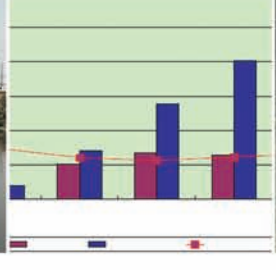
Karachi City Climate Change

Adaptation Strategy

A Roadmap

Farhan Anwar



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About the Author

Farhan Anwar did his Bachelors in Civil Engineering and Masters in Urban and Regional Planning and operates as an urban planning and environmental management consultant. He specializes in strategic planning for sector and institutional reforms and change management. His portfolio includes urban sustainability planning and managing participatory planning processes, stakeholder dialogue and consensus building using various participatory planning and social accountability tools - E.g. Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), Political Economy Analysis, Problem Tree/Logical Framework Analysis (LFA), Citizen Report Card (CRC), and Community Score Card (CSC). He has extended consulting services to the World Bank, Asian Development Bank (ADB), the Japanese International Corporation Agency (JICA), the World Conservation Union (IUCN), WWF Pakistan and several prominent Pakistani consulting firms. He presently also serves as a Visiting Faculty at the Department of Architecture and Planning, NED University of Engineering and Technology, Karachi where he teaches a Masters Course on Planning for Sustainable Development. He has structured and conducted a number of training workshops and brainstorming sessions to review and assess government policies, plans and projects as they relate to the development sector. He has a number of publications to his credit and contributes regularly to leading English language publications in Pakistan on urban planning, environment, and development issues.

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Climate change: Images of a city at risk

Contents

Foreword

The issue of climate change finds relevance to Karachi in that the rapid shifts in weather patterns and resulting adverse impacts on the physical and natural environment have a lot to do with human actions that are detrimental to safeguarding natures balance. In Karachi, we find that a lot is happening that is seriously damaging the urban environment. Land and water based ecosystems are being destroyed; air is being polluted and natural resources being mismanaged. *Shehri-CBE* has over the years focused its work on trying to document and prevent violation of land use that we feel is one of the fundamental urban development challenges facing the city having numerous direct and indirect consequences that are seriously constraining the capacity of the city to meet possible damaging climate change impacts. As green spaces are being encroached and coastal land is reclaimed to facilitate development that will cause irreparable damage to precious coastal ecology we are destroying natural defences that can protect us from climate change impacts. Ill planned densification of core city areas is resulting in creating as yet non-quantifiable social and environmental stresses. Uncontrolled urban sprawl is putting the already over stretched civic services to near breakdown status. What is more disturbing is that existing laws are being amended and new legislation is being enacted to facilitate the process of environmental damage just to benefit the short term financial interests of a few at the cost of the majority citizens.

This unfortunate state of affairs brings into focus the whole issue of bad governance that is at the core of all various unfolding social, political, environmental and financial crisis that the city is faced with. The institutions of state both legislative and executive relevant to the city are lacking both the willingness and capacity to meet these challenges and are often found either turning a blind eye or becoming part of the process of violation of rules and regulations meant to safeguard the city's interest. On a priority there is a need to make these institutions such as the city government, civic services agencies, land control and law and order agencies accountable to the public and capable of delivering effectively upon their mandate. In this regard, *Shehri-CBE* is spearheading efforts to improve access of citizens to information and through sustained advocacy influencing decision making processes so that public interest is protected. *Shehri-CBE* is also documenting important land related information such as the status of open spaces in Karachi, cases of land use violations, land grabs and land use conversions such as the ill planned policy measure of commercialization of traffic corridors or efforts to create high density zones without any planning provisions for environmental protection or viable service provision. At the same time *Shehri-CBE* strives to build capacity in public service institutions and promote meaningful civil society and service provider interaction to improve social accountability.

Shehri-CBE appreciates the continuing support of the *Friedrich Naumann Stiftung* in our efforts to improve governance, promote tolerance, strengthen the political role of the citizens and protect the physical and natural environment in Karachi and Pakistan. In this regard, this initiative of outlining a road map for developing a climate change adaptation strategy for Karachi, will certainly result in identifying areas for governance and service delivery reforms and strengthen informed advocacy efforts of the civil society to ensure good governance and quality living.

Amber Alibhai
General Secretary, Shehri-Citizens for a Better Environment

Foreword

In the recently published *Global Report on Human Settlements of 2011* by *United Nations,* the impacts of climate change on the cities across the world are discussed. Warmer and more frequent hot days, fewer cold days, recurring hot waves, rise in heavy precipitation, increase in drought occurrence, escalation of cyclone activity and upsurge in sea levels are common factors experienced by settlements in many regions. The impacts are felt by cities in varied frequency and time spans. But the key point of common concern – which is also emphasized by *UN Secretary General Ban Ki-moon* - is the accelerated vulnerability of poor and down trodden across the globe. In a well researched note, the *Report* refers the marginalized communities at the highest of risk level due to several reasons. Residence in potentially hazardous locations, inappropriate connection with physical infrastructure, lack of awareness and information (about impending disasters), potential loss of assets and livelihoods and inability to cope with disasters as well as concurrent losses are some factors that make the poor in developing countries prone to maximum destruction. Pakistan is no exception in this respect.

Due to an uncontrolled and sprawling fashion of urbanization in Pakistan, the precious natural resources have depleted fast. Whether the mangrove covers around Karachi and environs or the precious farmlands around the green terrains of Lahore, expanding residential and quasi-commercial developments continue unabated. Now the conflict of interest between pro-nature and anti-nature groups is so visible that it directly threatens the peace in cities. On 5th May, two activists who lobbied to safeguard the marine eco-system to conserve livelihoods of fisher folk were allegedly killed by their adversaries. Not long ago, activist *Nisar Baloch* was assassinated when he was campaigning to safeguard *Gutter Baghicha* in Karachi. It may be understood that the unplanned urbanization, depletion of natural environmental assets and unchecked fiddling with marine assets are recipes for a collective suicide! Haywire selection of development projects is also a cause for environmental degradation. Large scale energy intensive residential schemes along the main highways in Karachi, Lahore and other cities shall over burden the already fragile infrastructure and supporting environment. Deforestation, loss of farming foot print, pressure on drinking water sources, water logging and salinity are some of the serious issues that are likely to be further compounded in the regime of climate change.

The *Report* offers a rich repository of lessons and examples to benefit from. US and UK have begun retrofitting residential and other buildings to limit the emissions of green house gases (GHG). City of Los Angeles has decided to phase out coal based electricity generation plants and replace them with renewable energy works. Despite severe space constraints, Singapore has been implementing an ambitious garden plan that includes developing green connections, green roofing, conserving natural heritage and increasing park areas. Beijing has embarked to replace normal lights with energy efficient light bulbs in schools, streets, public spaces and terminal spaces.

The sooner we rise to the gravity of situation, the better it shall be for our people and cities. It is quite unfortunate to notice that the National Climate Change Policy has ignored the importance of cities in this respect. The government will do well by reviewing this serious flaw which can cause implications when the policy will be aligned with implementation.

Dr. Noman Ahmed
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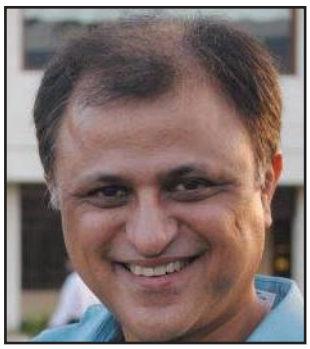
NED University of Engineering & Technology, Karachi

Acknowledgement



The preparation of the *Roadmap* has been a challenging and rewarding experience. Challenges faced were many. It was a short duration *Study*, completed by a small, yet committed team comprising of experienced professionals, fresh graduates and student interns. As climate change and its cross cutting themes, particularly within an urban context encompass a wide and diversified canvass, the need to prioritize objectives and scope of the Study was imperative and proved as the first major challenge. It was decided to profile the city within the context of preparing a *climate change adaptation strategy.* The *profile* thus prepared can be termed as a *Roadmap* to developing a comprehensive *Climate Change Adaptation Strategy for Karachi City.* The approach adopted involved looking into identifying some critical *vulnerabilities,* the city may be exposed to in the event of climate change. These *vulnerabilities* were then placed within the context of the possible consequences of climate change on key physical and natural environment and resources along with development and governance *processes* and *activities*. Recommendations have then been made to improve the *adaptive capacity* of the city.

I am thankful to *Shehri-Citizens* for a Better Environment and *Friedrich Naumann Stiftung* for providing me with the opportunity to be a part of this process. I am greatly privileged to have led a wonderful team of professionals engaging and working with whom has been an educative and stimulating experience. Sameer Hamid Dodhy, Amber Alibhai and Roland de'souza at *Shehri-CBE* and Muhammad Anwar at *FNSt* were a constant source of encouragement and guidance. Dr. Noman Ahmed at the *NED Engineering University* has for long served as an amazing resource and asset for the city – educating the future planners and always accessible with his keen insight on critical urban planning and development issues. The field team of fresh architectural graduates of *NED Engineering University* – Madiha Salam, Hira Salman and Ali Asghar Babat worked long hours with great commitment and enthusiasm, overcoming frustrations in accessing viable data, organizing efficiently what could be gathered and assisting with great competence in coordinating and documenting meetings and stakeholder discussions. In the finalization and compilation of this document, I am greatly indebted to the contributions of Mustafa Bhutto and Maryam Hamid Shafiq, project interns from the Institute of *Business Administration (IBA), Karachi.* Their patience, innovation and skill in meticulously working with and organizing countless graphics, illustrations, photographs and textual input proved of great value.

The *Study* gained a lot of credibility as a result of valued advice and assistance provided by the following individuals – Ayub Shaikh, KW&SB, Dr. Jamil Kazmi, Karachi University, Dr. Sarosh Lodhi, Dr.Mir Shabbar Ali, Dr. Muhammad Adnan and Dr.Atif Mustafa, NED Engineering University, Dr.A.R.Tabriz, NIO, Khadija Zaheer, Zeevar Scheik, IUCN, Naomi Alesworth Siddiqui and Dr. Babar Hussain, WWF and Dr. Badar Ghauri, Dr. Arjumand Zaidi and Dr.Muneeza Ali, Institute of Space Technology and Rozina Karmaliani, AKU.

In the end, it is hoped that this document can succeed in stimulating debate and consultation on this important subject of national sustainability and leads to the initiation of a process of evolving strategies and actions for climate change adaptation in urban Pakistan.

Farhan Anwar
Urban Planner, Project Team Lead
April, 2012

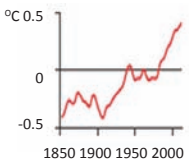
Introduction

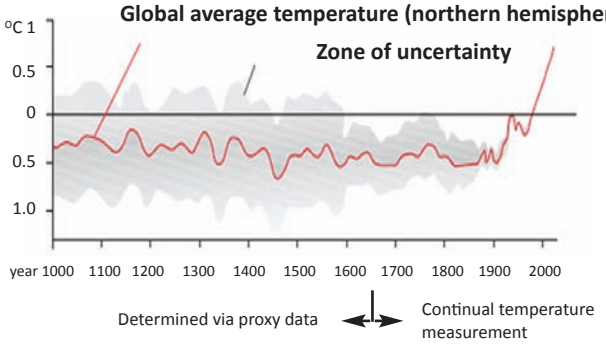
While there is still debate and conflicting views about the level of accuracy of the various projections and scenarios related with climate change, and the measures that need to be prioritized now for tackling possible impacts and consequences in the future, there is nevertheless a growing consensus that the global climate is changing. The world is becoming warmer and extreme weather conditions such as tropical cyclones, strong rain with flooding or long dry periods have increased in the past years . Within this context, a critical understanding is that it is the human influence that is largely responsible for these rapid shifts in weather patterns that are quite possibly pushing the earth's climate beyond a tipping point where certain adverse impacts and consequences may become irreversible. This alarming realization is now lending a sense of global urgency for devising appropriate systems, processes and methodologies to meet this challenge.

Fig. 1

The Temperature is 'Rising'

Deviations of the average global temperature of the earth.
Relative to the average temperature of the climatic period 1961 -1990 (equals zero)





Source: *simplified according to IPCC (2001/7007)*
(Source: *IPCC, 2007)*

Trace gases such as water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (laughing gas N_2O), and ozone (O_3) though only show up in very slight amounts in the earth's atmosphere, have a substantial impact on climate: all have the similar effect as *glass windows* do in a *green house.* They allow sun ray of shorter wavelengths to pass, while filtering longer wave lengths of radiant energy by partially hanging the sun rays after reaching the surface. These *gases* are therefore known as *green house gases.* They are responsible for the *natural green house effect* that keeps the earth's average temperature at about 15 °C – without them about -18 °C. The natural green house effect is what makes life on earth possible.[1] However, human activities such as the combustion of fossil fuels, industrial pollution, land use changes and deforestation, among others, have enhanced significantly the concentrations of GHGs in the atmosphere together with a reduction of the capacity of oceans and vegetation to absorb GHGs. This is referred to as an *additional or man-made green house effect* . With regard to this, carbon dioxide plays a key role. Its participation in the man-made greenhouse effect is placed at approximately 60 % with about three quarters of the man-made increase in CO_2 resulting from the burning of fossil fuels .

CITIES AND CLIMATE CHANGE

The strong link between climate change and urbanization is nothing new but the immensity of the challenge is now becoming more evident. If a single historical event can be identified for having the most significant impact in altering dramatically the ecological balance in the world than it has to be the onset of the age of *industrialization*. Since the onset of the industrial era,

[1] Information on the Topic of "Climate": Fundamentals, History and Projections (2005 ,Allianz Foundation for Sustainabiliy)

Fig. 2

The 'Additional Greenhouse Effect'

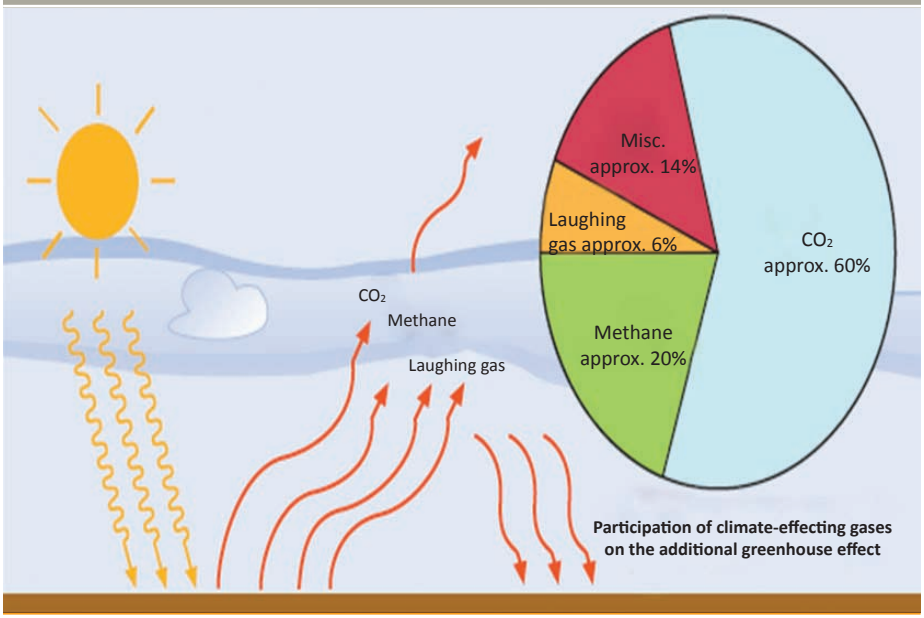
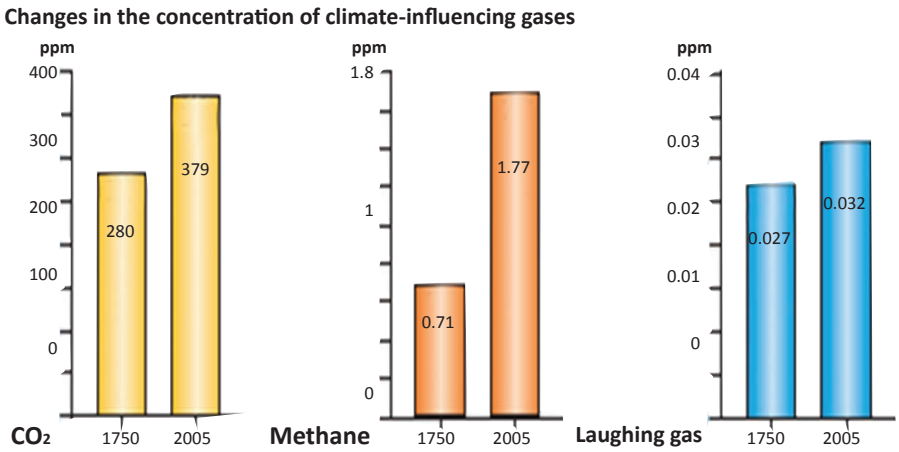


Fig. 3

The 'Contributors'



Source: According to IPCC (2007)

concentrations of CO_2 and methane (CH_4) have increased, with an increase of 70 per cent during the 1970 to 2004 period, and urban centers have played a key – though not yet fully understood – role in this process.[2]

Urban areas occupy only 2.8% of the earth's surface yet as of 2008 more than 50% of the world's population inhabits urban areas. Rapid urbanization is occurring largely in developing countries where a massive demographic shift has enormous implications in terms of poverty, natural resources and the environment. According to UN-HABITAT's recently published *Cities and Climate Change: Global Report on Human Settlements (2011)* 'the proportion of human-induced (or anthropogenic) greenhouse gas (GHG) emissions resulting from cities could be between 40 and 70 per cent, using production-based figures (i.e. figures calculated by adding up GHG emissions from entities located within cities). This is in comparison with as high as 60 to 70 per cent if a *consumption-based* method is used (i.e. figures calculated by adding up GHG emissions resulting from the production of all goods consumed by urban residents, irrespective of the geographic location of the production). The main sources of GHG emissions from urban areas are related to the consumption of fossil fuels. They include energy supply for electricity generation (mainly from coal, gas and oil); transportation; energy use in commercial and residential buildings for lighting, cooking, space heating, and cooling; industrial production; and waste'.

