulf City.* Stuttgart: University of Stuttgart.
6. IEA. (2009). *IEA country statistics energy balance for Kuwait.* Retrieved September 20, 2012, from http://www.iea.org/stats/balancetable.asp?COUNTRY_CODE=KW
7. IEA. (2011). *IEA Statistics. CO2 Emissions from Fuel Combustion. Highlights. .* IEA.
8. Lawrence Berkeley National Laboratories. (n.d.). *GenOpt - Generic Optimization Program, ©,.* (Available from http://simulationresearch.lbl.gov/GO/, version 3.1.0 used in this study, Performer) Berkeley,, CA,, USA.
9. O'Shea, M., & Spilling, M. (2010). Kuwait. *Volume 17 of Cultures of the world* , 56.
10. United Nations Human Settlements Programme (UN-Habitat). (2012). *State of the Arab Cities 2012: Challenges of Urban Transitions.* Kuwait City: UN-Habitat.
11. Wiedmann, T., & Minx, J. (2008). A Definition of Carbon Footprint. In C. C. Pertsova, *Ecological Economics Research Trends:* (pp. Chapter 1, pp. 1-11). Hauppauge NY, USA.: Nova Science Publishers.

Assessment of Renewable Energy Potential Based on GIS: A Case Study in China

Jie Zhang, Nguyen Xuan Thinh
TU Dortmund University, Faculty of Spatial Planning
August-Schmidt-Str.10, 44227 Dortmund,Germany
zhangjie_1213@hotmail;nguyen.thinh@tu-dortmund.de

Abstract: In China, most cities are experiencing rapid urbanization and economic growth. Huge energy demand caused by large population and strong economic growth lead to an inevitable increase in fossil fuels. Hence, the environmental problems caused by the CO_2 emissions require more attention. Renewable energy is an appropriate solution to meet the energy demand and reduce the CO_2 emission simultaneously. Estimation of renewable potential is the first and crucial step for utilization. This research estimated wind energy, solar energy and bioenergy potential using a Geographic Information System (GIS) approach. In order to demonstrate this methodology, Heibei province, Beijing and Tianjin cities in China are selected as a case study. Wind energy potential was assessed based on wind speed and wind turbine characteristics. Solar radiation and technology characteristics determine annual energy yield from solar. Bioenergy potential was derived from the MODIS remote sensing data. Due to the geographic and social constraints, not all theoretical renewable energy potential can be utilized. This study determined the geographic, social constraints and mapped the excluded zone for renewable energy power plants. The results show the spatial distribution of wind power density, solar radiation, usable biomass amount and annual energy yield from wind and solar energy. Total annual energy yields from wind, solar and biomass in the study area are 307 TWh, 2379 TWh and 143 TWh separately.

Key Words: renewable energy potential, wind, solar, biomass, GIS-based approach

1 Introduction

China, with its economy growing at more than 7% in 2013, continues to face increase of energy consumption. Since 2009, energy consumption in China has exceeded that of the USA and thus China became the largest energy consumption country in the world. Large consumption of fossil fuels brought increase of CO_2 emission. The amount of CO_2 emission in 2013 has reached 10 billion tons, accounting for 30 % of global CO_2 emission. Renewable energy is one of solutions to reduce CO_2 emission and satisfy the demand of energy consumption simultaneously. China has set the target that the share of renewable energy in the energy structure shall reach 20% by 2020.

Wind power comprises the largest development and market oriented utilization of renewable resources. Until the end of June in 2012, China's grid-connected installed wind power capacity has reached 52.58 GW.[1] Solar power is the conversion of sunlight into electricity, directly using Photovoltaic (PV), or indirectly using concentrated solar power (CSP). In regions with scare fresh water resources, the PV technology is more suitable.[2] PV development in China started from 2009 and

increased at an annual rate of 200-300%.In 2013, China has increased installed PV capacity of 11 GW with the total capacity of 17 GW, which accounts for 40% of global capacity.[3] Biomass resources is grouped into wood residues generated from wood products industries; agriculture residues generated by crops, agro-industries and animal farms; energy crops (i.e. crops and trees dedicated to energy production); and municipal solid waste.[4] Biomass can be used for direct heating in industrial or domestic application, in the production of steam for electricity generation or for production of gaseous or liquid fuels.[5] The total output of straw residues in China reached 841 million tons in 2005 accounting for 62% of global straw resources.[6] The Chinese government has attached high importance to the development and utilization of biomass as an energy resource since 1998.[7]

Considering the urgent energy demand situation, severe environmental problems caused by CO_2 and government's policy in China, the development of renewable energy is promising. Potential estimation of renewable energy is the first and crucial step for utilization. Defining the area where it is geographically feasible to locate renewable power plants is also a key issue. As Geographic information system (GIS) has spatial analysis and data management function, GIS-based methods have been broadly used for renewable energy potential analysis. Voivontas found both technically and economic wind farm sites in Crete using GIS.[8] He also evaluated biomass resource with the aid of GIS.[5] From that time, GIS has been often used to determine the potential for renewable energy developments.[9-13] This paper presents a GIS-based methodology to quantify wind, solar and biomass resources by estimating the annual electricity yield from wind, solar and biomass. In order to interpret this methodology, Hebei province, Beijing and Tianjin city are selected as a reference study. The whole research framework include following tasks:

- Quantify and map the distribution of wind power density, solar radiation and biomass amount.
- Define the geographical restriction areas for renewable energy farms.
- Transfer the solar, wind and biomass resources into annual technical electricity generation.

2 Study area

The study area of this research covers Hebei Province, Beijing, the capital city of China; and Tianjin, one of four municipalities (Fig 1). It occupies 217,141 km^2 and has a continental monsoon climate, with temperature -14 to -2^oC in January and 20-27^oC in July. Average annual solar radiation is between 4854 to 5981 MJ/m^2 and annual duration hours vary from 2319 to 3077 hours. Most central and southern parts lie within the North China Plain. The population of the study area was 95 million in 2013. Gross domestic production (GDP) reached 882.3 billion dollars, accounting for 11% of the national GDP.[14] The cumulative installed wind capacity in this study area was 8961.4 MV at the end of 2013, whereas the total capacity in China was 92038 MV. Installed wind capacity in this region is planned to reach 1.1 GW by 2015 based on the national twelfth five-year plan. In 2013, the installed capacity of on-grid large scale PV in has reached 260 MW.[15] Based on the incomplete statistic study,

there are 12 biomass plants projects constructed or under construction at the end of 2013. The total installed capacity exceeds 300 MW.

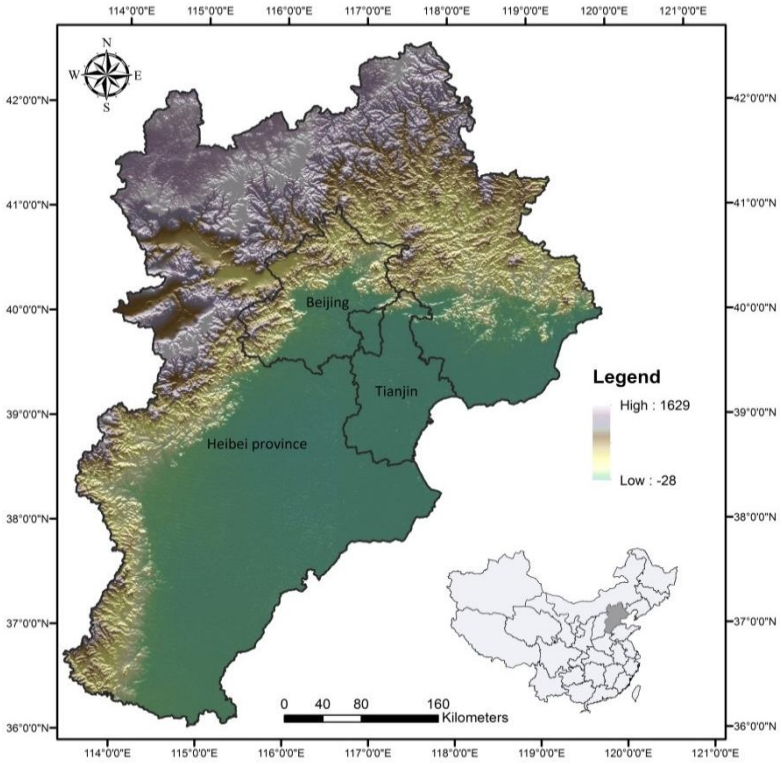


Fig. 1 The geographical position and elevation of study area

3 Methodology

3.1 Estimation of energy resource from wind

The height of wind turbine is different from the height of meteorological stations. Wind speeds measured at a given height can be extrapolated to another height within the boundary layer (wind turbine hub height) using the modified power law or 1/7th power law, given by the relation.[16]

$$\frac{V_2}{V_1} = \left(\frac{Z_2}{Z_1}\right)^{\alpha_m} \quad (1)$$

where

V_2 is the average wind speed at the hub height Z_2;

α_m is the modified power law exponent;

V_1 is the average wind speed measured at the measurement height, Z_1.

The modified power law exponent is calculated based on surface roughness length; it has a close relationship with landscape type. Detailed calculation formula can be found in the study of Mikhail and Hossain.[16, 17]

Weibull law is the most frequently used model to describe the distribution of the wind speed. The probability density function (PDF) of the wind speed is given by Takle and Brown.[18]

$$f\,(V) = \left(\frac{K}{C}\right)\left(\frac{V}{C}\right)^{K-1} \exp\left(-\frac{V}{C}\right)^{K} \quad (2)$$

where

f(V) is the probability density function of the wind speed;

V is the wind speed (m/s);

C is the Weibull scale parameter (m/s);

K is the dimensionless Weibull shape parameter.

In this study, K and C are estimated using formula from the study of Justus.[19]

The power of the wind that flows at speed V through a blade swept area A increase as the cubic of its velocity and is given by

$$P(V) = \frac{1}{2}\rho A V^3 \quad (3)$$

where ρ is air density. Wind power density of a site based on a Weibull probability density function can be expressed as follows: [20]

$$D = \frac{P}{A} = \int_0^\infty P(V) f(V) dV = \frac{1}{2}\rho C^3 \mathrm{Gamma}\left(\frac{K+3}{K}\right) \quad (4)$$

where D is power density with the unit of w/m^2 Wind power density is the indicator of theoretical power potential. The distribution of wind power density shows the variation of theoretical power potential. It is impossible to utilize all theoretical wind power potential due to geographical restrictions, social constraints and wind turbine technical characteristics. The wind farm location must avoid summits of large hills, avoid slope angle larger than 10%, and not be located within buffer zones of woodland, large settlements, ecological and historic sites. Buffer zones were developed based on the existing researches. [8, 21]

Feature	***Recommendation for buffer zones***
Protected natural area	Buffer zones around protected area:500m
Woody land	Buffer zones around woody land:500m
Airports	Buffer zones around airports:2500m
Slope	Slope greater than 15% is not allowed
Urban area	Buffer zones around residential area:500m
Water body	Buffer zones around water body:500m

Table 1 Criteria of restriction area for wind farms

Vestas 82(V82 1.65MV) wind turbine, produced by Vestas company was chose in this study. Vestas, Danish manufacturer, seller, installer, and servicer of wind turbines, has gained a market-leading position with more than 60GW of installed

wind turbines, comprising close to 19% of total global capacity.[22] The technical parameters of V82 are showed in Table 2:

Hub height	*Rated power*	*Rotor diameter*	*Swept area*	*Cut in speed*	*Cut off speed*
80m	***1650kw***	***82m***	***5281m²***	***3.5m/s***	***25m/s***

Table 2 Criteria of restriction area for wind farms

The wind energy (E) that can be extracted by wind turbines is defined in Eq. (5)

$$\mathrm{E_i} = \mathrm{D} * \mathrm{A} * \mathrm{C_p} * \mathrm{n} * \mathrm{h_e} \quad (5)$$

where

D is wind power density, calculated in wind power density model

A is the wept area of wind turbine

$\mathrm{C_p}$ is the percentage of power which can be extracted from the wind, depends on the available wind energy and on the operating characteristics of the wind energy extraction device .However, wind machines cannot use 100% of this power due to the Berz limit. The wind power available previous equation can be rewrite by adding a coefficient, called $\mathrm{C_p}$, which defined the maximum efficiency of the Betz limit (0.593).[23]

$\boldsymbol{n}$ is the number of turbine in the given grid, calculated as follows:

$$n = \frac{A_i}{(5*10*\varphi^2)} \quad (6)$$

where

$\mathrm{A_i}$ is the size of grid i. In this case, it is 1 km^2

φ is the rotor diameter of wind turbine 82 meter.

$\mathrm{h_e}$ is effective hours for wind turbine. Wind turbine cannot work when the wind speed is smaller than cut in speed or larger than cut off speed. Effective hours were calculated based on the study of Jiang. [24]

In 2011, more than 1500 GWh of wind power was not connected to grid, accounting for more than 12% of total wind generation in China. Therefore, annual wind energy production was adjusted by multiply 0.88 in this case.[25]

3.2 Estimation of energy resource from solar

Bristow and Campbell proposed a method for estimating the daily global solar radiation from daily maximum and minimum air temperature measurements. First step is to calculate the range in daily temperature extremes ΔT .[26] Second step is to calculate daily total transmission coefficient $\mathrm{T_t}$ using Eq. **Fehler! Verweisquelle konnte nicht gefunden werden.**).

$$T_t = A[1 - \exp(-B\Delta T^C)] \quad (7)$$

Where A, B, and C are empiric coefficients. A represents the maximum clear sky of the study area. It will vary with elevation and pollution content of the air. B and C determine how soon maximum T_t is achieved as ΔT increases.[26] Kreith and Kreider have described the empiric model to calculate A using air mass ratio.[27] The value of B and C were from the research work of Liu and Pan.[28] B and C in this study area are 0.019 and 1.876 separately.

Last step is to calculate daily measured irradiance based on Eq. (8)

$$T_t = \frac{daily\ measured\ irradiance}{daily\ extraterrestrial\ insolation} \quad (8)$$

Daily extraterrestrial insolation incident on a horizontal surface in (J/m^2) was computed using the equation from Levin.[29] The annual solar radiation is calculated as the sum of daily solar radiation.

Area with a slope of less than 2.5% with any aspect is acceptable for PV farm. Because of the relatively flat surface, southern exposure is not required as the solar panels can be titled to the south with no impact on potentials. The next set of criteria was applied to find areas with slopes of 2.5%-15% which have south-facing aspects (112.5-247.5^o), locations meeting this combination of slope and aspect are good location for solar farms because of the southern exposure Any location with a slope greater than 15% regardless of the exposure, is considered undesirable for solar farm development.[30] Another set of constraints is land use constraints, natural reserve and 500m buffer zones around protected area, water body, wetland, built-up area are excluded.

The PV production energy is determined by three main parameters, solar radiation of local area, size and performance ration of PV systems, it is calculated in Eq. (9):

$$E_i = G_i * A * A_f * \eta * pr \quad (9)$$

where,

E_i is electric power generation potential per year (GWh/year);

G_i is annual solar radiation received per unit horizontal area (GWh/km^2/year);

A is calculated total area of suitable land (km^2);

A_f is the area factor indicated what fraction of the calculated areas can be covered by solar panels. It is assumed as 10%.[31]

η is the efficiency with which solar system converts sunlight into electricity. Based on the existed research and technical report, η is taken as 14% in this study.[32, 33]

pr is the performance ratio of PV system. The best systems currently have performance ratios between 0.66 and 0.85, is considered as 0.75.

3.3 Estimation of biomass potential

Biomass potential in this study was derived from the annual net primary productivity (NPP); only residues from forest and farmland are estimated in this study. NPP is defined as the net flux of carbon from the atmosphere into green plants per unit of time. MODIS product (MOD17A3) provides NPP at 1 km resolution annually to estimate global NPP.[34] NPP includes both above and below-ground production and is

measured as the amount of carbon per unit area (gC/m^2). Only the above-ground biomass is used for energy production. The method, which is used to convert NPP from MODIS/Terra data to available biomass potential is based on the research of Shi et al (2008).[35]

Not all biomass can be used for energy production due to restrictions, such as soil carbon maintenance and other economic purposes (paper making). Usable biomass is introduced to express the part of biologically available biomass which can be used for energy production. It is calculated based on the following equation.

$$U = B * r * (1 - e - l) \quad (10)$$

where:

U is usable biomass

B is biologically available biomass

r is the fraction of B that is not the primary yield. For crops, usually only the residues (e.g. straws and steams) are used for energy production and thus r is much less than 1, but for fast-growing grass/trees that are dedicated to energy production, r can be equal or close to 1.[36]

e is the percentage of the excluded biomass used for economic purpose other than energy production, such as forage and papermaking.

l represents the loss during the whole process, e.g., the loss occurring during the harvest.

Energy from biomass is different from wind and solar, biomass need to be collected from the field and transported to the biomass power plants. The cost for biomass collection and transportation accounts for large percentages and hence biomass power plants should be located in the places with much biomass potential and convenient transportation. Location-allocation model in Network Analyst enabled in ArcGIS is selected to find optimal sites for biomass power plants. Top 10 sites are selected at first, considering the population density and existing coal power plants, only 4 sites are selected as the final optimal biomass power plant locations.

4 Results and discussion

Fig. 2 shows the spatial distribution of wind power density and annual wind power generation, calculated from Eq. (4) and (5). The spatial distribution of wind power density is largely determined by terrain and wind regime in study area. The north western area (Bashang Plateau) and east area near to see are endowed with excellent wind energy resource. The area of restricted region is 80189 km^2, account for 36.9% of total area. The regional potential is estimated to be 307 TWh/year; whereas, in 2012, total electricity consumption in study area exceeded 467.47 TWh. The energy consumption is far beyond the total technical potential of wind energy.

Latitude, continent, terrain and local climatic variations determine the solar energy resource.[37] The spatial variations of annual global solar radiation on the horizon, calculated based on Eq.(8) and annual PV electricity production, according to Eq.(9), are shown in Fig. 3. Annual solar radiation differs in value over the region from

1406 kWh/m^2 to 1960 kWh/m^2. Annual energy yield is estimated to be 2379 TWh for the large-scale PV plants, is 5 times of the electricity consumption in 2012.