[2] Global Report on Human Settlements 2011,United Nations Human Settlements Programme

The pace of urbanization in the world today is unprecedented, with a near quintupling of the urban population between 1950 and 2011.[3] While these figures may be alarming enough what is a cause of greater concern is the fact that most of the growth in urban population is centered in the developing and least developed countries that are least equipped to adapt to the possible consequences. The developing countries now host nearly three-quarters of the world's urban population and more than 90 per cent of the world's urban population growth is currently taking place in developing countries.[4] The rising mega cities of the world are thus mostly those that have high concentrations of growth centered in informal settlements and slums and often have profound deficits in governance, infrastructure, and economic and social equity .

The global response to the climate challenge is presently being geared towards developing and implementing *mitigation* and *adaptation* strategies. Mitigation within the context of climate change refers to the reduction of *greenhouse* gas (GHG) emissions and their capture and storage. As such, urban settlements and those too mostly in the developed world are the focus of mitigation strategy development and implementation. Drawing on

Table 1

Cities' Contribution to Global Anthropogenic GHG Emissions, by Sector

Sector	Percentage of global GHG emissions	Justification for estimating the proportion of GHGs from cities, from the perspective of the location of activities that produced them	Percentage of GHGs allocated to cities
Energy supply[a]	25.9	A high proportion of fossil fuel power stations are not in cities, especially the largest cities. One third to one half of emissions from city-based power stations.	8.6-13.0
Industry	19.4	A large proportion of heavy industry (which accounts for most GHGs from industry) is not located in cities, including many cement factories, oil refinehes. pulp and paper mills, metal smelters. Two-fifths to three-fifths of emissions in cities.	7.811.6
Forestry[b]	17.4	No emissions assigned to cities	0
Agriculture	13.5	Some large cities have considerable agricultural output, but mostly because of extended boundaries encompassing rural areas. No emissions assigned to cities.	0
Transport	13.1	Private use of motor vehicles a large part of this. Should commuting by car by those living outside cities be assigned to cities? Should city dwellers driving outside city boundaries be assigned to their city? 60 to 70 per cent of emissions assigned to cities.	7.9-9.2
Residential and commercial buildings	7.9	Large sections of middle- and high-income groups in developed countries live outside cities - and a significant and increasing proportion of commercial buildings are located outside cities.60 to 70 per cent of emissions assigned to cities.	4.7-5.5
Waste and wastewater	2.8	More than half of this is landfill methane; but a proportion of this would be released outside urban boundaries from waste generated inside cities. 54 per cent of emissions assigned to cities.	1.5
Total[c]	**100**		**30.5-40.8**

***(Source:** Global report on human settlements 2011,UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME)*

Notes; a A large pan of this is from fossil fuel power staoons. Excludes refineries, coke ovens, etc., which are included under industry.
b Land use and land-use changes.
c Total emissions for the GHGs covered by the Kyoto Protocol amounts to 49 billion tonnes of C02eq.
Sources: based on Barker« al. 2007: Saaerthwajte. 2008a. pS44

[3] United Nations, 2010
[4] United Nations, 2010

Table 2

Urban Population Projections by Regions (2010-30)

Region	Urban population (millions)			Proportion of total population living in urban areas (%)			Urban population rate of change (% change per year)	
	2010	2020	2030	2010	2020	2030	2010-2020	2020-2030
World total	3486	4176	4900	50.5	54.4	59.0	1.81	1.60
Developed countries	930	988	1037	75.2	77.9	80.9	0.61	0.48
North America	289	324	355	82.1	84.6	86.7	1.16	0.92
Europe	533	552	567	72.8	75.4	78.4	0.35	0.27
Other developed countries	108	111	114	70.5	73.3	76.8	0.33	0.20
Developing countries	2556	3188	3863	45.1	49.8	55.0	2.21	1.92
Africa	413	569	761	40.0	44.6	49.9	3.21	2.91
Sub-Saharan Africa	321	457	627	37.2	42.2	47.9	3.51	3.17
Rest of Africa								
Asia/Pacific	92	113	135	54.0	57.6	62.2	2.06	1.79
China	1675	2086	2517	41.4	46.5	52.3	2.20	1.88
India	636	787	905	47.0	55.0	61.9	2.13	1.41
Rest of	364	463	590	30.0	33.9	39.7	2.40	2.42
Asia/Pacific	674	836	1021	45.5	49.6	54.7	2.14	2.00
Latin America and the Caribbean	469	533	585	79.6	82.6	84.9	1.29	0.94
Least developed countries	249	366	520	29.2	34.5	40.8	3.84	3.50
Other developing countries	2307	2822	3344	47.9	52.8	58.1	2.01	1.70

Source: *UN.2QIQ;see also Statistical Annex. Tables A.1,A.2,A.3,B.1,B.2,B.3*

the definitions of the *Intergovernmental Panel on Climate Change (IPCC), adaptation* to (human-induced, or 'anthropogenic') climate change is understood to include all actions to reduce the *vulnerability* of a system (e.g. a city), population group (e.g. a vulnerable population in a city) or an individual or household to the adverse impacts of anticipated climate change. Mitigation and adaptation though are processes that need not be considered contradictory to each other - rather they complement each other in that focusing on one also strengthens the capacity indirectly of the other .

The outcome of successful adaptation is *resilience* – and is a product of governments, enterprises, civil society organizations, households and individuals with strong adaptive capacity. For cities or particular urban neighborhoods, it indicates a capacity to maintain core functions in the face of hazard threats and impacts, especially for vulnerable populations. It usually requires a capacity to anticipate climate change and plan needed adaptations. The resilience of any popula-

tion group to climate change interacts with its resilience to other dynamic pressures, including economic change, conflict and violence.[5]

While Pakistan is vulnerable to adverse impacts of climate change, its own contribution to the total global GHG emissions is limited (about 0.8%) and its per capita GHG emissions correspond to about one-fifth of the average for Western Europe (IEA/OECD 2006). Pakistan was thus ranked at 135th place on the basis of its per capita GHG emissions without land use change and at 149th place when land use change was also taken into consideration (US-DOE 2009).[6] As such, the main thrust of the country's response to climate change is bound to be on adaptation measures.

PAKISTAN – URBANIZATION AND CLIMATE CHANGE ADAPTATION

In Pakistan, demographic trends show that the country's population has been rapidly urbanizing, with an average annual rate of urbanization exceeding 4 per cent since 1951. It is estimated that by the year 2030, Pakistan will be predominantly urban with 45.6 per cent of its population living in urban areas and about 12 cities housing more than one million people. The urban population recorded during the 1998 Census was nearly 43 million and is currently (2010) estimated at 63.1 million. The urban population is estimated to surpass 121 million by the year 2030. The level of urbanization of 45.6 percent would then be the highest amongst the South East Asian countries.[7]

Fig. 4

Tackling the Climate Change Challenge

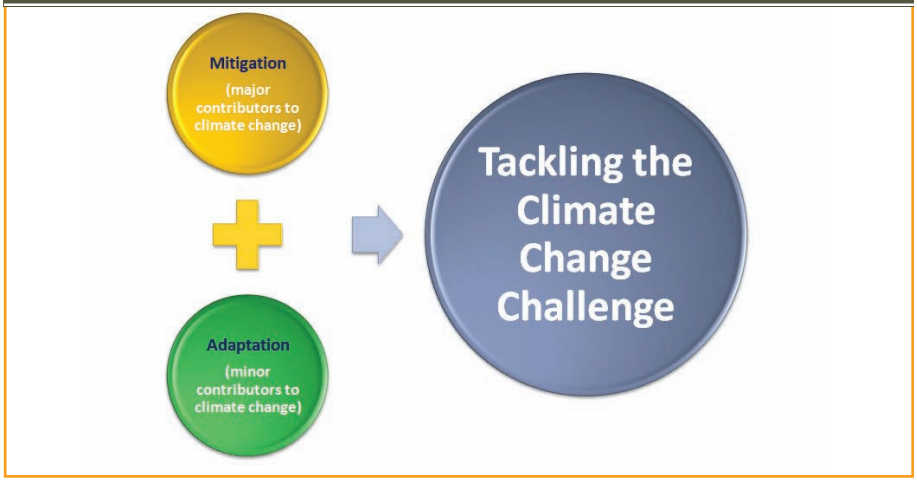
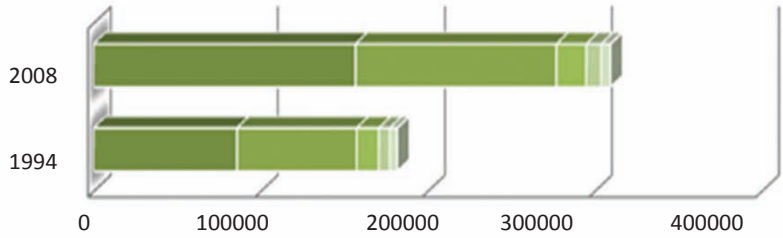


Fig.5

GHG Emissions in Pakistan (1994-2008)
All Data is in Million Ton Carbon Dioxide Equivalents (MTCDE)



	1994	2008
Energy	85816	156821
Agriculture	71632	120284
Industrial Processes	13297	17866
LULUCF	6527	8920
Wastes	4454	5505

Source: *National Economic and Environmental Development Study ,2011*

[5] Global report on human settlements 2011,United Nations Human Settlements Programme6
[6] Task Force Report on Urban Development, 2011,Planning Commission, Government of Pakistan
[7] Task Force Report on Urban Development, 2011,Planning Commission, Government of Pakistan

The Study – Objectives and Scope

To provide a process based 'framework' and a 'roadmap' for developing a comprehensive 'Climate Change Adaptation Strategy' for Karachi city by:

- Identifying the possible climate change scenarios
- Identifying some critical people and assets at potential risk
- Profiling major vulnerabilities in terms of critical hindrances (research, policy, planning and overall governance context) in the way of enhancing the adaptive capacity of Karachi City against climate change and climate variability
- Providing a list of actions for strengthening the resilience of Karachi City

Urban development challenges in Pakistan are complex and the way development is taking place is more in the nature of *mal-adaptation* rather than meeting the requirements of *adaptation* if relevance is drawn to the climate change context. In this regard it is a matter of some concern that in efforts to tackle the climate change challenge in Pakistan there is limited if any focus on *urban settlements* and even the recently notified *Climate Change Policy* for Pakistan, approved by the Federal Cabinet and to be implemented by the *Federal Disaster Management Ministry* directs attention mostly on *agriculture, forestry* and water resources and separates out urban activities into a *sector* based categorization rather than consider them in a holistic urban context.

Through this *Study,* an effort is being made to stimulate debate and dialogue around the urgent need to bring the urban context in perspective in Pakistan's drive towards effectively meeting the challenges of climate change. The focus is on Karachi City – the largest urban center of Pakistan offering the most complex set of urban development challenges anywhere to be found in Pakistan. The *Study* does not present an adaptation strategy in itself instead it identifies a process for relating the experiences of our urban growth in the classic framework of developing a comprehensive *urban climate change adaptation strategy.* It aims to identify and prioritize the people and assets at possible risk and the key actions required to make Karachi a more resilient city in addition to identifying the critical governance, institutional, technological gaps and constraints.

A key focus is on the need to understand that the context of climate change offers cities all over the world a viable option to capitalize on a window of opportunity that has suddenly opened up to manage issues that we have to resolve climate change or no climate change. Adaptation to *climate variability* consists of actions to reduce vulnerability to short-term climate shocks (whether or not influenced by climate change) – for instance, as a city government ensures that the drainage system can cope with monsoon rains or that green spaces are protected and enhanced to act as drainage basins. Most of the measures for adapting to *climate variability* (which will be taking place in most well-governed cities) will also contribute to *climate change adaptation* (as a co-benefit).

Section 1: Karachi City – Context for Adaptation

Karachi City has a land area of 3,640 km² and is located on the Arabian Sea coast in the extreme south of Pakistan.

Karachi has expanded exponentially both in terms of urban sprawl and in terms of growth in population. About 63% of the population of the metropolitan area lived within 10 kilometers of the city center in 1972. By 1981, it had declined to 52%, as urban development and concomitant population growth transformed the ring to between 11

Fig. 6

Karachi Geographical Location

Karachi – The Physical City

Location: Karachi, the provincial capital of Sindh, is also the largest city of Pakistan covering an area of 3,527 km2. It is located at 24º45" to 25º15" north and 66º37" to 67º37" east. It is bounded by Dadu District in the northeast, Thatta District in the south-east, the Arabian Sea to the south and the Lasbela District of Baluchistan Province to the west.

Topography: Karachi may be broadly divided into two parts; the hilly areas in the north and west and an undulating plain and coastal area in the south-east. The hills in Karachi are the off-shoots of the Kirthar Range. The highest point of these hills in Karachi is about 528m in the extreme north. All these hills are devoid of vegetation and have wide intervening plains, dry river beds and water channels. Karachi has a long coastline in the south. The famous sea beaches include Hawks Bay, Paradise Point, Sands Pit, and Clifton. China Creek and Korangi Creek provide excellent calm water channels for rowing and other water activities. Away from the shoreline are small islands including Shams Pir, Baba and Bhit.

Climate: Karachi has a moderately temperate climate with a generally high relative humidity that varies from 58 per cent in December (the driest month) to 85 per cent in August (the wettest month). A cool evening breeze is a great boon to the inhabitants. The winds in Karachi for more than half the year, including the monsoons blow south-west to west. The wind in winter changes to east and north-east maintaining an average temperature of about 21ºC. The hottest months are May and June when the mean maximum temperature reaches 35ºC. January is the coolest month of the year. During the rainy season in July and August, it remains cloudy almost every day with generally scanty rainfall. However, there are surprising variations from year to year. The average annual rainfall is 256 mm, but in certain years rainfall is higher and it may rain heavily within a short span of 48 hours.

Source: *The Case of Karachi, Pakistan, 2003, Arif Hasan, Masooma Mohib*

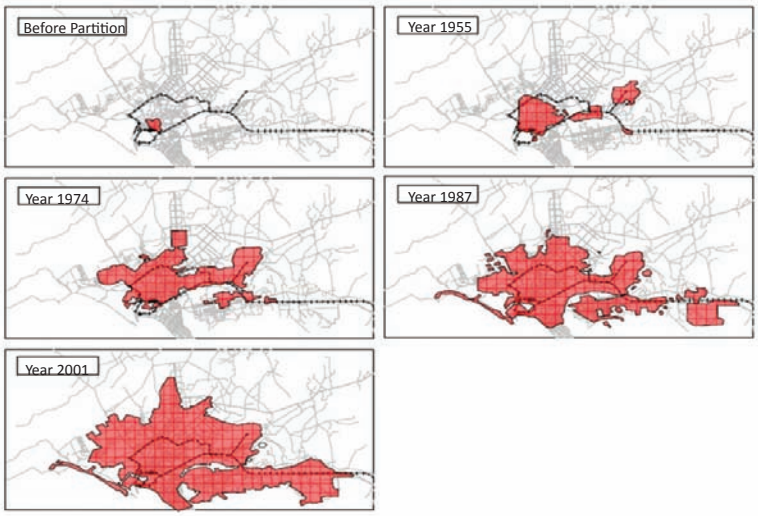
and 20 kilometers from the center. By 1987, the core area of Karachi (the area within five kilometers of the CBD) accounted for less than 20% of the total regional population.[8] At present over half of Karachi's population resides at a distance of more than 10 kilometers from the city center.

Karachi had very little industry up to the mid-twentieth century, but after the creation of Pakistan in 1947, it became the national capital, and Navel base, and the only seaport in Pakistan physically well protected against storms. Its other location based advantage has been land route connection with Iran, Afghanistan, China and Central Asian countries, and sea route connection with India, Sri Lanka and nearby Arab countries. Karachi has thus attracted significant employment opportunities and its population swelled dramatically, ushering in the modern age of Karachi as a port and dominant commercial and industrial center.