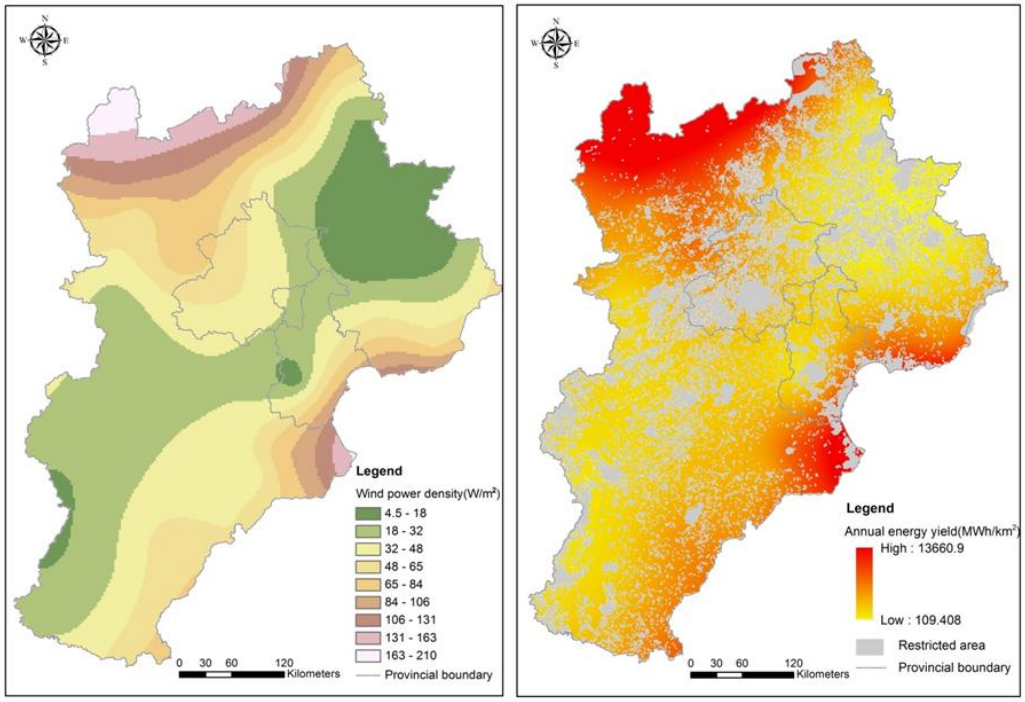


Fig. 2 Spatial distribution of wind power density and annual energy yield

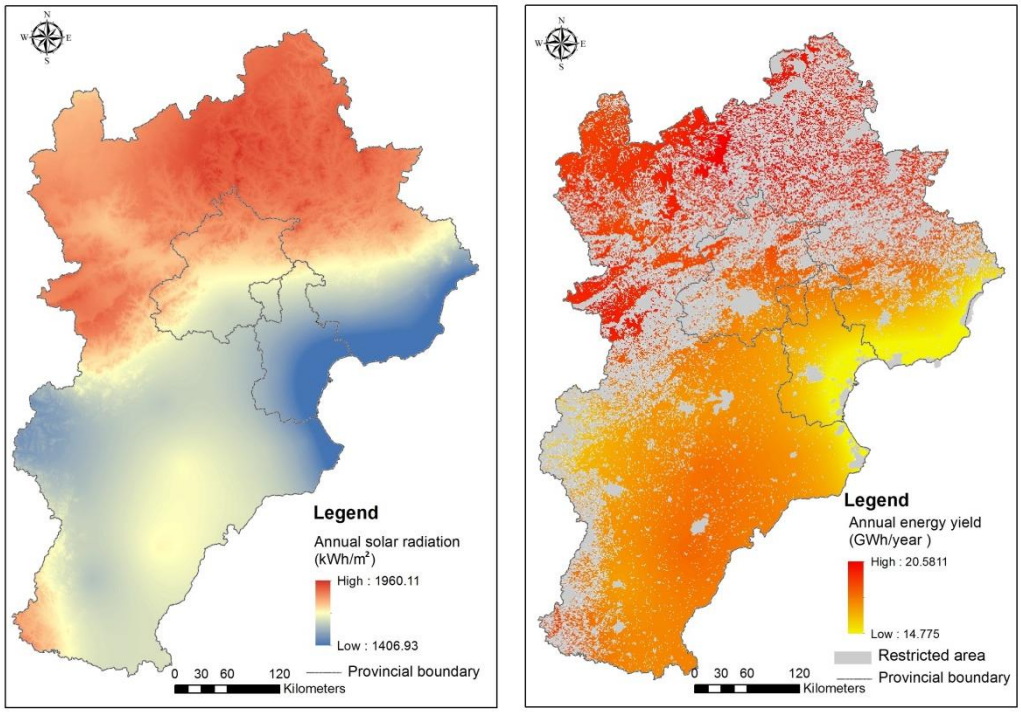


Fig. 3 Spatial distribution of solar radiation and annual energy yield

Fig. 4 shows the spatial distribution of biomass and final four optimal sites for biomass power plants. Northwestern part has more biomass due to the forest land cover type. Total amount of usable biomass reach 214 million tons. Based on the current technical report from biomass power plants, 1 kWh electricity needs averagely the combustion heat value from 1.5 kg biomass. Annual energy yield from biomass is 143 TWh.

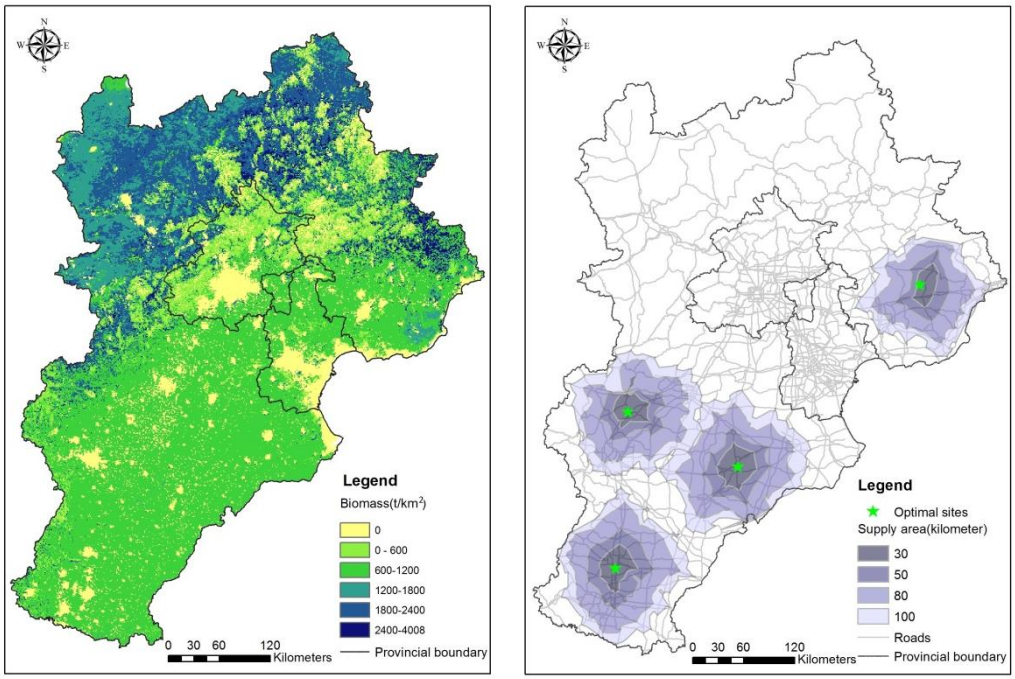


Fig. 4 Spatial distribution and optimal sites for biomass power plants

5 Conclusion

This paper presented a procedure to estimate the renewable energy potential at regional scale with the aid of GIS. The work integrated wind speed variable, solar radiation, usable biomass and technical characteristics to evaluate annual energy yield. The results of research work, especially the spatial distribution of annul energy yield could be used by investors and utilities of renewable energy projects. With the results of this study project developers can quickly identify new profit areas where to invest new renewable energy projects.

The Hebei province, Beijing and Tianjin cities have been analyzed as reference case. Analysis shows annual wind energy yield can reach 307 TWh. annual energy yield from solar is estimated to be 2379 TWh. Using biomass we can produce 143 TWh per year.

The mostly existing researches on renewable energy potential only estimate wind power density, solar radiation and biomass quantity. Few researchers in China calculated annual energy yield and define the restricted area for renewable energy power plants. The Methodology adopted in this study doesn't have geographical location limitations, is applicable to other areas.

References

[1] He, Y., Xia, T., Liu, Z., Zhang, T., Dong, Z., Evaluation of the capability of accepting large-scale wind power in China. Renewable and Sustainable Energy Reviews, 2013.pp. 509–516.

[2] Sun, YW., Hof, A., Wang, R., Liu, J., Lin, YJ., Yang, DW., GIS-based approach for potential analysis of solar PV generation at the regional scale: A case study of Fujian Province. Energy Policy, 2013, 58,pp. 248–259
[3] Website China Electricity Council, www.chinapower.com.cn,accessed on 15th April, 2014
[4] Easterly, J., Burnham, M., Overview of biomass and waste fuel resources for power production. Biomass & Bioenergy, 1996. 11, pp. 72-92.
[5] Voivontas, D., Assimacopoulos, D.,Koukios, E., Assessment of biomass potential for power production:a GIS based method. Biomass & Bioenergy, 2001, 20, pp. 101-112.
[6] Bi, Y., Gao, C., Wang, Y., Li, B., Estimation of straw resources in China. Transactions of the CSAE, 2009, 12, pp. 211-217.
[7] MOA/DOE Project Expert Team, Assessment of biomass resource availability in China. Beijing: China Environmental Science Press, 1998.
[8] Voivontas, D. Evaluation of renewable energy potential using a gis decision support system. Renewable Energy, 1998, 13, pp. 333–344.
[9] Zhang, H., Chen, H., Zhang, H. Utilization and spatial-temporal distribution of wind energy resources in Henan province based on GIS. Journal of Natural Resources, 2011, 26, pp. 1021–1029.
[10] Zhou, Y., Wu, W., Liu, G., & Hu, Y., Assessment on the land wind resource potential and micro sitting in Jiangsu based on GIS. Renewable Energy Resources, 2010,28, pp. 10–16.
[11] Janjai S, Pankaew P, Laksanaboonsong J., A model for calculating hourly global solar radiation from satellite data in the tropics. Applied Energy 2009, 86,pp. 1450–1457.
[12] Qin J et al. Estimation of monthly-mean daily global solar radiation based on MODIS and TRMM products. Applied Energy, 2011, 88, 2480–2489
[13] Thenkabail, P. et al., Biomass estimations and carbon stock calculations in the oil palm plantations of African derived savannas using IKONOS data. International Journal of Remote Sensing, 2004, 25, pp. 5447-5472.
[14] China statistic yearbook. Chinese Statistics Press, Beijing, 2013.
[15] Website China Energy Agency, www.nea.gov.cn. ,accessed on 19th April 2014.
[16] Mikhail, A. S. Height extrapolation of wind data. Journal of solar energy engineering,1985,1,pp. 10-14.
[17] Hossain, J., Sinha, V., Kishore, V. (2011). A GIS based assessment of potential for wind farms in India. Renewable Energy, 36, 3257–3267.
[18] Takle, E. S., Brown, J. M. (1978). Note on the use of Weibull statistics to characterize wind-speed data. Journal of Applied Meteorology, 17(4), 556-559.
[19] Justus, C., Hargraves, W., Mikhail, A., Graber, D. (1978). Methods for estimating wind speed frequency distributions. Journal of Applied Meterology, 17, 350–353.
[20] Chang, T.J., Wu, Y.T., Hsu, H.Y., Chu, C.R., Liao, C.M., Assessment of wind characteristics and wind turbine characteristics in Taiwan. Renewable Energy, 2003, 28, pp 851–871.
[21] Baban, M.J., Parry, T., Developing and applying a GIS-assisted approach to locating wind farms in the UK. Renewable energy,2001,24, pp. 59-71.
[22] Website Vestas: http://www.vestas.com/,accessed on 17th January 2014
[23] Lima, L. d. A., Filho, C. R. B. Wind resource evaluation in São João do Cariri (SJC) – Paraiba, Brazil. Renewable and Sustainable Energy Reviews, 2012, 16, pp. 474–480.
[24] Jiang, B., Zhao, S., Ma, Z., Hou, P., Xu, H., Temporal spatial distribution of the wind energy in Liaoning littoral. Marine Science, 2010, 35, pp. 56–62.

[25] Zhang, D., Xiong, W., Tang, C., Liu, Z., Zhang, X., Determining the appropriate amount of subsidies for wind power: The integrated renewable power planning (IRPP) model and its application in China. Sustainable Energy Technologies and Assessments, 2014, 6, pp. 141–148.
[26] Bristow KL, Campbell GS. On the relationship between incoming solar radiation and daily maximum and minimum temperature. Agriculture Forest Meteorology, 1984, 31, pp. 159–166.
[27] Kreith, F., Kreider.JF. Principles of solar engineering. Hemisphere Publishing Corp., Washington, DC, 1978; pp. 790.
[28] Liu, YJ, Pan, T. Spatial simulation of China's land surface solar radiation resources. Journal of natural resources, 2012, 27, pp. 1392–1403
[29] Levin, S A.Mathematical ecology. T. G. Hallam (Ed.). Springer 1986.
[30] Arnette, A N., Zobel, CW., Spatial analysis of renewable energy potential in the greater southern Appalachian mountains. Renewable Energy, 2011, 36, pp. 2785-2798.
[31] Gastli, A., and Charabi, Y., Solar electricity prospects in Oman using GIS-based solar radiation maps. Renewable and Sustainable Energy Reviews, 2010, 14, pp. 790–797.
[32] Hoogwijk, MM., On the global and regional potential of renewable energy sources. PhD thesis Universiteit Utrecht, Faculty Scheikunde ,2004.
[33] Stoddard, L., Abiecunas, J., O'Connell, R Economic., Energy and Environmental Benefits of Concentrating Solar Power in California, Overland Park, Kansas. National Renewable Energy Laboratory, 2006.
[34]WebsiteUSGS.http://daac.ornl.gov/NPP/html_docs/.html,accessed on 13 March 2014
[35] Shi, X. et al., Using spatial information technologies to select sites for biomass power plants:A case study in Guangdong Province, China. Biomass & Bioenergy, 2008,32, pp. 35-43.
[36] Liao, C., Yan, Y., Wu, C. Huang, H., Study on the distribution and quantity of biomass residues resource in China. Biomass & Bioenergy, 2004, 27, pp. 111-117.
[37] Šúri, M., Huld, T.A., Dunlop, E.D., Ossenbrink, H.A. Potential of solar electricity generation in the European Union member states and candidate countries. Solar Energy, 2007,81, pp. 1295–1305.

Planning for Cars, Planning for People: Options for a Transition in Urban Infrastructure

Juan Pablo Garcia
Consultant in Infrastructure Planning
Calle 116 # 22-15 apt 501, Bogota DC, Colombia
juanpablo_garcia@hotmail.com

Abstract: This paper reviews the impact of car-based mobility in urban systems and the planning principles that in the second part of the 20th century were adopted in response to this new reality. Then, some new concepts in relation to urban infrastructure both at the micro and macro scale are discussed. Finally, the case of Medellín, Colombia, in relation to mobility and public space, is presented.

Key Words: urban planning, urban design, street design, complete street, shared space street, urban highway removal, underground urban highway.

1 Cities, Public Space and the Motor Vehicle

Since cities appeared, in the dawn of civilizations, public space in urban environments was the realm of people, the place where pedestrians not only moved but also met and interacted. Streets and squares were always places for gathering, where neighbors encountered each other every day, where children played, where citizens exchanged not only goods but also, perhaps more importantly, opinions, ideas.

Thus, public space constituted the setting, the scenery, for the social and political life of communities. The agora in ancient Greece, the plaza in Mediterranean and Latin American cities, the main street in North America, are only a few examples of spaces that supported this vital human encounter and flows of ideas.

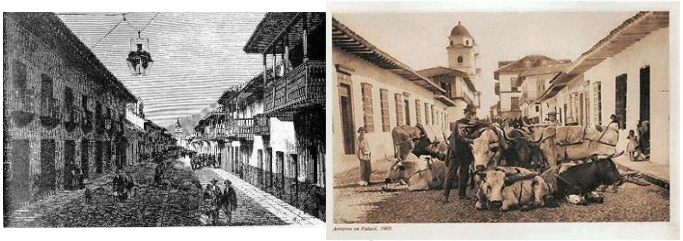


Fig. 1 Streets in Bogotá (XIX century) and Medellín, Colombia (1905) (Sources: http://upload.wikimedia.org and http://ciudaddemedell.blogspot.com)

Cities grew, spontaneously or consciously planned, around their public spaces. The structure comprised many variants of point and linear elements. Streets, boulevards, plazas of very different sizes, forms, functions, characterize the urban design of different cultures and its evolution over time.

As cities become larger and larger, means of transportation different from walking took a more important role. Horses, carriages were common in recent centuries. But their characteristics allowed for a coexistence with the pedestrian. Carriages and pedestrians shared the same space along streets and boulevards, at least until the volume of traffic reached a certain threshold. When that happened, public the urban

space began to be transformed, with an increasing separation, segregation between pedestrian and on-wheels traffic[1].

The motor vehicle, or car, was invented by the end of the 19th century. Essentially a carriage with an initially electric and then explosion engine, the car was, for a while, only a curiosity and a recreational object for wealthy people.

Fig. 2 Car parades in Medellín, Colombia (1926) and Sao Paulo, Brazil (1928) (Sources: http://smdu.prefeitura.sp.gov.br and http://www.colombia.su)

But mass production of cars was soon developed. First in the United States of America and then in Europe, industrial production became centered in car manufacturing. Most emerging economies also end up supporting economic growth on the industrial production related to car manufacturing.

And while car ownership rates in developed countries have already attained stability, this is not the case for developing economies. In them, car ownership is rapidly growing, even more with the increasing income of families in emerging economies.

2 Impact on Urban Structures and Tissues

As decisive as its economic and social effects was the impact of the motor vehicle in regional and urban structures. The enormous degree of mobility generated by the car induced a radical expansion of cities, especially in North America. A new pattern of urban structure arose: the suburbs. The old regional roads evolved into a complex structure of motorways, designed for different capacities and speeds. On top of them, cutting through the rural landscape, the highway.

Fig. 3 Streets in Rio de Janeiro, Brazil in the 1930s and in Medellín, Colombia in the 1940s (Sources: http://www.skyscrapercity.com and http://ciudaddemedell.blogspot.com)

The impact of the motor vehicle on urban tissues was evident very early. The separation of pedestrian and cars was now necessary: the pedestrian was definitely pushed aside the street, to the narrow stripes known as sidewalks. Most of the public space was then allocated to the motor vehicle flows. Priority was given to the car almost everywhere. Suddenly, cities became car-oriented.

[1] Even before the motor vehicle, conflicts arose between pedestrians and carriages in busy cities as London. A ruling by a judge in 1869 stated: “Foot-passengers have as much right to cross a street or thoroughfare as persons driving have to pass along it.” (Mr. Justice Mellor, The Times, London, 1869).

Fig. 4 Streets in USA (1930s), Canada (1949), India and China (present time) (Sources: http://www.railroad.net, http://www.throttlefmc.com, http://business.rediff.com, http://speakingppt.com)

During the fifties, with the post-war economic growth, a massive amount of cars were released onto the streets of American and European cities, and to a lesser extent, in cities of other countries. Since that time the situation has simply worsened. The car became the indisputable dominant force in the streets of cities across the globe: street space is primarily for cars. Many megacities have become dysfunctional, with unacceptable duration of trips and very high levels of pollution and CO2 emissions.

3 Planning in the Era of the Motor Vehicle

3.1 Planning Proposals

As the number of cars on urban streets was rapidly growing, the reduction of urban quality of life due to congestion on urban roads became obvious. Some authors in the 60s recognized the challenge posed by the motor vehicle in urban environments[2]. A more drastic segregation of traffic flows was proposed. The new towns built in the UK followed these principles, with separate networks for cars and for people.

Fig. 5 Stevenage New Town, UK (1960s) and Brasilia (1957) (Source: http://projectsreview2011.aaschool.ac.uk, http://odstatic.com, http://amanecemetropolis.net)

Planning of new cities, as in Brasilia, also applied the principles of traffic segregation. In this case, the functionality of the road network prevailed over other considerations. It has been said, perhaps unfairly, that Brasilia is a city for cars, not for people.

The outright segregation of vehicle and pedestrian flows has been criticized. Although it offers an answer to safety concerns, sometimes this is doing by forging a kind of pedestrian reservations [3].

[2] As Jane Jacobs [1] and Colin Buchanan. “It is impossible to spend any time on the study of the future of traffic in towns without at once being appalled by the magnitude of the emergency that is coming upon us. We are nourishing at immense cost a monster of great potential destructiveness, and yet we love him dearly.” [2]

3.2 The Urban Highway

In existing cities, the functional requirements of motor vehicle flows at the macro scale were not compatible with the urban structures and tissues. There was not enough space to put into place the enormous infrastructure needed to convey the huge traffic flows. Therefore, a new, massive, element was put onto existing urban tissues, disrupting and fracturing them: the urban highway.