Karachi, the capital of Sindh province, is now the commercial hub and gateway of Pakistan . It accounts for 95 per cent of Pakistan's foreign trade and contributes 30 per cent of Pakistan's industrial production (ADB, 2006a). Nearly 90 per cent of the country's head offices of banks, financial institutions and

Fig. 7

Phenomenal Urban Sprawl



Source: *Karachi Strategic Development Plan 2020, August 2007, CDGK*

Table 3

Population Statistics of Karachi – 1931-2020

Years	Population	Annual Growth Rate (AGPR) (%)
1931	2,63,565	-
1941	3,86,655	3.70
1951	10,68,459	11.50
1961	19,12,598	6.05
1971	35,15,402	5.00
1981	54,37,984	4.96
1998	98,56,318	3.52
2002	11,364,707	3.02
2005	15,120,000	4.15
2010	18,529,000	4.05
2015	22,594,000	4.05
2020	27,550,000	3.50

Source: *The fast growing megacity Karachi as a frontier of environmental challenges: Urbanization and contemporary urbanism issues, 2010, Salman Qureshi - (a) Estimated population using annual population growth rate (APGR), (b) Projected population by CDGK-MPGO (2007)*

[8] Karachi Land and Housing Study, 1989, Dr. D. Dowell, United Nations Centre for Human Settlements

multinational companies are located in Karachi (ADB, 2005a). The country's largest stock exchange is Karachi based. The city contributes 20 per cent of the national gross domestic product, accounts for 40 per cent of national employment in large-scale manufacturing and contributes 25 per cent of national and 40 per cent of provincial revenues (ADB, 2005b).

Karachi is divided into planned areas and unplanned areas. Unplanned areas are mostly in the nature of *katchi abadis* (urban squatter settlements). The *katchi abadis* represent the most recognizable face of *informal settlements* in Karachi and have existed from the time of the creation of Pakistan with instances of illegal sub-division of land documented as far back as the 1950's. The *katchi abadis* have grown at twice the rate of the planned areas. In 1998, 50% of the population or 700,152 households lived in *katchi abadis.* This population has now increased to 61% or 1.2 million households.[9]

Table 4

Composition of Karachi's Economy (1984/85 – 2006/07) (Rupee Billions at 1959-60 Factor Cost)

Sector	Value Added (1984/85)	Share in GRP (1984/85)	Long Term Growth Rate		Value Added (2006/07)		Share in GRP (2006/07)	
			a	b	a	b	a	b
Gross Regional Product	13.7				52.6	61.8		
Primary Sectors*	0.2	1.34%	3.3%	3.3%	0.4	0.4	0.7%	0.6%
Secondary Sectors*	5.1	37.4%	6.7%	3.5%	21.4	10.9	40.6%	17.7%
Tertiary Sectors*	8.4	61.2%	6.1%	8.5%	30.9	50.5	58.7%	81.7%

Source: *Karachi Strategic Development Plan (KSDP) 2020 – Kaiser Bengali*
*Notes: "a" is based on Bengali (1988) "b" is consultant's estimate based on discussions with GoSindh and World Bank *Agriculture, Forestry, Fisheries and Livestock; Mining and Quarrying **Manufacturing; Construction; Electricity and Gas Distribution ***Transport, Storage and Communications; Wholesale and Retail Trade; Ownership of Dwelling; Banking and Insurance; Public Administration*

CLIMATE CHANGE AND PAKISTAN – TRENDS AND SCENARIOS

Pakistan can be quite vulnerable to climate change because it generally has a warm climate; it lies in a world region where the temperature increases are expected to be higher than the global averages; its land area is mostly arid and semi-arid (about 60 per cent of the area receives less than 250 mm of rainfall per year and 24 per cent receives between 250-500 mm). During the last century, average annual temperature over Pakistan increased by 0.6 °C, in agreement with the global trend, with the temperature increase over northern Pakistan being higher than over southern Pakistan (0.8 °C versus 0.5 °C). Precipitation over Pakistan also increased on the average by about 25 %. Studies based on the ensemble outputs of *several Global* Circulation Models (GCMs) project that the average temperature over Pakistan will increase in the range 1.3-1.5 °C by 2020s, 2.5-2.8 °C by 2050s, and 3.9-4.4 °C by 2080s, corresponding to an increase in average global surface temperature by 2.8-3.4 °C by the turn of the 21st century. Precipitation is projected to increase slightly in summer and decrease in winter with no significant change in annual precipitation. Furthermore, it is projected that climate change will increase the variability of monsoon rains and enhance the frequency and severity of extreme events such as floods and droughts.[10]

[9] Participatory Development, 2010, Arif Hasan
[10] Task Force Report on Climate Change, February 2010 – Planning Commission, Government of Pakistan

CLIMATE CHANGE – THE KARACHI CITY CONTEXT

Main factors that contribute to variability in Karachi's weather are:

- *Western disturbances:* Occurs during the winter months, cause drizzle to light showers and decreases in temperature.
- *Tropical storms:* Occurs during summer months from late April till June and again from late September till November.
- *Southwest monsoon:* Occurs in summer from the July till September. These monsoon rains are quite heavy by nature and can cause significant flooding.
- *Continental air:* which is characteristically dry, prevails during the period when there is no precipitation in the metropolis [11]

In addition to these direct influences, changes in ocean and atmospheric conditions in distant locations also impact the climate of Karachi, particularly the monsoon. Historical weather data for Karachi indicates that there is no significant change in the average precipitation in Karachi. In contrast trends in temperature data clearly show an upward trend and increase in average temperature over the years.

Karachi City – The Context for Climate Change			
Flooding	**Drought**	**Extreme Heat Events**	**Sea Level Rise**
Significant human settlements (e.g. slums) exposed to fluvial, storm water flooding risk and hill torrents Sensitive national installations and significant human settlements (fishing communities) exposed to tidal flooding Other than the 'Malir River Embankment' no provision for flood defences and drainage channels chocked or blocked No provision of flood storage areas	The Hub River source, a rain fed source is a major water supply source for Karachi (5 million population served) Livelihoods of significant human settlements based in rural Karachi (Goths) dependent on farming mostly using ground water Ground water table is lowering and aquifers are threatened due to human activities such as sand extraction No water conservation , waste water recycling or rain water harvesting practices being promoted in the city	Inadequate health and emergency response infrastructure and services to cope with large scale spread of infectious diseases Shortage in energy and substantial energy loss Energy consumption increasing and no efforts to promote energy conservation Due to rising population density in 'inner city' and increased traffic /congestion the likelihoods of the 'Heat Island Effect' increasing even further	Sensitive national installations and significant human settlements (fishing communities) exposed to tidal flooding Biodiversity impacts/wetlands and tidal zones and loss/alteration of flora/fauna – possible salt water intrusion

[11] Climate Profile of Karachi, KW&SB Climate Change Adaptation Strategy,2012, Ujala Qadir, WSP

Over the past years cyclones tend to recur frequently though, most did not seriously impact Pakistan's coast. However,cyclone of 1999 seriously impacted Thatta and Badin districts of Sindh and affected 0.6 million people and caused loss of 202 lives. Cyclone Yemyin in 2007 had a much wider imprint affecting 26 districts of Balochistan / Sindh and 2.5 million people, causing 400 fatalities.[12]

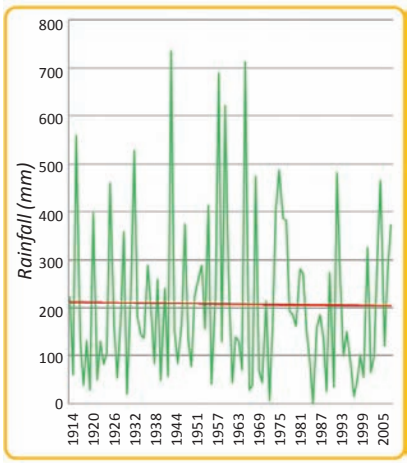
The capacity context for adapting to possible climate change scenarios in Karachi is grim. While Karachi still serves as the commercial backbone of Pakistan there is increasing socio-economic disparity and growing environmental degradation. Human settlements such as slums and hill settlements are exposed to fluvial, storm water flooding risk and hill torrents in the absence of appropriate protection and emergency response systems. Sensitive national installations and human settlements such as fishing communities are exposed to tidal flooding.

Other than the *Malir River Embankment* there are no provisions for flood defences and drainage channels are chocked or blocked. There

Fig. 8

Trends in Annual Precipitation for Karachi

- The **green** line in the figure below shows observed precipitation in Karachi from 1914 to 2010, which is clearly highly variable in nature
- The **red** line represents the average of the precipitation using a statistical regression analysis. This line indicates that there is no significant change in the average precipitation in Karachi

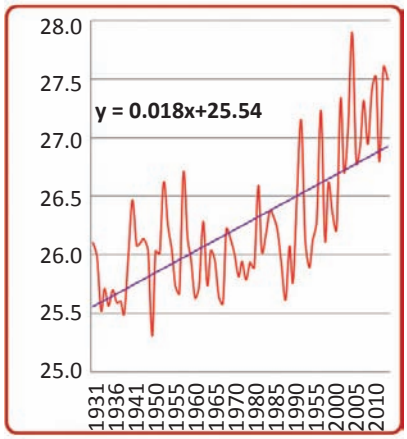


***(Source:** Climate Profile of Karachi, KW&SB Climate Change Adaptation Strategy,2012,Ujala Qadir, WSP)*

Fig. 9

Trends in Temperature Over Karachi

- The **red**line represents the observed temperature data for Karachi for the period 1931-2007 showing an upward shift
- The **purple** line is fitted to the data using regression analysis indicating the trend

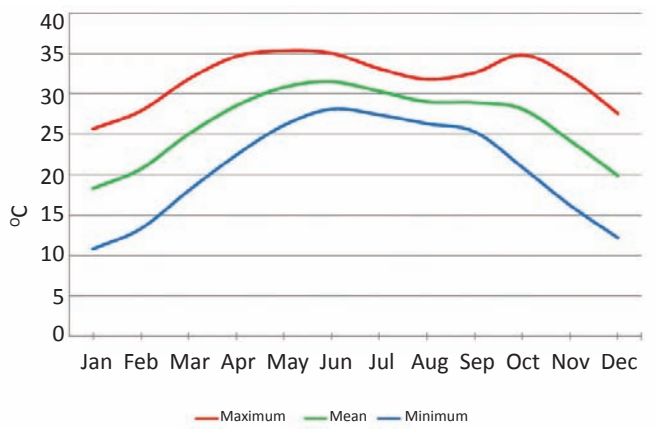


***(Source:** Climate Profile of Karachi, KW&SB Climate Change Adaptation Strategy,2012, Ujala Qadir, WSP)*

[12] Cyclone Contingency Plan for Karachi City, 2008, National Disaster Management Authority, Government of Pakistan

Fig. 10

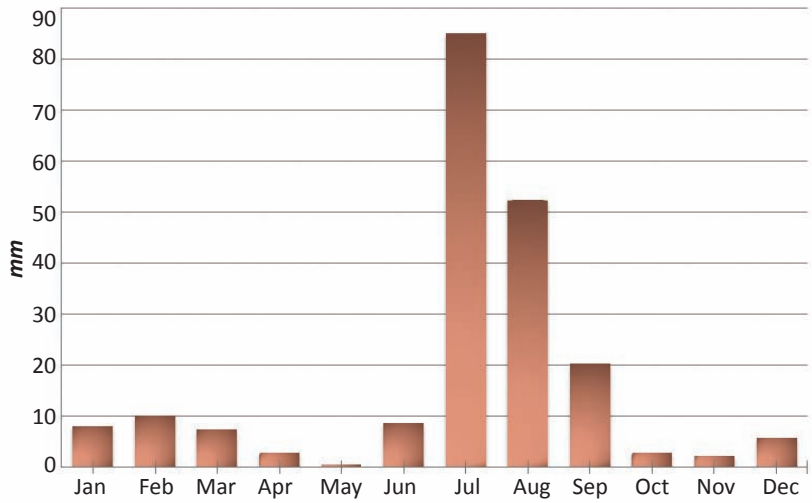
Average Temperature



***(Source:** Climate Profile of Karachi, KW&SB Climate Change Adaptation Strategy,2012, Ujala Qadir, WSP)*

Fig. 11

Average Rainfall



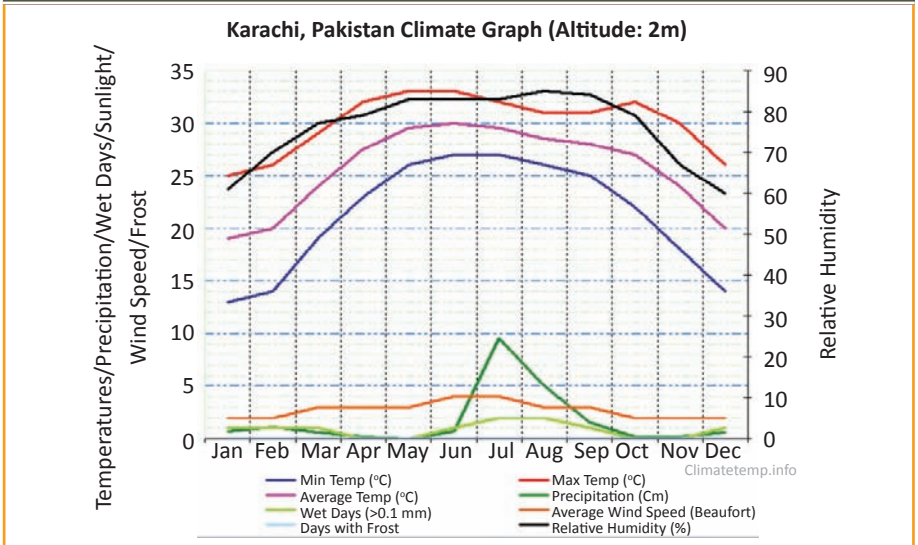
***(Source:** Climate Profile of Karachi, KW&SB Climate Change Adaptation Strategy,2012, Ujala Qadir, WSP)*

is no provision of flood storage areas. If we take the case of a possible drought scenario than the Hub River source, a rain fed source is a major rain fed water supply source for Karachi serving a population of 5 million. Livelihoods of significant human settlements based in rural Karachi Goths are dependent on farming mostly using ground water. Ground water table is already lowering and aquifers are threatened due to human activities such as sand extraction. No water conservation, waste water recycling or rain water harvesting practices are being promoted in the city.

There is shortage in energy and substantial energy loss. Energy consumption is increasing and no efforts ongoing to promote energy conservation. Due to rising population density in *inner city* and increased traffic /congestion the likelihoods of the *Heat Island Effect* taking place is quite likely. In the context of a possible sea level rise, adverse biodiversity impacts on wetlands and tidal zones and possible loss of flora and fauna can be anticipated. Mangroves that can act as a buffer against tidal flooding are already being devastated.

Fig. 12

Karachi - The Overall Climate Graph



***(Source:** Climate Profile of Karachi, KW&SB Climate Change Adaptation Strategy,2012, Ujala Qadir, WSP)*

Land use violations leading to encroachments of parks and playgrounds, coastal sensitive ecological land is eroding the natural barriers capable of reducing the adverse impacts of climate change.

Karachi for numerous reasons needs to get its house in order. The global focus on climate change and the availability of related substantial financial resources offers a window of opportunity for urban managers all over the world to access the resources and plan and implement measures to not only prepare for possible climate change impacts but generally improve the sustainability profile of their cities. Karachi, one of the fastest growing mega cities in the world, can definitely make progress in this regard.

Section 2: Understanding the Impacts

This *Section* discusses the various likely consequences of possible climate change scenarios placed within the context of the key *vulnerabilities* and c*limate change adaptation* challenges faced in Karachi City. While an exhaustive and detailed analysis of all aspects of the issues relevant to the discussion was beyond the scope of the present Study some important themes are contextualized in brief within a climate change adaptation framework and structure that can be constructed upon and further refined for facilitating the development of a comprehensive strategy.Effort has been made to standardize the format for discussion and analysis for each possible climate change scenario for assessing consequences and highlighting the critical challenges that get identified.

FLOODING

Within the context of *flooding,* the following *focus* areas are being considered:

- Vulnerable communities(Slums/low lying localities/hill settlements)
- Properties and assets at risk
- Emergency response capacity (health care/emergency medicine/fire services etc.)
- Natural defences – green spaces

Flood preparedness

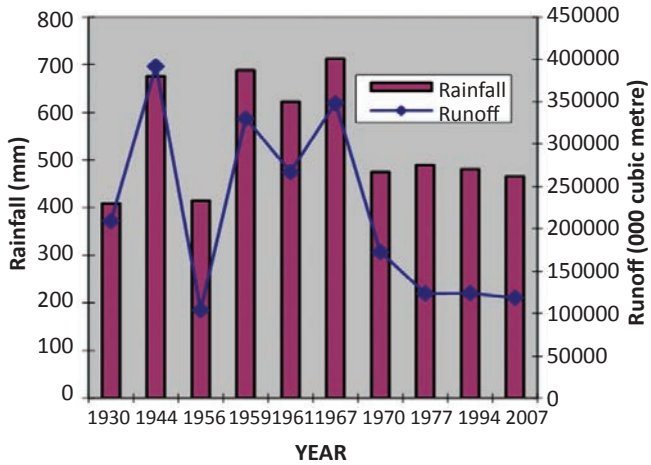
As stated earlier, while average precipitation levels have not significantly changed over the years in Karachi and are projected also to keep fairly stable in the long run, however, *climate variability* is always possible and Karachi has a context to flooding. However, first, let us consider Karachi's status in terms of *preparedness* for a possible urban flooding event. There can be three possible ways to prevent or reduce the impact of flooding:

- **Spatial planning** – This involves avoiding the creation of flood-vulnerable land uses in high flood-risk areas and identifying where current developments and settlements need to relocated while being possibly replaced by less flood-sensitive land uses. We find that a significant population of Karachi City residing in either informal/squatter settlements or in low lying localities is already located in areas of potential flood risk.

- **Flood defences and drainage systems –** Other than the 12 mile long *Malir River Embankment* no other flood defence mechanism exists. The drainage network is not designed to cater for appropriate rainfall intensity and probability and is also faced with issues of blockages and encroachments. The City *government has* responsibility for maintaining most of the drainage networks and flood defences, however they have no control over preventing abuses of the system that reduce working efficiency such as connection of sewage lines into drainage net-

Fig. 13

Flooding- Extreme Events



***(Source:** Surface Water Drainage and Flooding in Karachi City , S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan*

works, encroachments and garbage dumping.

- **Flood storage areas** – This involves designing some areas to deliberately flood (such as parkland or sports fields) so that other more vulnerable land uses can be spared flooding.At present, this option is not utilized in Karachi City while available *green spaces* are vanishing fast mostly due to encroachments and land use conversions through land grabs.

Sources of flooding

Karachi is prone to flooding from three possible sources (another possible source – *Tidal Flooding* will get assessed in the discussion on sea level rise):

- Fluvial flooding – from Lyari/Malir rivers and their tributaries (Malir – Chakora Nullah, Thado Dam/Lyari – Orangi, Gujjar)
- Surface water flooding - from heavy rainfall overcoming the drainage system
- Sewer flooding - from the overflowing of sewers

Drainage basins

Karachi has a context to flooding and has experienced severe floods which have occurred periodically. In 1977, severe floods occurred in the flood plains of the *Malir and Lyari river*s resulting in 267 deaths with more than 30,000 being made homeless and 100,000 temporarily dislocated. Houses were destroyed and roads were damaged. The total loss was estimated at about 5 billion rupees (Karachi Development Authority/KDA, 1981).

The *Malir River* basin and the *Lyari River* basin are the two main basins which contribute for about 80 percent of the surface runoff. While they are perennial streams and fresh water flow is dependent solely on rains and normally they serve as carriers of the city sewage, nevertheless there is a history to flooding events and the threats are real and cannot be totally ignored .

Other than the *Malir* and *Lyari* rivers, its tributaries and lined *nullahs*(drains) serve as an important component of the drainage network. They are severely stressed. One, they are not designed to cater for appropriate rainfall intensity and probability and two they are working at reduced efficiencies due to blockages and encroachments.The *Karachi Strategic Development Plan 2020* identified the following reasons for the massive inner city flooding experienced in 2006;

- *Due to irregular and illegal land utilization practices in the past,*

Water Basins

- The Malir River basin is the largest basin and source of surface runoff and sediments load. The Malir River forms as a result of the confluence of two main rivers the Mol River and the Khadeji River. The catchment area of the Mol River is about 620 square km and Khadeji River is 580 square km
- The Lyari River originates from the hilly ranges of Manghopir anticlines from the north of the city and south of the Hub dam where its height is about 190 meters. Its catchment area is smaller than the Malir River because of its shorter length and smaller number of tributaries. Its total length is about180 km while its catchment area is about 578 square km
- The Budnai basin is drained by Budnai Nadi and number of small but powerful streams originating from the ridges of Orangi hills and Jhill hills in Mochko and around Sona pass. The total length of Budnai stream is about 46 km and its catchment area is about 95 square km
- The coastal areas of Bin Qasim, Korangi and Jhill hills are drained by many hill torrents and small streams which are very active during rainy days

Source:*Surface Water Drainage and Flooding in Karachi City, S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan*

most of the natural drainage, nullahs and low lying areas which were left as open areas were converted into developed lands notwithstanding the requirements of providing alternate and man-made disposal channels and thus disturbing the natural flow conditions and consequently resulting in uncontrolled storm drainage pattern especially during a high intensity storm/rainfall

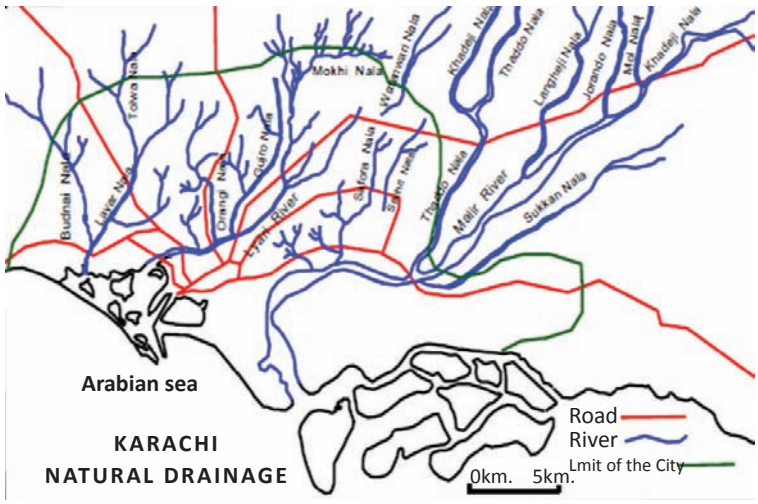
- *A substantial percentage of solid waste is regularly disposed in the open storm drainage channels especially from adjoining localities which obviously results in complete choking or partially interrupted flow conditions in the event of storm*

Assessing risks

The consequence of a flood is determined by who and what is exposed to a flood and their *vulnerability* to it.For assessing the current flood risk, the first requirement is to look at the *probability* of a flood occurring, the *consequence* of a flood and the associated risk and *vulnerability* of the *people* and *assets* that may be affected. The flood probability is usually expressed as a *return period,* or as an *annual percentage* that may be altered as climate change may increase the frequency and intensity of extreme weather, so that what is a 1 in 150 year event today may be a 1 in 100 year event in the future and with a possible greater intensity.

Fig. 14

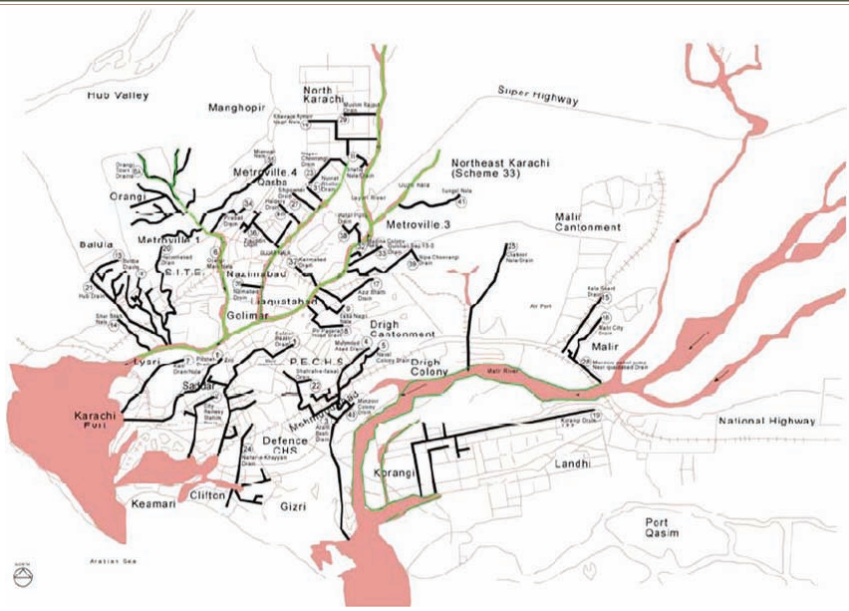
Natural Drainage (Basins) in Karachi



***(Source:** Surface Water Drainage and Flooding in Karachi City , S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan)*

Fig. 15

Karachi Drainage Network



***(Source:** KSDP 2020)*

Flooding - Possible Impacts

- Loss of life and personal injury (especially vulnerable communities slums/hill settlementsand low lying inner city neighborhoods)
- Direct damage to property, infrastructure and utilities
- Contamination and disease from flood and sewer water
- Social unrest
- Possible relocation and resettlement of communities

Exposure and vulnerability

The *exposure* and *vulnerability* of people to flooding are determined by factors that include:

- exposure – for example, living in low lying localities/along (and on!!) river beds – in the flood plain
- vulnerability - for example, age (the very young and old), health, disability, living alone or not having a support network, low income and inadequate housing

Land uses/assets also vary in their vulnerability to flooding. They can be classified into *highly vulnerable* to flooding (including police, ambulance and fire stations, emergency command centers, power stations, water supply facilities and housing/property in low lying localities); more vulnerable (including hospitals, industries, housing, schools); *less vulnerable* (including shops, offices, restaurants, waste and water treatment sites).

However, the people and assets at risk can only be identified with some degree of accuracy if the probability is worked out and linked with the establishment of a *Flood Risk Zone.* Vulnerability factors can then be combined to produce *an index of flood vulnerability* which can then be plotted using census data to map vulnerability.

In the case of Karachi City, the only such working was done by *WAPDA* in the *Feasibility Report on Malir River Basin,* (1990). It was found that the highest peak discharge in the *Malir River* caused the floods of 1944. Its *recurrence interval* was worked out as about 81 years while its chance of occurrence being about 1 percent each year. However, while surface runoff calculations were done but a *flood plain* could not be identified that could have served as a *viable flood risk zone* for the *Malir river* basin settlements. The *Malir River* in Karachi passes through thickly populated residential and industrial areas. The worst flooding was in 1977 in terms of its magnitude of loss of life and damages, when abnormal rains occurred on June 30th, (in only 7 hours, 9.4 inches of rainfall with maximum intensity of 2.6 inches per hour during a period of 110 minutes was recorded). The city was cut off through railroad and air from the rest of the country. Roads were inundated. Due to the lack of flood protected embankments and presence of encroached settlement in the bed many houses were washed out. The *Pakistan Air Base* (Drigh Road) and *P.N.S Mehran* were also flooded. A flood wave hit the *Korangi Industrial Area* particularly *National Oil Refinery and Korangi Thermal Power* station.[13]

In addition to the possibility of *fluvial flooding* is the concern about *surface water flooding* impacts exacerbated due to extensive blockages and encroachments in and along the drainage channels. This is not a new concern. One identified cause of the 1977 floods was the existence of encroachments and squatter settlements in the bed and along the banks of the *Malir River.* Portion of *Mahmoodabad*, whole *Manzoor Colony, Rehman Colony, Kashmir Colony, Liaquat Ashraf Colony, Azam Basti etc.* exist on the bed of the *Malir river.* As a result the width of the river at *Qayumabad* had reduced to 550 feet instead of its original width of 5000 feet.[14]

[13] Surface Water Drainage and Flooding in Karachi City , S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan

[14] Surface Water Drainage and Flooding in Karachi City , S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan

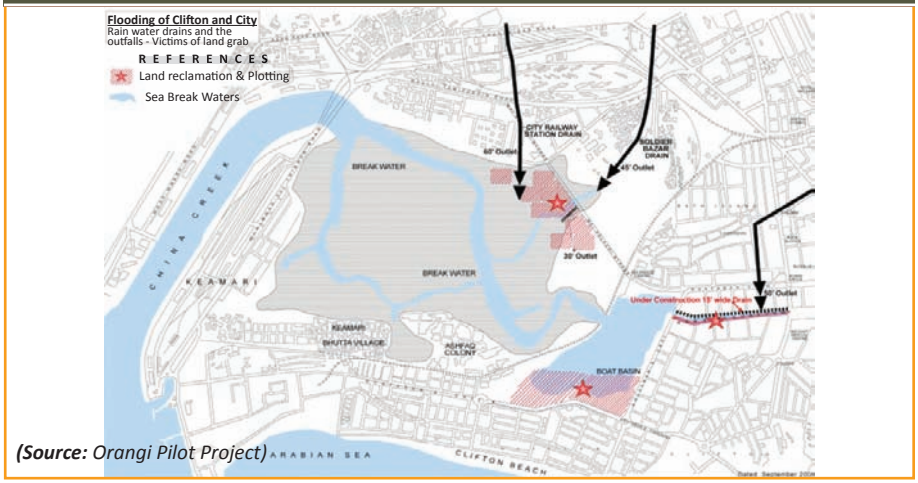
Sewers overflow normally during flooding events mainly because of capacity constraints and also as they are deliberately opened to act as drainage options to flush rain water.

Flood protection

It was as a response to the floods of 1977 that the first and only flood protection project – the *Malir River Embankment* - was completed by the *Sindh (provincial) Government* with the help of *Federal Government* in 1984 when a 12 miles long flood *embankment* was built on both sides of the *Malir River* starting from the bridge of the National Highway to the mouth of the river at *Gizri* creek. While after the construction of the embankments the adjoining areas have so far been protected from flood related damage, however, the height of the embankment was based upon the surface runoff of 240,000 cusecs for which return period is 50 years while the maximum runoff in 100 years is 409,000 cusecs and matters such as climate change and possible increasing of the intensity and reduction in the return period were not factored at that time.

Fig. 16

Drainage Network: Blocked and Chocked



***(Source:** Orangi Pilot Project)*

At risk – people and assets

In the absence of identified flood plains for either the *Malir,* or *Lyari* river basins and detailed and updated working on assessing the probability of flooding, it is difficult to establish a viable *flood risk zone* for Karachi City. However, there can be no denying the fact that significant numbers of human settlements, and those too comprising of vulnerable communities reside in a possible flood risk zone in addition to nationally important institutional assets.

Settlements along embankments
Mohammad Arshad, Shehri-CBE

Residing alongside blocked drains
Mohammad Arshad, Shehri-CBE

People - An idea of the scale of the vulnerability and risk can be made by considering three possible risk zones and communities. They can be categorized as follows:

- ***Katchi abadis*** - The *katchi abadis (urban squatter settlements)* that represent the most recognizable face of *informal settlements* in Karachi have existed from the time of the creation of Pakistan with instances of illegal sub-division of land documented as far back as the 1950's. Presently, about 61% of the population is housed in such settlements and of these a high proportion occupies undesirable real estate such as along the *Malir/Lyari* river beds .This can mostly be attributed to massive population influxes, ever escalating land prices and the incapacity of the relevant government authorities to provide viable housing options for the financially and socially marginalized and vulnerable communities. The process initiated quite some time back and has since then taken the form of a very concrete and visible settlement pattern. Their risk when considered in context of flooding can be expressed in terms of most critically their location (exposure) and then possible lack of land tenure - not all *katchi abadies* are regularized - lack of formal access to civic services

Fig. 17

Extent of Flood Defences – Malir River Embankment

(Source : *Surface Water Drainage and Flooding in Karachi City , S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan)*

Settlements along nullahs
Mohammad Arshad, Shehri-CBE

Settlements in a high flood risk zone
Mohammad Arshad, Shehri-CBE

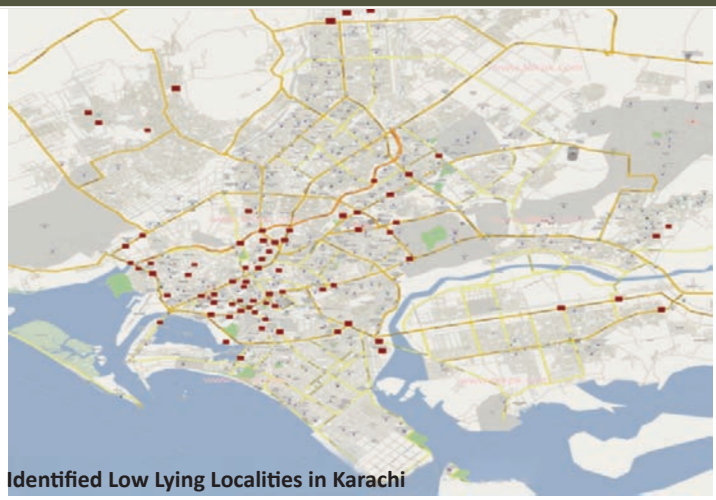
such as water, inappropriate housing structures, absence of financial cover to reclaim structural such as housing damages, loss of livelihoods and health costs (vulnerability).