Fig. 6 Evolution of urban highways
(Sources: http://www.fhwa.dot.gov, https://c1.staticflickr.com)

But then a paradox was evident. No matter how many urban highways were built, they really did not solve the problem of congestion. Expanded capacity induced new demand, rapidly clogging the expensive infrastructure. Then, public pressure called for additional lanes, bridges, intersections, or even highways, and the cycle of supply generating new demand repeated itself.

And this was not the only problem of urban highways. The sheer size of the infrastructure, the noise and pollution associated with massive traffic flows, the disruption of urban tissues, and the very low quality of mostly leftover space besides and underneath the very often elevated highways caused acute urban decay. Vast areas bordering the bridges, viaducts and intersections of urban highways fell into a vicious circle of loss of property value, degradation of buildings, criminality. Many studies have underscored the high social and economic cost of this mobility infrastructure.

3 Towards New Concepts

It is now clear that a car centered city is unsustainable, not only at the local but also at the global scale. We have already realized the impact of our fossil-fuel based societies on earth climate. As an increasingly larger proportion of the world population live in urban areas, cars are disproportionately contributing to global warming.

Therefore, we must find and implement new concepts for the way our cities function and evolve. To encourage public transportation, transit, is a clear answer. To promote alternative means of transportation for medium and short distances, like biking and walking, is also a strategy, that requires a high-density, compact city.

Mobility in a city is a very complex problem. It has many dimensions and many challenges that need to be faced. In this paper, some of the new concepts related to road infrastructure are discussed: at the micro level, the balanced and the shared space street; and, at the macro level, the removal and/or undergrounding of highways.

3.1 The Balanced Street

The balanced or complete street takes some street space and gives it back to people: pedestrians, bikers, skaters, transit users. The idea is that the car is only one of several options for urban mobility, one that disproportionately consumes space.

It also recognizes that the purpose of streets is not only to allow for the movement of people from one point to another. Streets are also, and even mainly, places of social encounter, of recreation. Designs following this concept allocate street space following the redefined set of priorities.

Fig. 7 The balanced street (Sources: http://www.smartgrowthamerica.org, http://www.bryanplace.org)

A related scheme is the Bus Rapid Transit, in which priority is given to public transportation. Accordingly, some lanes are taken from cars and are dedicated to transit systems, based on buses. It also relates to bike lane systems. Biking is encouraged along protected lanes, completely or partially separated from the motor vehicle.

Fig. 8 TransMilenio BRT and bikeways in Bogotá, Colombia (Sources: http://www.virtualtourist.com, http://es.investinbogota.org)

The balanced street redefines priorities. Streets are designed first for pedestrians and bikers, then for transit and cars come last. It is a politically sensitive idea, and it has not always been easy to implement.

3.2 The Shared Space Street

This concept challenges the notion that vehicle and pedestrian flows should be segregated. It assumes that the street space is primarily for pedestrians, they have the right-of-way. Motor vehicles have to adjust to the behavior of people on the street.

Fig. 9 The shared apace street (Source: http://bettercities.net)

As the drivers do not have a clearly defined space for them, they tend to be far more careful than when driving on the usual segregated street. Accident rates in shared space streets seem to be similar to those on segregated streets.

3.3 Removing Urban Highways

By the end of the 20th century the concept of the urban highway entered into a deep crisis. As cities tried to cope with increasing traffic building new highways, they soon found out that demand also increased, and congestion came back.

There was not enough room for new highways, therefore existing ones were progressively expanded, adding new lanes on-ground, or building a second, even a third level. The sometimes colossal infrastructure crushed traditional neighborhoods, or environmentally significant areas, as rivers. As this kind infrastructure grew older and became closer to the end of its life span, some cities started to think in its replacement by friendlier solutions [4].

One of the most widely known examples is in Seoul, Corea, where the elevated highway built on top of the Cheon-ggye-cheon river was demolished, without being replaced, and an outstanding park was then built.

Fig. 10 Seoul, Cheon-ggye-cheon river restoration (Source: Seoul, Cheon-ggye-cheon)

Other cities are proposing similar actions. In some of them, an intense public debate has taken place over this issue, underlining the importance of the car for many citizens. In other cases there has been less discussion. In 2013, Rio demolished its peripheral elevated highway, as part of the ambitious project Porto Maravilha.

3.3 Elevated Parks

Another option is not to demolish the elevated infrastructure but to reuse it as a longitudinal public space. This has been the case for decommissioned elevated railroad lines in Paris and New York. The same principle has been proposed for elevated highways, or parts of them.

Fig. 11 Elevated parks in Paris, New York, Seattle, Dallas and Bogotá
(Sources: Paris Municipality; New York, Highline Park; Asla, Seattle Olympic Sculpture Park, Dallas, Revista Semana)

An alternative is to leave on-ground road infrastructure and cover it with vast platforms that support elevated parks. Examples of this scheme are found in Seattle, Dallas and Bogotá, Colombia (Bicentenario park, in construction)

3.3 Underground Urban Highways

Other alternative is the undergrounding of urban highways. Obviously a more expensive solution, it offers appalling results. One of those projects, near the start of construction, is the covering of the A7 highway in Hamburg. But perhaps the best known of such projects is Madrid Rio, completed in 2011. It is a vast complex of public spaces that cover the undergrounded M-30 urban highway in Madrid.

Fig. 12 Hamburg A7 Highway project and Madrid Río on top of M-30 Highway
(Source: Hamburg A7 Highway project; Madrid Municipality and Burgos Garrido Architects)

Many other cities are considering the undergrounding of their urban highways. In South America there are examples in Santiago, Chile (Costanera highway), Lima, Peru (Rimac river highway) and in Cartagena, Colombia, where a one kilometer stretch of the highway between the city and the sea is being built below ground.

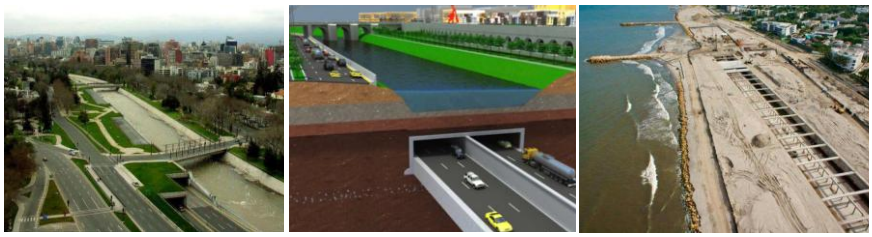


Fig. 13 Undergrounded highways in Santiago (Chile), Lima (Peru) and Cartagena (Colombia)
(Sources: Costanera project; Rimac project; Anillo Vial de Crespo project)

4 The Case of Medellín, Colombia

Medellin, the second largest city in Colombia, has been experimenting with many new options for attaining a more human-centered urban environment, particularly in relation to mobility systems and infrastructure. With 3.5 million inhabitants in an urban metropolitan area of around 230 km2, Medellín is, with 15,000 inhabitants/km^2, one of the dense cities of the world. This is due in part to the constraints of its territory, a long and narrow valley surrounded by steep hills.

This geographical setting offers both advantages and disadvantages to mobility. Its linear form, with the Medellín River as an axis, allowed for an urban highway and metro system which serve a large part of the urbanized area. However, this linear structure also creates difficulties. Most of the urban and regional traffic is channeled through a single axis. In addition, the transverse elements, running up the steep slopes, have limited capacity and technical restrictions.

These challenges have spurred creativity. A different approach to mobility and its infrastructure is taking hold, one that conciliates functionality with quality of urban life.

4.1 A Comprehensive and Flexible Public Transportation System

One objective is to develop a far more comprehensive public transportation system, one that responds to the very diverse geographic conditions of the city. Traditional components of the system, as the Metro and buses, are being articulated with BRTs (Bus Rapid Transit), tramways, cables, escalators, bike lanes.

Fig. 14 The Metro and Metrocable systems in Medellín
(Sources: http://www.colombia.travel/es, http://200.93.163.76 http://www.laciudadviva.org, Metrocable)

The axle of public transportation in the valley is the metro system, with a longitudinal line along the river, and a shorter traverse line. The fragmented urban tissues of the dense informal settlements on the hills result in very limited degree of accessibility. Therefore, a cable transportation system, until then associated with recreational purposes, was tried with success as a transit system.

Fig. 15 Metroplus Bus Rapid Transit and Ayacucho Tramway project
(Sources: http://metroamericas.com)

Conceived on the model of Curitiba (Brazil) and Bogotá (Colombia), Metroplús, the Bus Rapid Transit of Medellín, started operations in December 2011, with 12.5 km of dedicated lanes, and additional feeder lines. A tramway line, currently in construction, runs along a traditional street in Medellín and ascends the increasing slope, until it reaches a head station with projected cable lines to settlements further uphill. The project includes an urban renewal project along the line. A second tramway line has been planned for the western area of the city.

Fig. 16 Escalators on streets in hilly areas (Sources: http://www.medellin.gov.co, http://4.bp.blogspot.com)

Again, the problem of accessibility for settlements in extremely steep slopes generated a new approach, escalators on streets. Residents are now able to reach their uphill dwellings with reasonable comfort and safety conditions. The escalator system, comprising several segments, links to nearby pedestrian paths, and even to bike lanes that have been built crosswise to slope direction. Thus, the catchment area of this infrastructure for the neighborhood scale is substantially enlarged.

4.2 Medellín River Parks Project

Another long-term objective for Medellín is to reconnect its urban tissue, fragmented by the main axis of urban highways that divide the city in two halves, and its relation to the Medellin river, that flows encapsulated and isolated in between the highways.

The vast and heavy infrastructure along the banks of the river has had a very negative impact on the river fringes. As it has happened in many other cities, the functionality of urban infrastructure has been obtained at the cost of urban degradation.

Fig. 17 A degraded river, disconnected from the city by urban highways
(Source: Medellín River Parks project – SMG / Latitud architects)

The Medellin River Parks project, planned to start construction in 2015, aims to preserve the functionality of the highway system while creating a decisive axis of public space and of biotic connectivity along the valley. These seemingly conflictive goals are reconciled through a set of new urban design concepts: underground urban highways; elevated parks; green urban infrastructure, tactical urbanism.