- ***Low lying localities*** - The city areas which were developed in between1726 to 1947 are known as the *old city.* These areas house much of the wholesale business and commercial activities. In addition, the *commercial business district* (CBD) is also located here. These localities are densely populated and congested and are low lying, bounded by the *Lyari* River and *Karachi harbor.* Similarly, other low lying localities further inland (e.g. along drainage channels) - a mix of residential and commercial land uses are also at possible risk. In the inner city, the low-lying areas of *Saddar, Chundrigar Road, Bunder Road* and *Lyari* become heavily inundated during the rainy spells mainly due to inadequate storm water drainage system. Extensive flooding occurs in parts of the *Gulshan-e-Iqbal* along the *University Road, Societies Union area along Shahrah-e-Faisal* and *Tipu Sultan Road.* *Katachi abadis* of *Mehmoodabad* and *Manzoor Colony* located on the *Malir river* bank are also worst affected by excessive flooding and stagnant water.[15]

- ***Hill settlements*** - During the past decade or so, extensive settlements have taken place either

Fig. 18

A High Risk Zone and Communities (Madiha Salam, Shehri-CBE)



Identified Low Lying Localities in Karachi

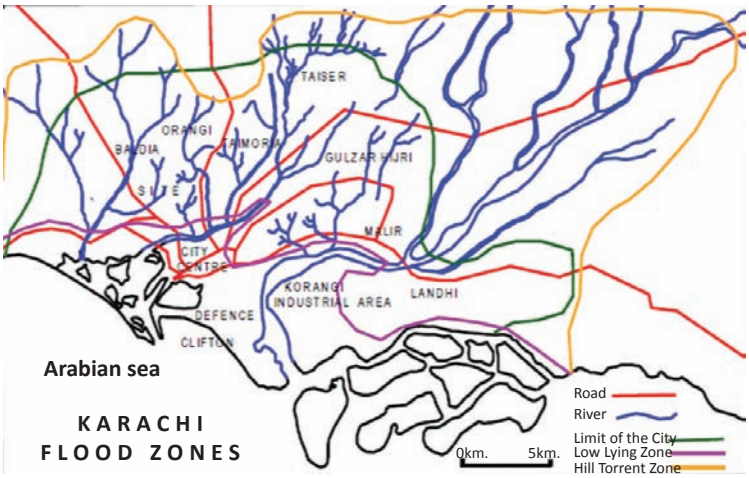
The downtown – a low lying area
Mohammad Arshad, Shehri-CBE

Nehre-Khayam drainage channel along Karachi Grammar School-
Mohammad Arshad, Shehri-CBE

[15] Karachi Strategic Development Plan 2020

Fig. 19

Flood Zones in Karachi



***(Source** : Surface Water Drainage and Flooding in Karachi City , S. Akhtar and M.R Dhanani, 2012, Department of Geography, University of Karachi, Karachi, Pakistan)*

on the hills dotting the Karachi landscape or on the foothills – mostly inhabited by the more recent immigrants to the city. As such a significant new *flood risk zone* has been created that can be critically endangered due to hill torrents and possible landslides.

Property and assets - It is again difficult to establish an accurate list of properties and assets that may get impacted and to what extent. However, if we just consider the industrial assets that are quite possibly located in a likely *flood risk zone* than we need to place a high value on initiating urgent flood prevention and protection measures. The *Sindh Industrial Trading Estate* (S.I.T.E), the *F.B Area Industrial Zone, the North Karachi Industrial Zone and the Landhi/Korangi Industrial Trading Estates* (L.I.T.E/K.I.T.E) are located right along the Lyari and Malir Rivers respectively.K.I.T.E got extensively flooded in the 1977 floods and has since been protected by the *Malir River Embankment.*
If we consider essential civic services than it is indicated that a fairly extensive water supply and sewerage system related infrastructure such as *pumping* stations is located along mostly the *Lyari* River in *towns* that border on the river. An example is that of *Lyari town*.

Emergency response

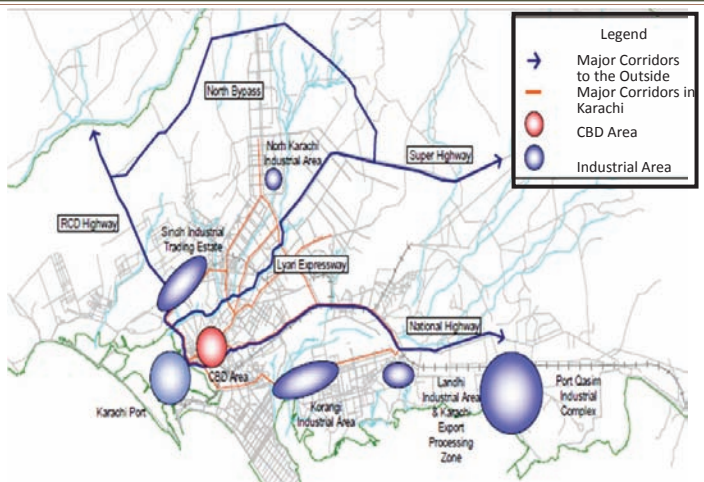
There is limited if any quality research analyzing the status of emergency response systems such as emergency medicine, healthcare, fire services etc. For the objectives of this *Study,*to assess the emer-

Dangerous slope in a hill settlement
Mohammad Arshad, Shehri-CBE

Living in a hill torrent zone
Mohammad Arshad, Shehri-CBE

Fig. 20

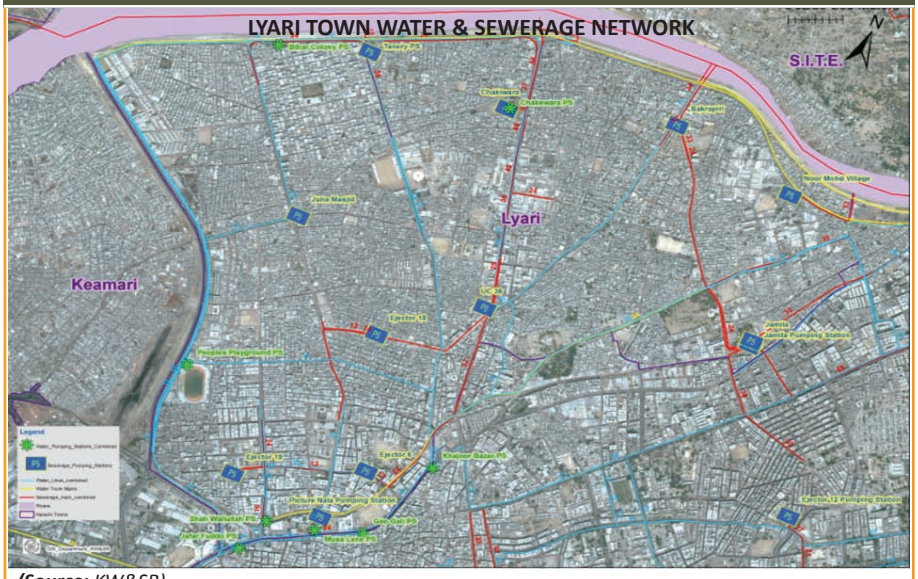
Industries along the Lyari and Malir Rivers



***(Source:** Special Assistance For Project Formation (Saprof) For Karachi Circular Railway Project In The Islamic Republic Of Pakistan ,2009,Jica*

Fig. 21

Water Supply Infrastructure Along Lyari River



***(Source:** KW&SB)*

gency healthcare response,a research paper(Pakistan: The new target of terrorism. Are Karachi's emergency medical response systems adequately prepared? – 2009-Muhammad Ahmed Siddiqui, Ahmed Jawad, Saeed Minhas, Asma Ansari, Afrah Siddiqui, Sana Mehtab)assessing the efficacy and preparedness of the pre-hospital and hospital emergency medical systems and post graduate trainees in the city (two prime emergency care hospitals) to deal with a massive terrorist (not climate change!) strike has been sourced to give some idea on this important aspect of preparing for climate change scenarios.

In this research a cross-sectional survey of postgraduate trainees was conducted at *Jinnah Postgraduate Medical Center and Civil Hospital Karachi* from 21st July 2007 to 24th July 2007, to evaluate the preparedness and self identified deficiencies of doctors involved in massive trauma casualty management. Out of the 90 respondents questioned regarding a self assessment of their training, only 3 (3.3%) of them were confident about their management of bomb blast victims. Eighty-seven (96.6%) of the respondents felt they required some further training (44.4%) or comprehensive training (52.2%). No simulated drills or courses had been conducted for disaster management in the emergency department of the surveyed hospitals. Most of the ambulance drivers had no paramedic training. Ambulances are equipped with a stretcher and an oxygen cylinder only. No resuscitation measures were found available in the ambu-

lances.An overwhelming 96% of the doctors felt they were deficient in their training and management of such scenarios.Despite availability of communication between ambulances of the same organization, no-communication links are available between the ambulance services and intended hospitals.

With regards fire services, an evaluation made recently by *Muhammad Masood Alam, Executive District Officer, Municipal Services Group of Offices, City District Government Karachi in* the context of *Vulnerabilities and Hazards of Karachi and Preparation of District Disaster Plan 2011,* is self explanatory:

- No Fire Hydrant System throughout the city is available
- Non-provision of training on international standard
- In availability of fire training institute/school
- Non implementation of safety rules
- Acute shortage of water for fire-fighting purpose
- Shortage of fire fighting staff
- Shortage of fire station
- Absence of coordination and co-operation of different agencies on scene of incident
- Shortage of special fire fighting units snorkel, hazmat rescue units and ambulances

Vanishing green spaces – vanishing defences

Green spaces act as basins where rain water can infiltrate and thus reduce the potential flood threat as compared to impervious concrete built up spaces. Green spaces or the vegetation cover in Karachi is already limited. According to the findings of a recent study funded by the *Asian Development Bank (ADB) – Comprehensive Plan for Forestation, Aesthetic Plantation and Landscaping for Karachi, 2008* –total vegetation cover in Karachi as estimated through satellite imageries is 62,643 acres which works out as 7% of the total land area of 907,001 acres. A greater cause for alarm is however, the rate at which these already minimal green spaces are disappearing.

In another research work undertaken recently - *Ecological disturbances due to high cutback in the green infrastructure of Karachi: Analyses of public perception about associated health problems – 2010- Salman Qureshi a,b,_, Syed Jamil Hasan Kazmi b, J¨ urgen H. Breuste, 2010-* an effort was made to assess whether the effect of the reduction of Karachi's green infrastructure has had an impact on human health conditions in the city. The initial phase of the study consisted of examining the extent to which the-green infrastructure had changed due to the combined effects of development and the monsoon using remote sensing and GPS survey techniques.This involved a time series analysis of the pattern of green infrastructure conducted using time series sets of LULC data covering the

Emergency response – A critically inadequate capacity
Mohammad Arshad, Shehri-CBE

Gutter Baghicha

Gutter Baghicha (GB) is a 120-year old amenity sewage farm and sewage treatment plant on the Manghopir Road in District West. It was established in the late 19th century on 1,216 acres for the treatment of sewage from the newly established town of Karachi, where vegetables, cereals and other crops and trees/flowers were grown with the effluent

After the emergence of Pakistan in 1947, over 55% of the land was encroached upon for non-amenity use (katchi abadis, industries, workshops, etc) over the next five decades. In 1957, two hundred acres was resumed by the government for inclusion in the adjacent Sindh Industrial Trading Estates scheme. In 1982/83, a number of katchi abadis on GB land were 'regularized'.

Since 1993, local residents and environmental NGOs have been trying to save what is left (about 430 acres) of the original 1,216 acres of GB The main controversy for many years was the unlawful allotment of 200 acres to the KMC Officers' Cooperative Housing Society (KMC-OCHS), and additional plots proposed to be converted to other such non-amenity uses.

Numerous cases have been fought in the Supreme Court (SC) and Sindh High Court (SHC) over the past 18 years, until finally Suit 1484/2008 (filed by Ardeshir Cowasjee, Abdul Sattar Edhi, Shehri and area residents, including Nisar Baloch of Gutter Baghicha Bachao Tehreek (GBBT)against City District Government Karachi (CDGK), KMC-OCHS, etc), which requires recording of evidence, is pending in the SHC.

Two local activists, Nisar Baloch and Nadir Baloch, members of the Gutter Baghicha Bachao Tehreek, have been shot and killed in November 2009 for their efforts to save the park.

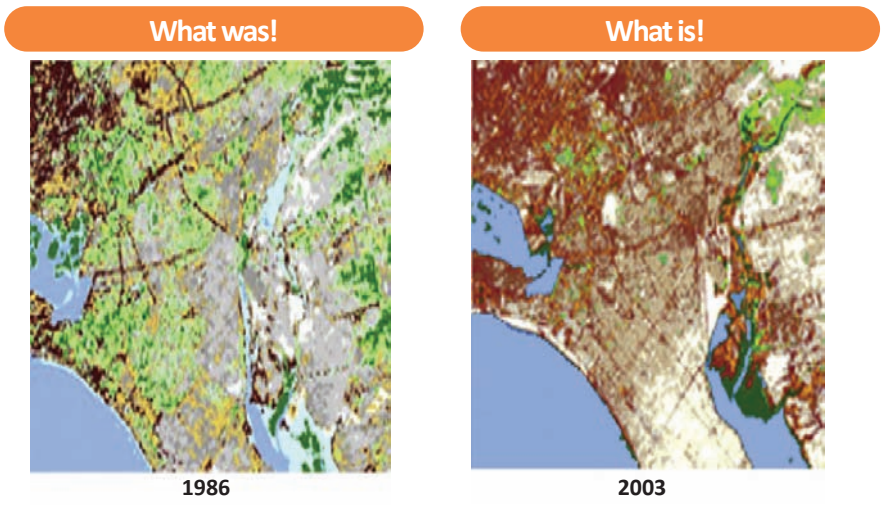
period 1986–2003 and using LandsatThematic Mapper (TM) and Enhanced Thematic Mapper (ETM+)imagery. Through this process, a wide-ranging spectrum of landscape patches was identified and examined in relation to the overall reduction in green infrastructure, involving the loss of, or reductions in, specific green areas. In the absence of the most recent satellite images, an extensive GPS-based field mapping exercise was undertaken(Fig 22). The findings verify the reduction of urban green, in both highly urbanized as well as less-urbanized areas. The rate of deterioration of green cover is particularly dramatic after 2000 when extensive development activities started in the transportation sector and can be seen in the time series (1986–2003).

In North-Eastern area of Karachi for example, in the year 2000, the built structures of North-Eastern areas (viz. Gulistan-e-Jauhar) expanded from 19.4% to 47.4% in 1990 but green areas remain virtually unchanged. A marked difference in the vacant/barren areas can be observed where the barren land in 1990 was about 30%, which fell to only 2.7% in 2000. These areas formed the focus for much of the new development.[16]

[16] Ecological disturbances due to high cutback in the green infrastructure ofKarachi: Analyses of public perception about associated health problems – 2010- Salman Qureshi a,b,_, Syed Jamil Hasan Kazmi b, J¨ urgen H. Breuste aDepartment of Geography and Geology, University of Salzburg, Hellbrunnerstrasse 34, Salzburg 5020, Austriab Department of Geography, University of Karachi, University Road, Karachi 75270, Pakistan

Fig. 22

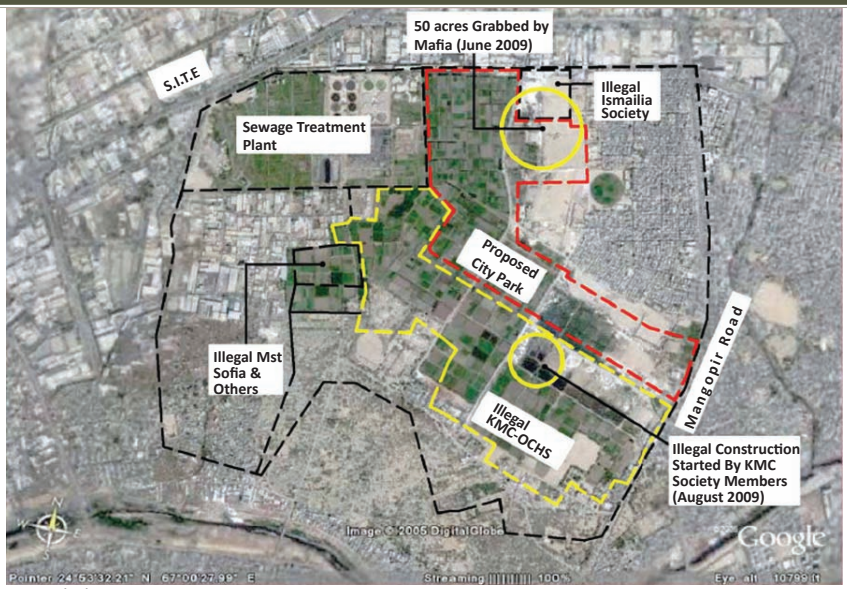
Vanishing Green Spaces



Source: *Ecological disturbances due to high cutback in the green infrastructure of Karachi: Analyses of public perception about associated health problems, 2010*
Salman Qureshi a,b,, Syed Jamil Hasan Kazmi b, J¨ urgen H. Breuste a

Fig. 23

Encroaching Gutter Baghicha



Source: *Shehri-CBE*

With relation to farming land an interesting though worrying trend is indicated. The cultivated area dropped from 61% in 1960 to only 19% in the year 2000. There is a sharp fall after the 1990's with percentage cultivated area falling to only 19% in 2000s mainly owing to the haphazard expansion of the city, development of new residential schemes and un-checked sand/gravel mining.However, while since 1990, there is indicated an increase in land purchased for agricultural purposes it is not reflected in any increase in the cultivated area!