The objective is far more ambitious. The Medellín River Parks project is at the core of a very large program of urban regeneration. The idea is to divert urbanization pressure from the surrounding hills, with low accessibility and environmentally sensitive, to the flat areas of the valley, well served with underused infrastructure.

Fig. 18 First phase of the Medellín River Parks project
(Source: Medellín River Parks project - SMG / Latitud architects)

5 Conclusions

There is a growing opinion among planners that for many cities the car should not be in the future the primary mode of personal transportation. The car is needed, many

trips for many purposes require its flexibility, comfort, and even its efficiency, at least under no congestion conditions.

However, especially when cities surpass certain population and density thresholds, the sheer size of space and infrastructure that the car requires, the seemingly unavoidable congestion that generates, its impact on quality of city life, and the amount of energy it gobbles, makes car-based transportation an unsustainable system. Global warming has underlined the urgency of finding and implementing alternatives for urban mobility. That includes a wide spectrum of policies and strategies. Many of them relate to urban infrastructure.

There are new attitudes toward the allocation of the scarce urban public space. During the 20th century, the car overran cities. First at a micro level, the street, cars displaced pedestrians. Then massive networks of urban highways were built in order to convey the enormous accumulations of vehicles, very often rupturing, isolating and degrading the contiguous urban tissues.

In the 21st century, a new set of priorities comes through. People are recuperating public spaces. Planners and urban designers are proposing, in this people focused era, new schemes at different scales, from the very simple to the very complex.

Nevertheless, the real problem, the challenge, is the transition to more sustainable urban systems in existing cities. Urban structures develop over large periods, involve huge investments, and cannot be changed at will and suddenly.
Therefore, strategic actions should be put in place, actions that while still allowing for the car-based mobility to flow, clearly signal a future with a very different relation between the city and its citizens.

References

[1] Jacobs, Jane: 'The Death and Life of Great American Cities'. New York. Random House, 1961.
[2] Buchanan, Colin: ´Traffic in Towns'. Ministry of Transport. London, UK. Penguin Books 1964.
[3] Hamilton-Baillie, Ben: 'Towards Shared Space' in Urban Design International. 2008, 13, pages 130-138
[4] ITDP - Embarq 'The Life and Death of Urban Highways'. New York: ITDP, 2012
[5] Congress for the New Urbanism: 'Charter of the New Urbanism'. Chicago, Il: CNU, 2001.
[6] Drissen, John: 'The Urban Transformation of Medellin, Colombia' in Architecture in Development, 2012 (retrieved from http://architectureindevelopment.org/news.php?id=49).
[7] The Economist: 'Medellin's Comeback: The Trouble with Miracles' in The Economist, June 7th 2014 (retrieved from 'http://www.economist.com/news/americas/21603432-transformation-colombias-second-city-will-be-hard-copy-trouble-miracles).

Double Benefit from Green Street Design: A Life-cycle Perspective

Alvaro Rodriguez-Valencia
Institute of Transportation Studies
University of California Davis
1605 Tilia Street
Davis, CA 95616, USA
Email: rod@ucdavis.edu

ABSTRACT

Transportation plays a major role in contemporary environmental problems. In the past, negative impacts resulting from transportation activities have largely been associated with vehicle operations rather than infrastructure construction and maintenance: this paper focuses on the latter. Roads dominate the urban right-of-way (ROW) and account for a substantial part of urban developed land. However, the ROW serves two more functions beyond enabling movement: the place function and the environmental function. In this paper we focus on the effects of the environmental function. We conduct an exploratory life-cycle assessment (LCA) on two hypothetical street layouts in order to compare these effects of roads and green infrastructure allocation within the ROW. The first street layout was selected based on a typical low-traffic road cross-section. The second was the result of redistributing the three uses: narrowing the roadway, inserting two wide plant strips with trees, and widening the sidewalk – assuring no substantial reduction in service for motorists. We evaluated the negative environmental impacts in terms of greenhouse gas emissions (GHG) and energy consumption over a 30-year horizon. The results indicate a 30% reduction in energy consumption and 49% reduction in GHG emissions. The source of the latter reduction comes both from road abatement and trees processing capacity. The purpose of this research is to simulate theoretical changes of street design in order to shift the practice of street design from a primarily functional and aesthetic scope to one that includes the environmental as well.

Keywords: Road abatement, three functions of the street, right-of-way allocation, street, environmental function of the street, urban forestry, low-traffic street, life-cycle, climate change mitigation.

The "Avoid-Shift-Improve" Model: A Powerful Planning Tool for Transportation Schemes with Low GHG Emissions

Juan Carlos Páez Zamora
Inter-American Development Bank
1300 New York Ave. N.W.
Stop SW 506
Washington D.C. 20577
United States of America
Email: juancarlosp@iadb.org

Abstract. This paper is intended to provide planners with a different approach to manage traffic, traffic congestion and greenhouse gases emissions in urban areas due to mobile sources, through the so-called "Avoid-Shift-Improve" or ASI model. Even though the paper explores some of the most common strategies to achieve good traffic management with minimal GHG emission, it is not by any way intended to include all the possible available solutions.

Key Words: ASI model, Transport, Avoid, Shift, Improve, Greenhouse Gases, GHG.

1 The ASI model: where to start?

For much too long, planners and transport engineers have approached traffic problems assuming that congestion could be solved by predicting future traffic growth and building new road capacity to serve that forecasted demand. This belief was based on the understanding that stop-and-go traffic, low travel speeds, and poorly-maintained roads were typically associated with greater traffic delay, higher levels of fuel use and higher levels of greenhouse gas (GHG) emissions.

This so-called *traditional* or *predict-and-provide* approach has unfortunately failed to account for induced traffic, especially in growing metropolitan areas. Indeed, time has showed that building new highways or expanding old ones do in fact boost mobility but if implemented as stand-alone initiatives, they often tend to exacerbate (rather than to solve) long-term congestion and air pollution.

As an alternative to the traditional way of traffic planning the "Avoid-Shift-Improve" or ASI model has emerged, aiming at meeting key performance goals for the transport system by balancing both supply and demand with low GHG emissions. The model is based on three principles: *avoiding* unnecessary travel activity; *shifting* travel from less efficient to more efficient modes; and *improving* the efficiency of the traffic activity.

The origin of traffic congestions and GHG emissions in a city can intuitively be blamed to the number of motor vehicles on a street or road (actually the traffic density), their travelling speeds, their year of make and the type of fuel they use.

In fact, vehicles generate GHG[1] not only when they are moving but also (in lesser quantities) when they are in idle either during the process of refuelling or while being parked (see Fig. 1). Therefore, the more vehicles are in a certain area, the more emission of GHG should be expected.

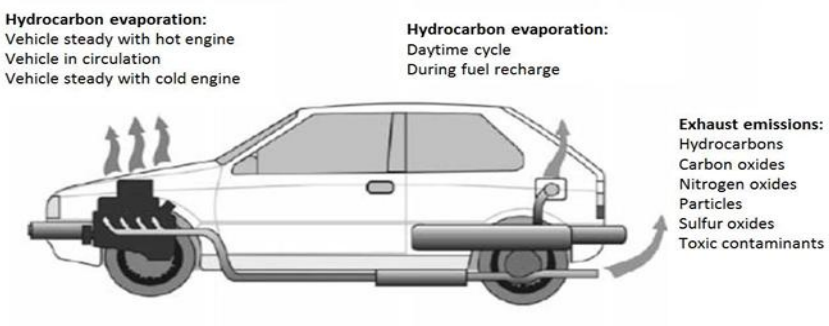


Fig. 1 Main emission sources from a vehicle (Source: INE-SEMARNAT 2005)

Along with the number of vehicles in the streets, their speeds also play a very important role. Indeed, the perception that air is cleaner in places where traffic flows than in those areas where cars are jammed is true but only up to a point. Empirical data show that there is a range of optimal speeds where the GHG emitted by fossil combustion propelled vehicles is the lowest and that traffic speeds outside this range (either greater or lesser) result in an increase of GHG production (see Fig. 2).

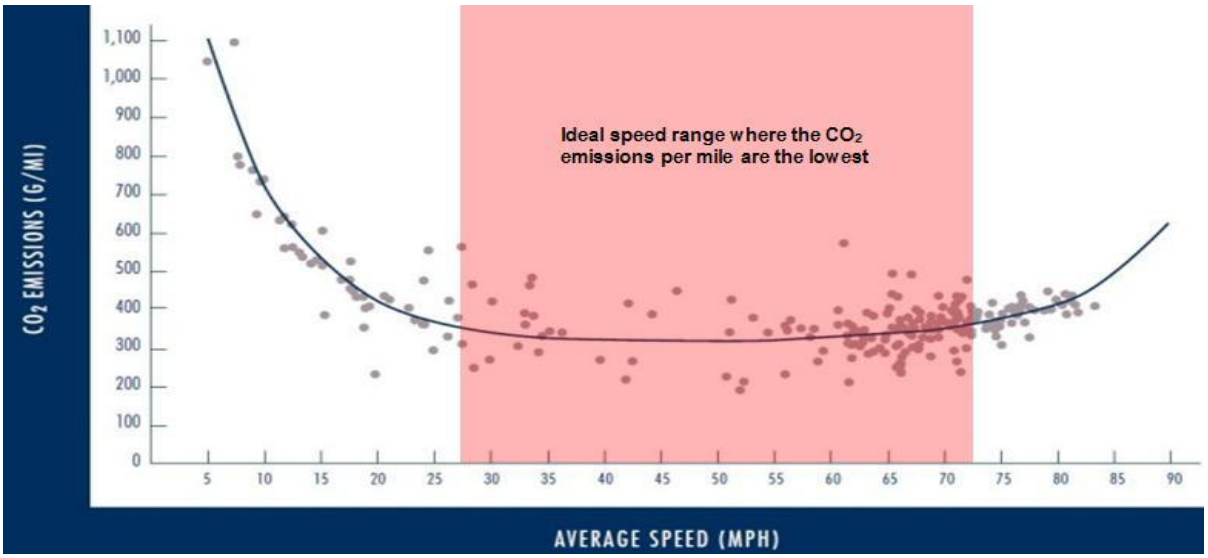


Fig. 2 CO_2 emissions and vehicle speed (Source: Barth and Boriboonsomsin University of California)

Air quality also seems to be better in cities where the automobiles are newer. As a matter of fact, experimental data also show that internal combustion engines have maintained a tendency to be more efficient and less polluting with time (see Fig. 3).