End note

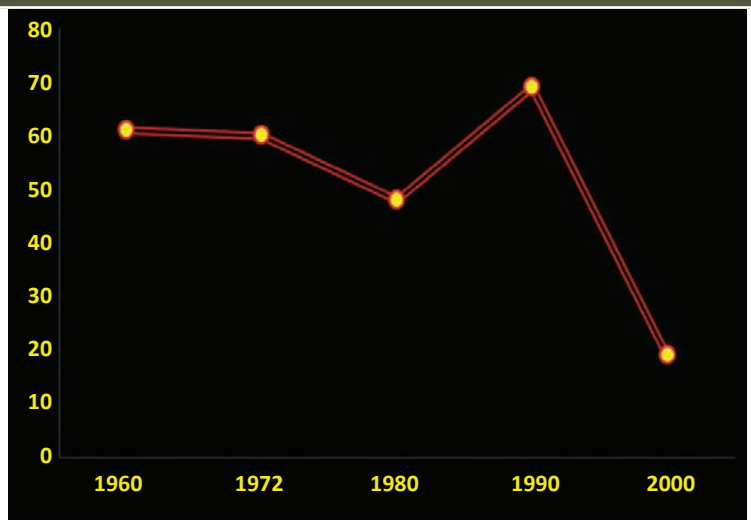
Karachi has had to face urban flooding events in the past and it can happen again. It is however difficult to work out a probability and related intensity with any degree of accuracy owing to serious gaps in data and associated research both in terms of anticipated precipitation levels and the translation of additional rainfall into an urban flooding event. The risks while they cannot be accurately quantified in terms of exposed and vulnerable people and assets there is sufficient indications that risks can be quite substantial. The potential people and communities likely to be in the flood hazard zone are also fitting the profile of being highly vulnerable. The assets at risk figure significantly not only at a local but national level in terms of

Critical Challenges

- A Flood Risk Zone (E.g. 'Flood Plain' of Lyari/Malir Rivers) not identified
- Significant settlements of 'vulnerable communities' in potential high flood risk zones
- Drainage networks neither designed to cater for appropriate rainfall intensity and probability and also faced with blockages/encroachments
- No effective policy/regulation to prevent settlements in the 'river beds', 'hills' and encroachments of drainage channels and land use changes impacting adversely on the flood prevention and management capacity
- Green cover in the city that could facilitate improved drainage (parks/play grounds, farming land) shrinking
- Critical gaps and shortcomings in the 'emergency response' systems – health/emergency/trauma facilities, fire services, law and order services (E.g. 'safe shelters') etc. – 'evacuation plans' and required procedures and facilities

Fig. 24

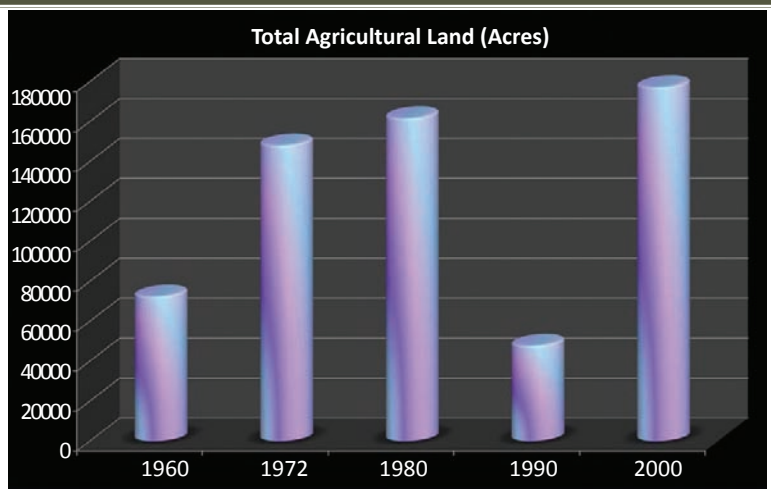
Farmlands Also Vanishing



***(Source:** Department of Geography, University of Karachi)*

Fig. 25

What is Happening in the Agricultural Lands!



***(Source:** Department of Geography, University of Karachi)*

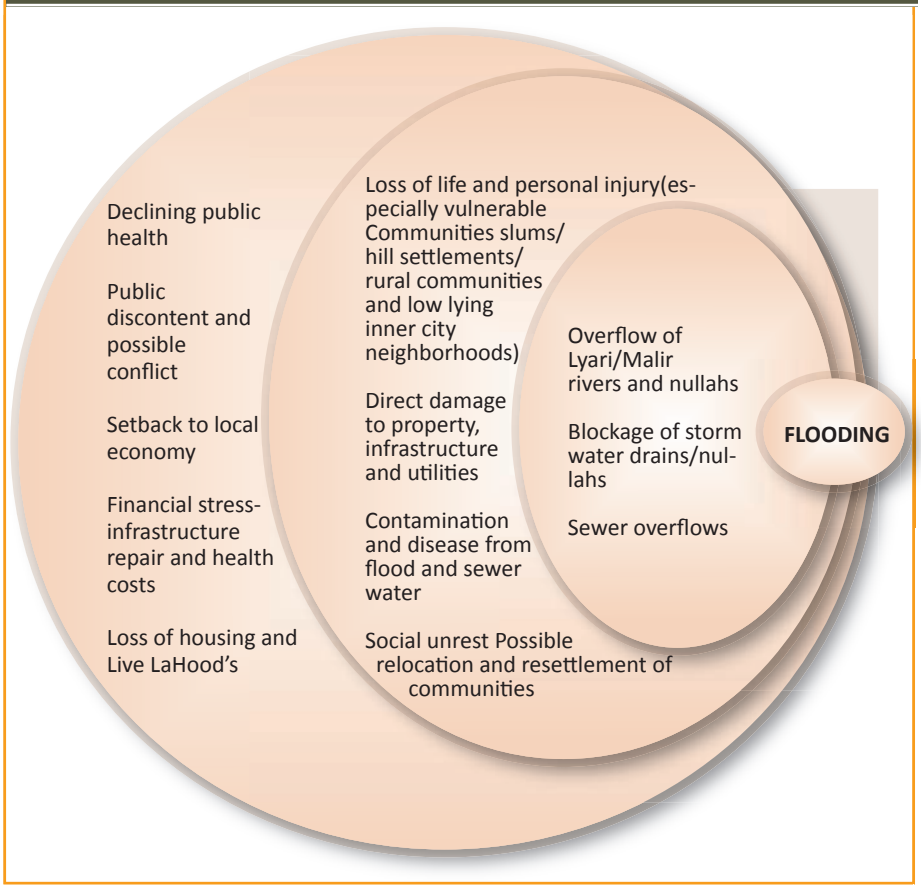
their contribution to the national economy and growth. Issues related with the way we are managing (mismanaging!) the city land and institutions further complicate and magnify an already existing risk.

The focus has been to take either a fire-fighting approach with all the associated inadequacies in response mechanisms in tact or to take short term ad-hoc measures with no sustainability attached to them. Climate change adaptation is all about being prepared. From reducing the risk of damage to being better equipped to meet the possible consequences is what adaptive capacity is all about. For that to happen, a paradigm shift in planning priorities is required. The need is to move urgently on multiple fronts to address this issue that may include an intensified focus on research and analysis and implementation of relevant policy frameworks for facilitating required planning and project based interventions.

The scope of the *Study* could not allow detailed focus into a number of cross-cutting themes such as possible impact and consequences for the local economy, social and larger scale governance aspects etc. However they are also of fundamental importance as a climate change scenario has what can be called as a *cascading effect* with one sector of the urban scene linking with the other to create a complicated collage of short and long term damages and setbacks to the growth process of the city.

Fig. 26

Karachi City - Cascading Consequences for 'Flooding'



DROUGHT

Drought is caused by lack of sufficient rainfall. Droughts can either be short and sharp, or prolonged.Judicious management of water resources, in terms of meeting the supply and demand gap can greatly reduce the possible adverse impacts of a drought upon us and on the environment. Within the context of drought, the following focus areas are being considered:

Drought – Possible Impacts

- Reducing river flows
- Reducing ground water replenishment (recharge)
- Increasing evaporation
- Increasing loss from broken water mains due to increasing subsidence
- Increasing demand for water from people and wildlife
- Adverse impacts on people and livelihoods dependent on farming

- Public water supply (the Hub River Source)
- Urban farming and agriculture (Rural Karachi)
- Bio-diversity

Water supply

About 90 % of population in Karachi use the water supplied by the sole public water service provider – the *Karachi Water & Sewerage Board* – (KW&SB) through pipelines or by tankers and the remaining 10% of population may depend mainly on groundwater.[17]

A system already in stress

There is intermittent supply of water at low pressure through rationing and in most parts of the city water is supplied once or twice a week, each time for the duration of several hours. The percentage of non-revenue-water (NRW) is high owing to leakages (decaying infrastructure), theft and an unsatisfactory status of revenue collection. In most parts of the city, residents are obliged to spend money on constructing underground water tanks,suction/booster pumps, rooftop storage tanks, and water filtering systems. As such, while the basic cost of piped water in Karachi may be cheap, the associated indirect costs are unreasonably high.

The expense of not having an adequate supply of potable water is compounded by the inevitable medical bills resulting from the treatment of water-borne diseases (typhoid, cholera, and hepatitis are common) and the loss of income due to sick time.

Rising water demand

The population of Karachi was estimated to be 4.4 million at the time of independence in 1947 but it has undergone numerous expansions. According to the census in 1998, its population was 9.8 million. Its current population is informally estimated in the range of 18 million. In future, it could be the second largest city of the world(Butler, 2005), as it is expecting to accommodate27.5 million people in 2020 (CDGK-MPGO, 2007).

Water Supply Sources

The Indus river, the main source of water for Karachi, is severely constrained by dry season demand, but has abundant wet season discharges. Urban and industrial water for Karachi is taken from the Kotri Barrage and discharged through the KalriBaghar Feeder Upper (KB Feeder Upper) to KinjharLake.Kotri Barrage is the lowest barrage on the River Indus.Kinjhar Lake is a natural reservoir with a catchment area of 910 km2

The Hub Dam is a multi-purpose dam (municipal, industrial and irrigation purposes) constructed on the Hub River approximately 50 km to the north-west of Karachi City. The catchment area of the dam extends across two provinces namely Sindh and Balochistan covering a total area of 3,410 sq miles (8,730 km2). There has been an agreement between the two provinces that, at the Regulator located at the end of the Hub Main Canal, 63.3% of the total flow from the dam will be diverted to the Karachi Water Supply Canal (Sindh) while 36.7% to the Lasbela Canal (Balochistan)

Dumlottee Well Field built by the British in the latter half of the 19th century located on the banks of Malir River in the Dumlottee area about 30 km to the northeast of the city. A number of large diameter shallow wells constructed in the Malir River alluvium provided about 8 mgd of water to Karachi through a gravity conduit. For many years since then, the well field remained as the main source of supply for Karachi with supply being augmented in a phased manner. However, the supply from this system has gradually decreased over time to 4 mgd by 1985, and to 1.5 mgd in 2002 and afterwards. At present, this system can produce merely 1.4 mgd of water during only a few months after the rainy season.

Source: *The Study on Water Supply and Sewerage System in Karachi, the Japan International Cooperation Agency (JICA), 2008*

[17] The Study on Water Supply and Sewerage System in Karachi, the Japan International Cooperation Agency(JICA), 2008

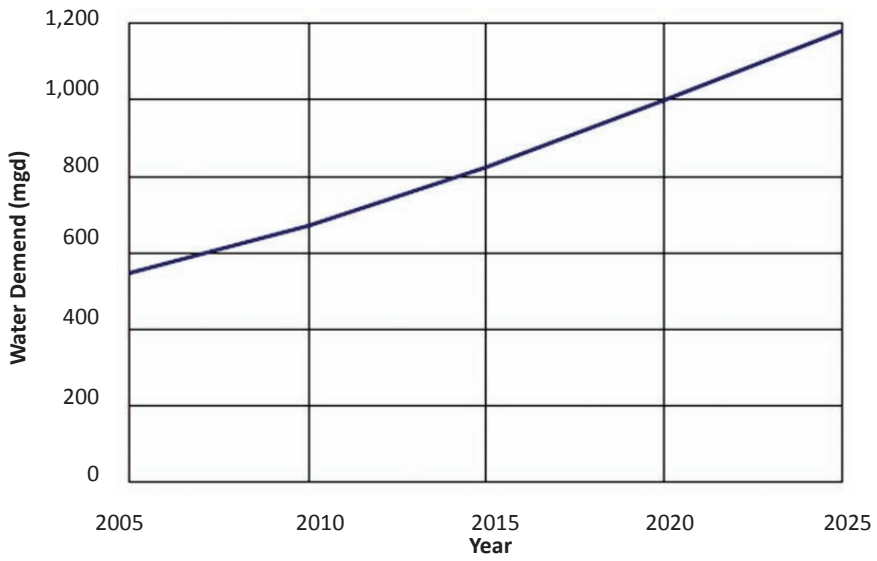
With the phenomenal increase in population will develop an ever greater demand for water from an already stressed water utility. The Study on Water Supply and Sewerage System in Karachi prepared by the Japan International Cooperation Agency (JICA) in the year 2008 estimates that the water demand would increase to 1,182 mgd by the year 2025.

At risk – the Hub river/dam service area

If we consider the water supply sources for Karachi City in the context of a possible drought scenario than the Hub river/dam source is most relevant. Completed in 1981, the dam was first filled up in 1984. It was again filled up in 1989, 1992, 1994, 1995 and 2003. The last time the dam was filled up was August 2007. **During the 8 years from 1995 to 2003, the dam was never filled up (reduced rainfall – drought).As a result, the supply from the dam reduced to almost zero during the four years from July 1999 till June 2003.**[18] Five major localities in Karachi inhabited by about 5 million residents are dependent on the Hub river source. Following the drought period (199-2003) when immense problems were faced in meeting the water demands of the affected population, the KW&SB initiated a project linking the Indus river supply with the pumping station at *Manghopir* (from where water sourced

Fig. 27

Karachi Water Demand

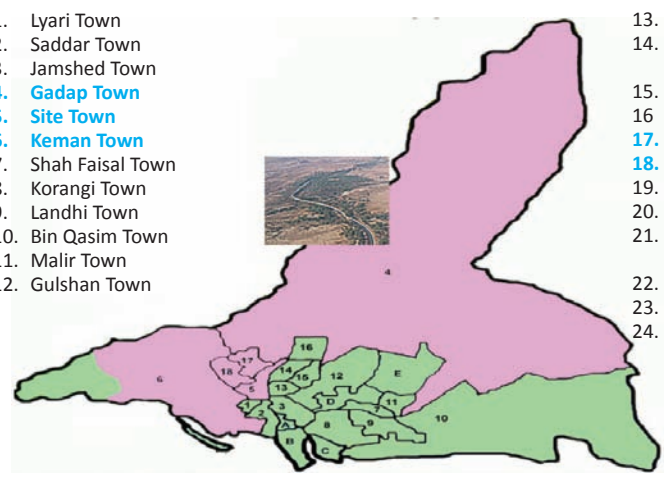


Source: *The Study on Water Supply and Sewerage System in Karachi prepared by the Japan International Cooperation Agency (JICA), 2008*

Fig. 28

Public Water Supply
(The Hub River Source – (100 MGD)
Service Area/POPULATION SERVED – 5 million

1. Lyari Town
2. Saddar Town
3. Jamshed Town
4. **Gadap Town**
5. **Site Town**
6. **Keman Town**
7. Shah Faisal Town
8. Korangi Town
9. Landhi Town
10. Bin Qasim Town
11. Malir Town
12. Gulshan Town
13. Liaquatabad Town
14. North Nazimabad Town
15. Gulberg Town
16. New Karachi Town
17. **Orangi Town**
18. **Baldia Town**
19. A. Karachi Contonment
20. B. Clifton Contonment
21. C. Korangi Creek Contonment
22. D. Faisal Contonment
23. E. Malir Contonment
24. F. Manora Contonment



[18] The Study on Water Supply and Sewerage System in Karachi prepared by the Japan International Cooperation Agency(JICA), 2008

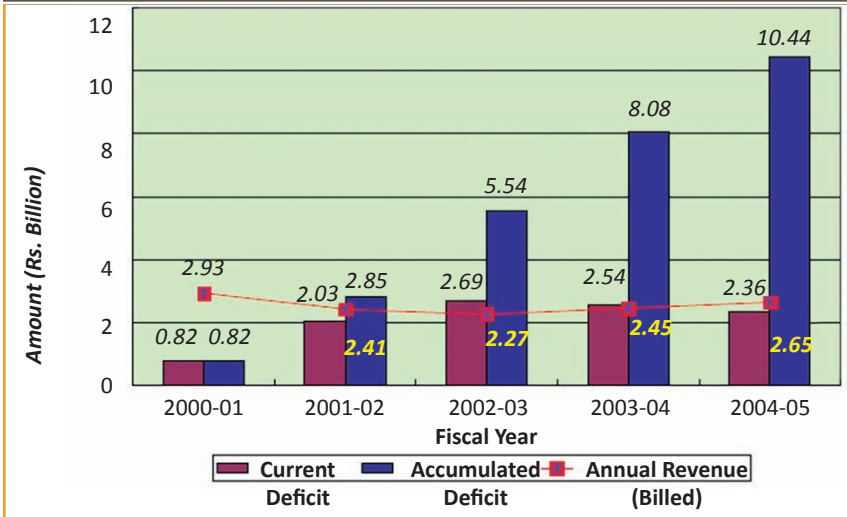
from the Hub dam is supplied to the city) so that in case of water scarcity at the Hub source, the water supply from the Indus source can be diverted.However, as even the Indus source is under stress and not meeting the existing demand, this measure cannot be a very viable solution in the long run when demand is expected to increase substantially.
The socio-economic profile of a majority of the residents of the service area would also place them in a vulnerability context.

KW&SB – utility in stress

As discussed, Karachi already faces a high supply demand gap and population pressures leading to increased demand are likely. Rainfall is already limited and the impacts of a likely drought period could be severe. However the capacity of the service provider to meet the possible consequences may be a greater cause of concern. If one only looks at its financial status than the situation is quite grim. Examination of the financial statements of KW&SB for recent years shows an extremely worrying trend as regards its short term financial positions. Over recent years, KW&SB has continuously been operating in deficit. The annual deficit ranges from Rs.2,000 to 2,700 million (US$33.3 to 45.0 million). At the end of the fiscal year 2004/05, the accumulated deficit totaled to Rs. 10,435 million (US$173.9 million). These deficits have eventually been subsidized by

Fig. 29

KWSB Financial Crisis



Source: *The Study on Water Supply and Sewerage System in Karachi prepared by the Japan International Cooperation Agency (JICA), 2008*

Fig. 30

Water Supply at a Glance

POPULATION **18 MILLION**

MAXIMUM WATER DEMAND (@ 54 gpcd) **972 MGD**

MINIMUM DEMAND (@ 30 - 54 gpcd) [Av: 42 gpcd] 756 MGD

AVAILABLE SUPPLY **680 MGD**

- **INDUS SOURCE** (KINGER LAKE SURFACE WATER)
  - Greater Karachi 280 mgd
  - Gharo 28 mgd
  - K-II 100 mgd
  - Additional 40 mgd
  - K-III 100 mgd
  - Steel Mill 22 mgd
  - PQA 08 mgd

  578 MGD
- **HUB DAM** (SURFACE WATER) **100 MGD**
- **DUMLOTTEE WELLS** (GROUND WATER) **2 MGD**

WATER LOSSES (35%)

Total : 680 MGD

(Source: *KW&SB)*

federal and provincial governments.[19] To detail the other serious challenges being faced by the KW&SB in terms of technical, management constraints and a larger enveloping crisis of institutional governance would require a separate study in itself.

At risk – rural economy and livelihoods

Historically and also supported by the nature of the physical landscape, resource availability and topography, the rural hinterland of Karachi has been distinguished by its agriculture and grazing based land use and associated economy and culture. The *Karachi Development Plan* 1974-85 had stated that Karachi *can respond to the challenge of rapid urbanization, building on the achievements but rejecting the destructive practices of the past. The opportunities are there. The metropolis lies at the edge of a hinterland that makes it possible to create an efficient agro-urban complex, using urban wastes to support the production of much of the food supply needed by the urban population.*

While the agro-urban economy and associated livelihoods of Karachi are threatened due to a variety of factors that are beyond the scope of this Study, a focus would be given to state of the water resources critical to sustaining the sector economy. Source of water for irrigation and farming is sub-surface water. The resource base is threatened from two serious resource management challenges. One, the rapid depletion of the available water due to resource mismanagement that may include over-abstraction, water intensive farming among other factors is mostly responsible for rapid lowering of the ground water table and two, destruction of the aquifer mainly due to uncontrolled and unregulated sand mining and extraction to sustain the construction activities within the city.

Farming – Still providing livelihoods to a large community
Farhan Anwar, Shehri-CBE

The ever descending water table
Department of Geography, University of Karachi

There is limited if any focus on harvesting already limited water resources or initiating measures to promote water conservation or facilitate recharge of the aquifers. *Malir River* has been providing some of the important construction material like gravel and sand for a long time. This gravel and sand has been excavated since 1940s, however, the rate of excavation and the geographical spread of the activity has scaled up considerably in the last decade or so.

Exposed and vulnerable
Farhan Anwar, Shehri-CBE

An average sand mining truck approximately carries 318 cubic feet of gravel. At an average about 1000 such sorties are undertaken in a day. It is indicated that most of the river belt has now been excavated up to a depth of 20 feet. In some places the removal has reached to a dangerous level mark of 30 feet.[20] Possible salt water intrusion from the sea may also become an issue where

[19] The Study on Water Supply and Sewerage System in Karachi prepared by the Japan International Cooperation Agency(JICA), 2008
[20] Department of Geography, University of Karachi, 2007

coastal groundwater levels drop due to over abstraction, reduced recharge and sea level rise.

Over abstraction – damaging the aquifers
Department of Geography, University of Karachi

The need to preserve and enhance to the extent possible the existing ground water resources and protect it from unsustainable uses is urgent. In 2004, *KW&SB* conducted a study to explore the possibility of developing groundwater sources in the region as a source of water supply for Karachi. The study was titled *Feasibility Study to Explore Groundwater Source in Karachi District* and explored the availability of groundwater from the basins of *Malir, Gadap, Lyari* and *Hub* to supplement the existing supplies. After extensive surveys and analyses, this study concluded that since there was limited precipitation and minimal groundwater recharge in Karachi, the sustainable yield of ground water was already in balance with the existing pump discharge from about 1,000 existing wells and it was difficult to develop new wells. *The Study on Water Supply and Sewerage System in Karachi,*prepared *by the Japan International Cooperation Agency (JICA), 2008 went further* by recommending that *more stringent controls should be put in place on the construction of new wells in order to maintain the current groundwater balance in the region.*

Bio-diversity

To provide a sample and a glimpse of the possible impacts of drought on bio-diversity already under water stress, a profile is provided of the *Khirthar National Park* – the largest national park in Pakistan containing many threatened and protected flora and fauna specie including the *Sindh urial* or wild sheep (gad) and the Sindh Ibex or wild goat (sarah).[21] Not many people are aware that part of the *Khirthar National Park* constitutes 20% of the District Karachi landmass!

Khithar National Park – endangered wildlife

As a result of low average annual precipitation, and the concentration of rainfall in a short monsoon season, there are no permanent rivers in the Park. Groundwater discharging from springs or drawn from wells provides the only source of water to sustain wild and domestic animals, irrigation and human use in the *Khirthar National Park.* In the year 2000, a *Baseline Environmental Study* of the *Khirthar National Park* was conducted by a team of scientists and academics from the *University of Melbourne, Australia.* As part of the *Study,Ground Water Modeling* was also done that indicated a precarious water balance with the water resources already under severe stress. It was found that the steep gradients and short length of streams in the mountains will result in a very short time of *concentration* for runoff, and consequently, there will be only a short period for infiltration through the beds of mountain streams. Therefore little recharge is expected in the mountains.

It was estimated that total consumptive use of water by *evaporation* from irrigated land in the Park was between 10,000 and 20,000 ML/a. This was 10-25 times greater than the amount drawn for drinking (around 800 ML/a), water supplies for domestic animals (around 270 ML/a) or taken by wild animals (around 40 ML/a).

Ground water recharge to aquifers in the Tuang Valley was estimated to be around 9000 ML/a, but *withdrawal* for *irrigation* was found to be around 28,000 ML/a. Though figures, it was stated were subject to errors of estimation but it was

[21] Sindh –State of Environment & Development, 2004, IUCN, The World Conservation Union, Pakistan

Critical Challenges

- It seems efforts have been shelved for now to assess the ground water potential of Karachi – e.g. recharging the aquifers in the Malir river basin by setting up infiltration basins/check dams to facilitate rain water storage/harvesting and recharging of aquifers
- A major hindrance is the absence of a ground water use policy in Pakistan – Karachi can take the lead in this regard by formulating a 'ground water use policy for Karachi!
- Lack of focus on promoting conservation and recycling practices to reduce stress on available fresh water resources
- Funding constraints to rehabilitate decaying urban water supply infrastructure

clearly evident that the ground water resources of the *Tuang Valley* in the *Park* were already overdeveloped.

End note

The probability of a drought affecting Karachi would depend upon how much rain falls, how long are periods of reduced rainfall, and how sensitive the supply-demand balance for the various service areas is to drought. Ideally, based on such an analysis the water service provider could divide its supply area into smaller *water resource zones,* which are defined on the basis of water supply connectivity. Such estimation for us does not exist. However for us, a critical realization should be that a drought scenario will not bring a crisis, it may aggravate an already existing crisis. There is a need for the *KW&SB* to move on a number of fronts. There is an urgent need to reduce the loss of water through leakage management that can happen within the context of a larger initiative to rehabilitate the decaying infrastructure and prevent theft. Water efficiency can be improved through introducing water metering that can lead to proper estimation of demand and development of related trends in fluctuations in uses and also identifying the more water stressed areas. There is a need to promote water conservation practices both at the service provider and the consumer level. There is huge water efficiency potential in using reclaimed water for non-potable uses. The focus presently is directed mostly on augmenting water supply (e.g. focus on K-IV project to bring 100 mgd more water for Karachi for the Indus river source). Though an option in itself, it can only provide optimal benefits if other factors mainly at the distribution level that are hindering efficiency in water supply and usage are tackled on an urgent basis simultaneously, if not with a greater priority. However, for all this to happen, the water utility needs to be financially viable to begin with. A political will for holistic institutional reforms backed by relevant policy and administrative interventions are the only way to address this challenge.

Within the context of the rural agro-urban sector in Karachi, there is an urgent need to protect and replenish the ground water resources through relevant policy and project based interventions in addition to looking at promoting judicious use of the water resources. This can happen within a larger framework of protecting the threatened land use of the rural hinterland and developing a new vision of this land mass and related economy as a viable and sustainable source of providing food security for Karachi and also acting as a barrier to the unplanned, unregulated and unsustainable urban sprawl.

EXTREME HEAT EVENTS

Heat waves are typically defined as extended periods of hotter than average temperatures, although the precise timing and temperature differential varies regionally. Within the context of extreme heat events, the following focus areas are being considered.

- Urban Heat Island Effect (natural and anthropogenic factors)
- Increasing water usage

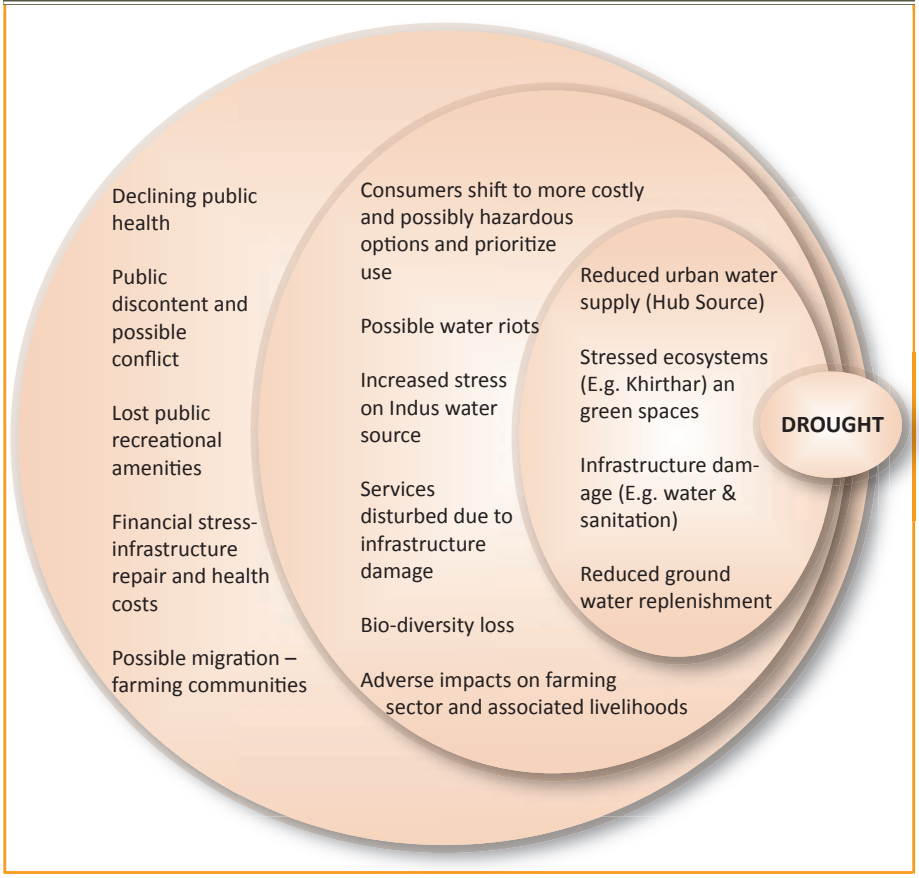
There is a lack of specificity in the definition of an extreme heat event or heat wave due to the importance of local acclimatization to climate, which varies geographically. Previous research shows that populations in different locations have varying abilities to deal with temperature extremes. For example, studies in *Phoenix* (US) have found no statistically significant relationship between mortality rates and high temperatures below 43°C, while in *Boston* (US), an increase in the rates of mortality is observed at 32°C.[22]

Extreme Heat Events - Possible Impacts

- The 'Urban Heat Island' effect
- Increasing water usage
- Increasing energy demand for cooling – air conditioning
- Increased 'load shedding'
- Heat related illness and deaths
- Damage to temperature related infrastructure (such as electrical systems and transport networks)

Fig. 31

Karachi City
Cascading Consequences for 'Drought' and Reduced Rainfall



There can be several explanations for these variable responses. If extremely high temperatures occur at infrequent intervals then the residents may not have the proper level of preparedness to cope with sudden variations. Housing structures have a role to play as in places where cold weather is more of a norm,most homes are built from heat-retaining materials and few homes have central air conditioning. As a result, during extreme heat events, ambient air temperature inside such homes can be dangerously high. As a result of climate change, extreme heat events are predicted to become more frequent, intense and longer lasting over most land areas. In the case of Pakistan generally and In Karachi particularly, temperature levels are expected to rise. In Karachi, generally summers are hot and prolonged and temperatures in excess of 30^{0}C are quite the norm. During the *Study,*no such data could be located which could indicate deaths due to sustained more than average heat waves – say in excess of 40 ^{0}C.

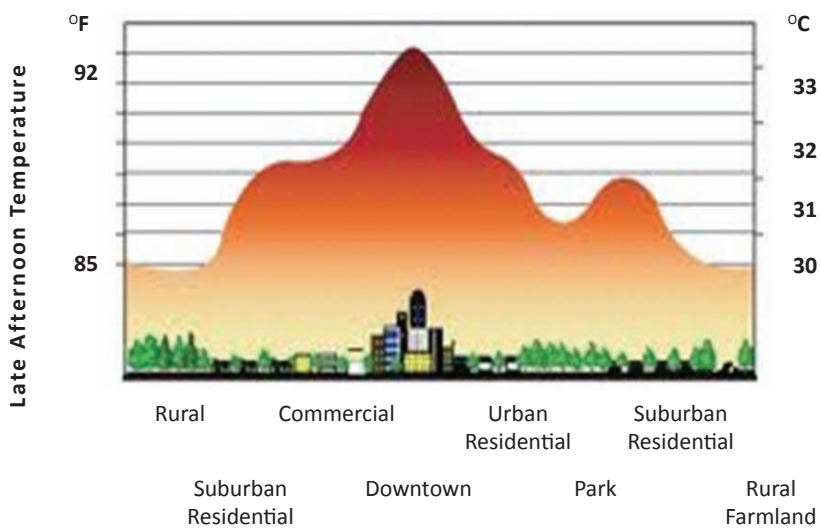
[22] Global report on human settlements 2011,United Nations Human Settlements Programme

Urban heat island effect

Urban settlements due to their specific land use and development profiles can generate unique local conditions while interacting with heat events. The most significant of such effect in the context of climate change and extreme heat events is known as the *Urban Heat Island effect. The urban heat island* describes the warmth of the surfaces and atmosphere that urban areasoften experience in comparison to the rural areas that surround them. Compared to rural areas, cities tend to have higher air and surface temperatures due to the urban heat-island effect.

Fig. 32

The Classic Urban Heat Island Effect Profile



The Urban Heat Island Effect

The fabric of buildings and roads that make up the urban realm absorbssolar energy. By earlyevening, the buildings androads start to radiate this stored energy as heat,which escapes slowly, especially in narrow or tallstreets where it is re-absorbed and re-radiatedfrom the buildings that line the street. Thisabsorption and retention of heat is why urbanareas can be warmer at night than rural areasand is known as the 'urban heat island effect.

For the average developed country city of 1 million people, this phenomenon can cause air temperatures that are 1°C to 3°C higher than the city's surrounding area. At night, when urban heat-island effects are strongest, temperature differences can reach 12°C. By increasing temperatures, urban heat-island effects can aggravate the heat-related negative implications of climate change and impose costly energy demands on urban systems as they attempt to adapt to higher temperatures.Extreme heat events negatively impact upon human health and social stability, increase energy demand and affect water supply. Heat waves are more likely to impact upon vulnerable populations, including the elderly, very young, individuals with pre-existing health conditions and the urban poor. The urban poor indeveloped countries are especially at an increased risk from extreme heat events because of their low adaptive capacity.[23]

The scale of these effects is however, not uniform across cities. The physical layout of a city, its population size and density, and structural features of the built environment all influence the intensity of the *urban heat island effect*. In some cities, the heat generated by traffic movement, air conditioning systems, industrial emissions and other energy uses builds on the heat being radiated from the buildings and roads, further raising temperatures. This can be termed as an *anthropogenic* (man-made)contribution to the urban heat island effect.

[23] Global report on human settlements 2011,United Nations Human Settlements Programme

Karachi – a potential for urban heat island effect?