[1] CO, CO_2, NO_x, SO_4, volatile organic compounds (VOC) and other gas compounds.

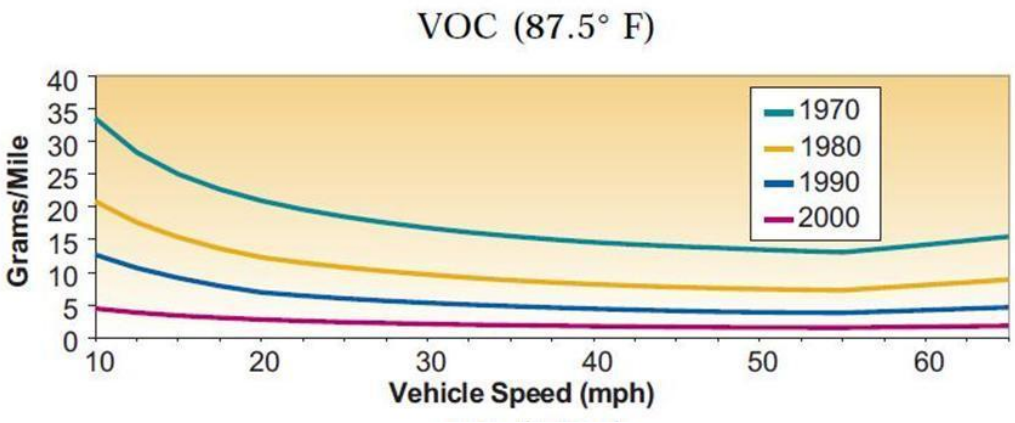


Fig. 3 Variation of Volatile Organic Compounds (VOC) emissions according to the vehicle's speed and year of make (Source: U.S. EPA, "Automobiles and Ozone." Fact Sheet OMS-4. January 1993)

Lastly, areas where vehicles use better or more environmental friendly fuels also appear to have better air quality. This perception also seems to be truth as the type of fuel used by the vehicles has a big incidence in the amount of pollutants expelled to the atmosphere (see Table 1).

Fuel / Properties	Net calorific value (MJ/kg)	Density (kg/m^3)	Energy density (MJ/l)	Carbon content (%)	Carbon emission on combustion		CO_2 emission on combustion		
					g/litre	kg/gal	g/litre	kg/gal	g/MJ
Petrol	44	730	32	87	635	2.89	2328	10.6	72.8
Diesel	42.8	830	36	86	713	3.24	2614	11.9	72.6
LPG (mainly propane)	46	510	24	82	418	1.9	1533	7	65
Bioethanol (from sugar beet)	27	789	21	52	410	1.87	1503	6.8	71.6
Bioethanol (from wheat)	27	789	21	52	410	1.87	1503	6.8	71.6
Biodiesel (from rapeseed oil)	37	880	33	77	678	3.08	2486	11.3	75.3
Biodiesel (from waste vegetable oil)	37	880	33	77	678	3.08	2486	11.3	75.3

Table1 CO_2 emissions from different types of fuels (Source: Biomass Energy Centre)

Leaving perceptions aside and focusing on empirical evidence, it can be noted that as many countries in the world develop and modernize, the number of vehicles also tends increase. The reason behind this fact could be, among others, the rising GDP per capita and, therefore, the increase in the purchase capacity of the people; the downward trend in the price of automobiles (not only private, but also public vehicles) which makes easier to buy them; more disperse urban development patterns, that require better transportation linkages; cheap or subsidized fuel, which makes more attractive the use motor vehicles; and the lack of public transportation systems that can provide a cheap, timely and good service.

As the number of vehicles increases the transport infrastructure becomes saturated making travel speeds decrease, producing traffic congestion and, thus, generating more GHG emissions. Therefore repairing, enhancing or constructing new roads and streets to cope with the crescent demand is still a valid option especially when it turns evident that the carrying capacity the existing transport infrastructure has already been exceeded. However, this solution is appears to be incomplete as most of the already collapsed infrastructure was designed precisely in this way.

The "Avoid-Shift-Improve" or ASI model emerges as an alternate planning tool that can help dealing with traffic congestions and GHG emissions, as it promotes the adoption of strategies to reduce the number of motor vehicles in the streets, bring traffic speeds to optimal levels; promote the renewal of vehicle fleets and encourage the use of transportation modes that are environmentally friendlier.

2 Avoid: The "A" part of the ASI model

Even though most of the "avoid" proposals of the ASI model might have some ingredients of the "shift" and "improve" schemes, hereafter the most common suggestions will be mentioned.

Pricing motor vehicle mobility is a good tool to avoid or reduce unnecessary trips and decrease GHG generation. It includes measures such as the management of motor fuel taxes and subsidies; the establishment of road user fees and tolls; congestion pricing; cordon pricing, and license plate restriction.

In most countries *fuel taxes* have already been adopted to generate income, part of which is often used for building or improving the transportation infrastructure. Additional taxes, besides raising that revenue, make traveling more expensive and thus can help to discourage many single-driver trips, promote the use of alternative less consuming and more efficient fuel vehicles, or make people prefer non-motorized modes of transport. Unfortunately, this strategy has a counter side: in weak or medium strength economies any increment of fuel prices may produce direct impacts[2] in the individual's in-house economy and can generate some important social pushbacks.

Road pricing, often been used to generate revenue to pay for road network investment and maintenance or other transport services, can also be used to manage traffic congestion by establishing higher tolls for peak hours that can prevent people from travelling during those times and persuade them to move in less demanding hours where the tolls are cheaper or inexistent.

Congestion pricing is a sort of road pricing scheme where toll prices fluctuate according to traffic congestion. When applied appropriately it can actually smooth traffic flow, encouraging travellers to modify their travelling patterns to less congested times of the day, or to choose other routes or travel modes. This strategy is sometimes employed in the so-called exclusive lanes[3] which normally have an electronic road pricing system that allows the road manager not only to establish the

[2] In these type of economies it is very common to find that the share of costs due to transport in the prices for goods and services is significant.

[3] Priced facilities that operate parallel to unpriced ones, giving motorists who are able and willing to pay a higher level of service in exchange for less time travel

toll fare according to the level of traffic congestion, but also to collect them electronically without disturbing the natural traffic flow (see Fig. 4).

Fig. 4: Congestion pricing: Control panel, fares display chart and in-vehicle collecting fare system (Source: Virginia Department of Transport VDOT Express Lanes System)

Congestion pricing has unfortunately a downside: it may increase GHG emissions when the priced facility adds new capacity to the network and produces induced demand; or when the adoption of the strategy increases the traffic speed to values outside the ideal speed range.

Cordon pricing is a form of congestion charging that discourages the use of vehicles in a given area by imposing a fee to enter it (or to drive through), often at the perimeter of a city centre.

License plate restrictions, sometimes called “peak and plate” is a strategy conceived to reduce the number of automobiles on the streets by prohibiting the free circulation during periods of time (usually peak hours or even days of the week) of certain vehicles whose license plates meet some particular requirements (e.g. plate ending in certain numbers). In order to be implemented effectively, this measure normally calls for a very strong on-street traffic control, as well as a very sound public information campaign to alert travellers when, where and how the strategy is to be implemented.

Commuter travel reduction policies are a group of strategies conceived to reduce vehicle travelling by offering people incentives and options for commuting by different modes. They include measures such as alternative work schedules, flexible time schedules, compressed work weeks, and telework; rideshare matching and incentives; and monetary incentives for alternative mode use.

Alternative work schedules, flexible time schedules, compressed work weeks, and telework are alternatives that can be used to allow people either to adjust their journeys to more convenient travelling hours or simply to refrain themselves from going to their offices and to work from home instead. *Rideshare matching and incentives* aim at optimizing the travelling trips by stimulating people to travel together. *Monetary incentives* for alternative mode use, is also a way to motivate people to use more ecological friendly types of transportation.

3 SHIFT: The “S” part of the ASI model

The “shift” part of the ASI model is intended to persuade people to prefer non-motorized or more efficient travelling modes to motorized ones, and by this means prevent the generation of GHG. Building or improving the pedestrian infrastructure, traffic calming and building or improving bicycle infrastructure, networks and support

programs are examples of efficient solutions used to encourage the shift part of the ASI model.

Having in mind that all trips, even those motorized, begin and end with walking, **building or improving pedestrian infrastructure**[4] can motivate people to walk or ride instead of driving, especially short distances. However, many cities in developing countries this kind of infrastructure either inexistent or in poor shape, making uncomfortable or dangerous to walk, forcing them to use motorized transportation modes instead.

When the resulting traffic speeds can be guaranteed to fall within the range where the GHG emissions are the lowest, **traffic calming** can also be a good option. It can be achieved by implementing certain street design features[5] to promote lower vehicle speeds and volumes. This measure also decreases the chances of people who walk or bike to get hit by the traffic and encourages them to continue using these non-motorized forms of transport.

Where topographical, climate and road capacity conditions are adequate, the **construction or improvement of biking facilities**[6] is an excellent alternative to promote the use of this kind of non-motorized traffic solutions. However, for these initiatives to be successful, other improvements such as overall citizen safety conditions, secure parking facilities for bicycles, showers and lockers at workplaces, information on cycling routes and safe cycling practices and, especially, enforcement of traffic laws for both motorists and cyclists, should also be adopted.

Land use strategies are another group of possible solutions within the "shift" framework of the ASI model, since they discourage the use of the automobile as the main source of transportation by reducing trip lengths and making walking, bicycling, or using the public transit system easier or more comfortable. They include, among others, the adoption of planning codes and practices, transit-oriented development (TOD), and car free zones and activities.

Urban *planning codes and practices* can be used to ensure that new developments patterns do not make people dependent on the use of the automobile. Indeed, when planning at a regional level, job and housing areas have to be brought together as close as possible to ensure shorter trips, reduce energy consumption per (motorized) trip and make transit and non-motorized modes more viable.

Planning at the site or subarea level should consider minimal building setbacks, short blocks, and "active" street-fronting (instead of blank walls) to produce a more pedestrian-friendly environment; as well as higher development density and mixed-use zoning where housing and commercial developments coexist and reduce average trip distances between residential areas and job centres.

The design of the public and private street space, including roads and sidewalks[7], has an important impact on travel choices because it affects the safety and comfort of pedestrians, bicyclists, and transit riders. Overly wide streets lacking central medians, for example, make streets hard to cross and often squeeze out space for

[4] Sidewalks, pedestrian crossings at intersections or facilities for disabled people or for strollers.
[5] Such as Speed bumps
[6] Bike paths and trails, cycle tracks, bike lanes, bike routes, and other types of roadway sharing.
[7] Often called the public realm.

sidewalks or cycle paths. “Skinny streets” are more conducive to traffic calming but usually provide very little space for pedestrians and almost none for bikes. “Complete street” design can serve pedestrians, cyclists, public transport vehicles, and private cars.

Transit-oriented development or TOD is a planning approach that pursues compact development of urban areas where high-densities and mixed-use schemes that are located within short walk distances (between 0.4 and 0.8 kilometres) from each other or from major public transit stations. However, when using the TOD approach it has to be kept in mind that the dominant mode of transport present at the time of urbanization of an area has a very strong influence on its long-term transport dependence. In fact, when an area has developed around the automobile, it becomes very difficult to provide walkable and public transport friendly environments. In contrast, when it emerged around public transport with greater reliance on walking and cycling, it becomes easier to sustain those models of travel.

Car free zones or “pedestrian only” areas are planning options often used to literally pull out vehicles of the streets by prohibiting their use in specific areas. In addition to car-free zones, *car free events*, which promote physical activity for recreational purposes in spaces and main transportation arteries on some specific dates or days of the week, can also be a way to partially remove automobiles form the streets. While car free zones can dramatically reduce the concentration of GHG in the area where it has been adopted, car free events provide a modest GHG emissions reduction benefit as the measure is not constant in time.

Parking is an extremely important link between transportation and land use as cars remain most of their time parked[8]. **Parking management** lead not only to a more efficient use of public space but also can serve as a means to persuade people to refrain using their own vehicles or to use alternative modes of transportation. They include, among others, parking pricing, managing the supply of on-street parking and setting parking requirements for buildings and other land uses.

Parking pricing, which refers to setting the right price for parking to achieve the most efficient transportation network, can discourage people to use their private cars to travel to places where parking fares are considered expensive and, thus, induce them to the use of public transportation which is often less expensive.

Managing the supply of on-street parking can also be used to improve efficiency of the transportation network by setting the number of on-street parking spaces that maximize the effectiveness of the network and establishing the areas and hours where on-street parking needs to be restricted or prohibited. This measure can dramatically increase the carrying capacity of streets and improve traffic speeds.

Setting parking requirements for buildings and other land uses in order to reduce the number of parking spaces available can also motivate people to refrain from buying more cars and hence to use the public system or other ways of non-motorized transportation mode.

[8] Sometimes up to 95% of their time,

4 Improve: The “I” part of the ASI model

The “I” part of the ASI model supports the modification of the traffic and GHG emissions conditions by improving the overall transport setting through the adoption of schemes that include, among others, operational improvements, fare system improvements, integrated bus rapid transit (BRT) corridors and metro rail transport (MRT).

Operational improvements are a group of strategies conceived to improve the overall existing transportation settings by replacing the obsolete transportation fleet (both public and private), improving in-city transportation infrastructure and enhancing the public transportation system.

In fact, one of the reasons why people tend to use their own private vehicles is usually because the exiting public transportation system is obsolete, unreliable, dangerous, too expensive or uncomfortable, or all of these issues combined.

The deteriorated conditions of a great share of the public transport units, found in many cities of developing countries, are primarily the cause for poor service efficiency, long travel times and unreliable time schedules. Consequently, when pursuing better travelling conditions the *replacement of old, obsolete and dangerous units* should be a starting point. Unfortunately this is not always a simple task since public transportation in these cities is often provided by owners-operators of small deteriorated units who are usually grouped in very powerful and reluctant-to-change unions or associations. Moreover, this measure touches directly their pockets and can generate serious pushbacks to the replacement schemes.

Vehicle retirement programs (implemented by regulation or incentives) are also initiatives that encourage automotive owners to invest in the renovation of their units. When implemented in a bus-based public transportation system, these programs can provide cleaner and more efficient vehicles as older buses are typically heavier, less aerodynamic and consume higher amounts of fuel. Furthermore, newer buses can also be more efficient by carrying more passengers per vehicle and can be available with hybrid, electric or any other kind of environmental friendly propulsion systems that can further reduce the fuel consumption and related GHG emissions.

The geometrical layout of the city can also be blamed for generating bottlenecks that refrain traffic to flow easily and, therefore, *improvements in the in-city transportation infrastructure* may also be needed to eliminate those conflict points. These improvements can be achieved by adopting simple solutions such as including green light priority for buses, converting shared road space to dedicated bus lanes, eliminating roundabouts, redirecting the traffic flow direction or enlarging the radius of curvature of the corners at some intersections.

The *enhancement of the public transportation system* is usually a more complex activity that normally requires planners to evaluate how the system has been working and to conceive way it should be working in the future. This activity calls for a number on analyses to determine, among other issues, the routes, schedules and frequencies of buses and other types of public transportation units according to the demand; the size and type of the public units; and the location of the stops and transfer stations.

The way how transit fares are set and thereafter administrated in a transportation system also plays an active role in how traffic behaves in a city. **Transit fare system improvements** can reduce GHG emissions by increasing the willingness of people to use the public transportation. It can also produce a modification on peoples' travel behaviour by affecting not only by how much they pay, but also by how and how often they do.

Fare integration, that simplifies the payment process by using a common form of payment among the different public transit operators in a city, and *pre-paid instruments*, which help people optimize their time by avoiding them to constantly have to pay an individual fare each time they use one of the components of the transport system, also are very good options to attract potential users to the public transport system. Pre-paid fares even have a secondary psychological effect: customers often do not think so much about the cost when using fare cards.

When changes in the fare levels (or in the way fares are set or administrated) result in either the increase of the average travel speed, a better schedule adherence, the reduction in travelling times or improvements in the reliability of the service, the transportation system tends to be more attractive to its potential users and therefore it is more likely that it would be preferred to individual travelling solutions. However, if the fare establishment or administration results in the opposite, the tendency will surely be to increase the number of private vehicles in the streets as people will definitely prefer to use their own transportation means instead of the public solutions.

Public transport system integration, where a costumer can use several public transportation modes in selected corridors by paying only one fare, appears to be an excellent solution to improve public transportation schemes in big cities, as it usually leads to changes in average traffic speeds, congestion, and delays, as well as to make public transport more attractive.

Integrated bus rapid transit (BRT), a bus-based public transport system[9] (similar to rail but more flexible and with lower capital and operation costs) that delivers fast, comfortable and low-cost urban mobility through the implementation of segregated bus lanes to maximize system efficiency, can also improve dramatically the way public transportation behaves in a city, as it encourages the elimination of excess supply of old inefficient buses, increases bus and mixed traffic average speeds, fosters changes in mode shares, helps to produce changes in fleet composition, vehicle load factors, and, in the long run, changes the trip distribution and land use patterns.

Light rail transit (LRT), metro rail transit (MRT), and commuter rail services (CRS) can also boost the efficiency of a public transportation system by making more attractive the public system through the provision of better services, rapid and secure transportation, and predefined schedules. Unfortunately, these solutions are usually very expensive, often represent important engineering challenges and usually are not always considered viable solutions in some contexts. In addition to the financial, economic and environmental requirements they need to meet, they also require a high and steady demand.

[9] A BTR usually also provides preboarding fare collection, platform-level boarding, fast and frequent operations, and good marketing and customer service.

Once in operation, the GHG savings from rail transportation come from shifting travel from buses and cars into a less carbon intensive transportation mode. The success of this system depends in part on the source of electricity for rail propulsion and on what happens to street space that may become less intensively crowded due to new rail services. However, the construction of rail transportation often has a big GHG footprint which may take several years to offset. Notwithstanding, in the long run, rail investments can prompt significant transit-oriented development that can further reduce GHG emissions.

References

[1] Barth, M.J, and Boriboonsomsin, K. 2008. Real/world carbon dioxide impacts of traffic congestion, Trasportation Research Record, 2058, 163.171.

[2] Hook W. and Wright L. 2007. Bus Rapid Transit Planning Guide. New York> Institute for Transportation and Development Policy. www.itdp.org/microsites/bus-rapid-transit-planning-guide

[3] INE-SEMARNAT 2005. Gases de Efecto Invernadero Generados por Fuentes Móviles. www.semarnat.gob.mx

[4] Inter-American Development Bank. 2013. Mitigation Strategies and Accounting Methods for Greenhouse Gas Emissions form Transportation.

[5] Inter-American Development Bank. 2013. Parking and travel Demand management Policies in Latin America.

[6] Pucher, j. and Buehler, r. 2009. Integrating Bicycling and Public Transport in North America. Journal of Public Transportation. 12.3: 26.

[7] U.S. Environmental Protection Agency. 1193. Automobiles and Ozone. Fact Sheet OMS-4. January 1993.

[8] U.S. Environmental Protection Agency. 2006. Greenhouse Gas Emissions form the US Transportation Sector 1990-2033. Office of Transportation and Air Quality. EPA 420 R 06 003, March 2006.

[9] Virginia Department of Transport VDOT. E-Zpass. www.ezpassva.com

[10] World Resources Institute. 2013 EMBARQ. Saving Lives with Sustainable Transport.