In Karachi it is difficult to assess if the urban heat island effect is taking place and if so at what strength.As heat waves affect the whole of the city, mapping the intensity of the urban heat island represents the best available measure of determining how temperatures vary across a city. Surface temperature mapping is the best way at assess the likelihood and intensity of the phenomenon. However, available data on land surface temperatures in Karachi is inconclusive owing to its random nature and not being specific to determining urban heat island *effect.* Karachi has the potential of developing a typical temperature profile of an urban heat island, where temperatures rise from the rural fringe towards the city centre.

Following are factors in urban growth in Karachi that may contribute or are already contributing to raising the temperature levels in the city due to human actions.

Population density

There is a strong relationship between density of development and intensity of the urban heat island. Karachi's population is expected to increase to 27.5 million by 2020.[24] The population density within the core of the city is on the rise and is projected to increase even further in the next decade and more . According to the *KSDP* 2020:

> *With mounting pressures exerted by the population growth over the last two decades, two basic trends in land use are observed. Recently, commercial growth has taken place along major arterials. While most residential neighborhoods have acquired one or two storey structures, significant densification has taken places through construction of upper floors and subdivisions of large plots. In many old and new areas, apartment buildings, 5-6 storeys high, have replaced the low-density bungalow type housing.*

Then there are some other developments that given our experiences in ill planned development are raising some serious concerns. The provincial government of Sindh passed the *Sindh High Density Development Board Bill,* 2010 in the provincial assembly on May 31, 2010, that was assented to by the *Governor of Sindh* on June 20, 2010 and through a Notification issued on June 24, 2010 was made an Act of the Legislature of Sindh. The *Act sanctions the Board to identify and earmark the high density zones in the urban centers of the cities of the province and in consultation with respective utility agencies, keeping in view the general principles of the Master Plan.* High Density Zone is described as *an area designated under the Act for construction of high rise buildings in the urban centers of the Province.*

An ever expanding city
Mohammad Arshad, Shehri-CBE

[24] Karachi Strategic Development Plan 2020

Citizens Protest!

A *Resolution* was passed in a Seminar organized by *Shehri-CBE* that clearly indicates some fundamental crisis in urban development in Karachi. Relevant excerpts are quoted below:

Having gathered here today, 16th June 2011, at the Auditorium of the IEP, Karachi, to examine:

- *The Sindh High Density Development Board Act 2010, and*
- *The Sindh High Density Development Board (Rules & Procedures) 2011*

We citizens (engineers, architects, town-planners, environmentalists, economists, other professionals, activists and concerned members of the public) express our disappointment and dismay at the legislation and rules that have been passed by our parliamentary and government representatives allegedly for the benefit of the city and its residents.

The relevant issues include:

1) The recommendations made by leading professionals of Karachi in the lead up to these legislation/rules have been entirely set aside or diluted beyond recognition.

2) While purporting to *"identify and earmark the high-density zones in the urban centers of the cities of the province, in consultation with the utility agencies, keeping in view the general principles of the Master Plan"* (extract from the Act 2010), the legislation and rules have only been simplistically and crudely amended to permit:

a) enhanced building sizes on existing plots (up to twelve times more)
b) amalgamation of plots (up to any size)
c) commercialization of residential properties
d) elimination of set-backs (required for ventilation and sunlight penetration), and
e) inadequate parking facilities

3) The corresponding strengthening of the utility services, and expansion of the physical and social infrastructure (which will not be so simple to implement) has been disregarded. The implication on the rest of the city has been overlooked, and the poorer sections of society have been forgotten

4) Such over-exploitation of the city will convert what is left into a concrete jungle, and destroy the social fabric. Amenity plots all over the city are being ruthlessly grabbed by encroachers today, while the government looks on silently. Utilities (water, gas, electricity) are becoming scarcer with each passing day, traffic chaos is multiplying, law and order is deteriorating and pollution will soon overwhelm us. Protests, public riots and violence are increasing.

5) It is imperative that planning must be realistic, simple, and in line with our countries resources, both physical and human. While imitating the developed countries is fashionable, we must try for the possible.

While the development of a High Density Zone in itself is something quite normal for a large urban settlement, the history and practice of disregarding the relevant social and environmental consequences and lack of transparency of major urban development projects in Karachi and in the province generally has made the citizens wary of the likely adverse consequences should such a plan is put into practice. Maybe a discussion and focus on climate change and an urban heat island effect can provide an appropriate context for stimulating discussion regarding this government decision.

Transport

Automobile load on the roads is increasing with more emphasis on the use of private vehicle. During 1990 to 2008, the observed growth in vehicles is comparatively greater than the population growth. There were 1,113,000 registered vehicles in Karachi in 2002 and 8,420,000 registered vehicles in 2007. During this short time period, we saw the regular growth in vehicles. The observed

growth during this time period is about 656% and it is many time more that the growth in urban population.[25]

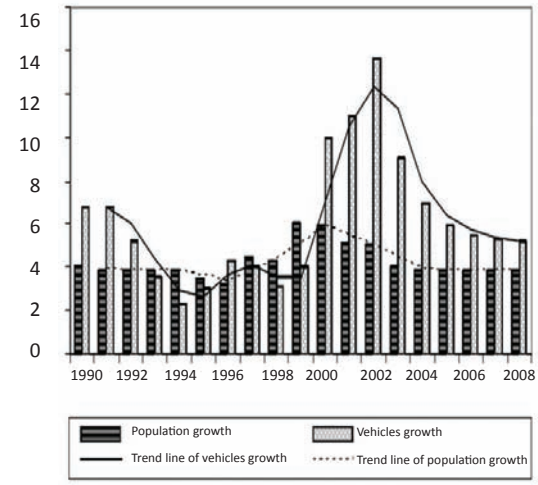
The numbers are likely to grow multifold. In the *JICA demand forecast study - Special Assistance for Project Formation (SAPROF) for Karachi Circular Railway Project, 2009* - vehicle ownership in 2020 was estimated at 61.6%. With the average number of household members taken as 3.9, which was obtained from the *JICA* person *trip study,* the number of households in 2020 was estimated at about 7 million and the number of vehicles owned estimated at about 4.3 million - equivalent to 156 vehicles per 1,000 people..

Promoting private transport use
Mohammad Arshad, Shehri-CBE

Fig. 33

Population and Vehicular Growth

There were **1,113,000** registered vehicles in Karachi in **2002** and **8,420,000** registered vehicles in **2007**. During this short time period, there was a regular growth in vehicles. The observed growth during this time period is about **656%** and it is many time more that the growth in urban population!



Source: *The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi S. H. Sajjad, N. Blond, A. Clappier, Asif Raza, Safdar Ali Shirazi and Khadija Shakrullah, African Journal of Biotechnology Vol. 9(13), pp. 1941-1948, 29 March, 2010*

The emission of air pollutants is directly related to fuel consumption. Pakistan's consumption of petroleum products is growing at an annual rate of approximately 6 per cent, almost half of which is consumed by the transport sector[26]. Vehicle-generated air pollution is severe, with high concentrations of fine and ultra fine particles in the air which can cause respiratory problems among a large number of Karachi's urban residents (ADB, 2005b). The fastest growth in mobile sources has been in two-stroke delivery vehicles, but the number of diesel trucks and buses has also increased up to three times. International experience indicates that a major share of the emission load from motor vehicles can beat tributed to a relatively small number of smoky diesel and two-stroke vehicles (ADB,2005x). The main sources of ambient air pollution in Karachi are old and ill-maintained vehicles,waste burning (8,000 tones of waste generated/day), re-suspended dust, and smallscale businesses using 'dirty fuels' for manufacturing and production purposes. Air pollution levels in Karachi are extremely high by international standards and rising each year (WB 2005).

[25] The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi S. H. Sajjad, N. Blond, A. Clappier, Asif Raza, Safdar Ali Shirazi and KhadijaShakrullah, African Journal of Biotechnology Vol. 9(13), pp. 1941-1948, 29 March, 2010

[26] A Strategic Approach for Air PollutionReduction in Karachi,Dieter Schwela, Gary Haq and Mohammad Aqib Uddin, Stockholm Environment Institute, IUCN, Pakistan Clean Air Network

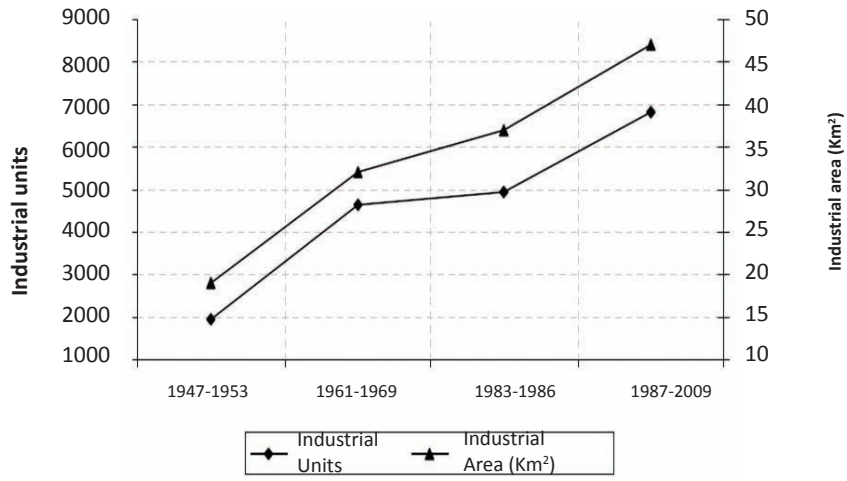
While regularly updated data on vehicular emissions is not available some recent surveys indicate a significant air quality implication of the growth in traffic load. Ambient air quality monitoring including SO_2, NO_2, CO, CO_2 and PM_{10} was carried out at 4 locations along the *Karachi Circular Railway* (KCR) route for the *Special Assistance for Project Formation (SAPROF) for Karachi Circular Railway Project, 2009.* The various sources of air pollution in the project area were indicated as industrial emissions, vehicular traffic, and dust arising from field road side and construction activities. The prime objective of baseline air quality survey was to determine the baseline of ambient air quality in and around the KCR route.The ambient air quality data indicated much higher value of suspended particulate matter at all the four locations than the prescribed limits. The values of SO_2, NOx and CO were found to be within or slightly over the permissible limits.

Industrial growth

The major industrial development in Karachi was during 1947 to 1969 and during 1986 to 2009. The high growth rate in urban population and urbanization was also observed during in the era of industrialization. The computed growths in industrial units and industrial area are 249% and 147%, respectively. It clearly shows that the proportion of increasing trends between industrial units and area is not uniform and the industrial zones became denser with time.[27] The emissions from industrial sources are discussed briefly in the overall context of fossil fuel consumption and C02 emissions separately.

Fig. 34

Industrial Growth on the Rise!



Source: *The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi -S. H. Sajjad, N. Blond, A. Clappier, Asif Raza, Safdar Ali Shirazi and Khadija Shakrullah, African Journal of Biotechnology Vol. 9(13), pp. 1941-1948, 29 March, 2010*

Fossil fuel consumption and CO_2 emissions

Consumption of coal in 1980 was 262,000 short tons that increased to 1,009,000 short tons in 2007 with an increase of 285%. During 1993 to 2000, the coal consumption was quite stable but during 2000 to 2006 increased a lot. This rapid increase is mainly due to increase of consumption of coal in cement industry. The per day consumption of oil and petrol jumped from 16,000 barrels in 1980 to 51,000 barrels in 2007 with an increase of 219%. This oil and petrol are mainly used in transport and power sectors (Sheikh, 2010). After 1993, along with the transport sector, the consumption of oil increased mainly due to usage of oil in thermal power stations which were established just after 1992 (Pakistan, 1994). After 2001, thousands of the old diesel engine vehicles were replaced by the compressed natural gas (CNG) engines. Consumption of natural gas increased from 40 billion cubic feet in 1980 to 186 billion cubic feet with an increase of 365%. Its consumption has been regularly increasing with time. It is mainly consumed in power generation, industries and houses. Its consumption in transport sector is vibrantly increasing with time.

[27] The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi

CO_2 emission

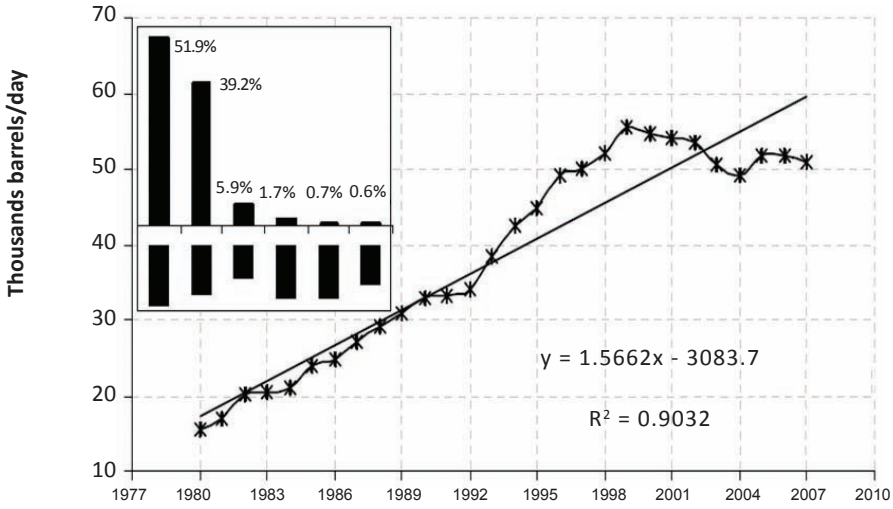
Total per-capita energy consumption in Pakistan is 12.4 million BTUs (1 BTUs = 1,055.055 joules) that contributes 0.7 metric tons per-capita energy related CO2 emission in environment. Figure 9 is showing the regular increase of CO2 emission in atmosphere over Karachi. The rate of emission of CO2 is not only rapid but it is showing a regular and positive trend without any significant down fall throughout the computed time. It is observed that the CO2 emission in atmosphere has reached up to 151 million metric tons in 2006 that was just 39 million metric tons in 1980. This 287% increase in CO2 during 1980 to 2007 is the result of mass urbanization and energy consumption in Karachi

***Source**: The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi*
S. H. Sajjad, N. Blond, A. Clappier, Asif Raza, Safdar Ali Shirazi and Khadija Shakrullah, African Journal of Biotechnology Vol. 9(13), pp. 1941-1948, 29 March, 2010

A few critical *vulnerabilities* to be highlighted that render the power generation facilities and systems under severe stress during extreme heat spells include extended and sustained load shedding schedules (supply-demand gap) and frequent tripping of generation units.)

Fig. 35

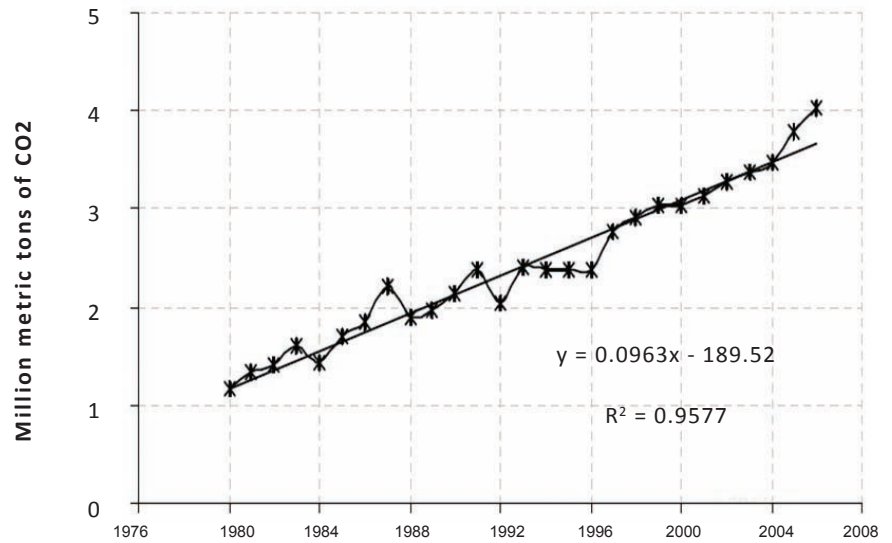
Karachi City - Energy Consumption Trends



***Source:** The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi - S. H. Sajjad, N. Blond, A. Clappier, Asif Raza, Safdar Ali Shirazi and Khadija Shakrullah, African Journal of Biotechnology Vol. 9(13), pp. 1941-1948, 29 March, 2010*

Fig. 36

Karachi City - Co_2 Emissions Profile



***Source:** The preliminary study of urbanization, fossil fuels consumptions and CO2 emission in Karachi -S. H. Sajjad, N. Blond, A. Clappier, Asif Raza, Safdar Ali Shirazi and Khadija Shakrullah, African Journal of Biotechnology Vol. 9(13), pp. 1941-1948, 29 March, 2010*

Increasing energy demand
Mohammad Arshad, Shehri-CBE

Widening gap in supply and demand
Mohammad Arshad, Shehri-CBE

Water usage

In extreme heat events, a much greater than normal pressure is exerted on the potable water supply sources with increased consumption. As there is no water metering at the retail level in Karachi, there is no way of accurately assessing the fluctuations or trends in water consumption. However, recently a public perception survey in the form of

Informal service provision - Accessing a public water supply network
Mohammad Arshad, Shehri-CBE

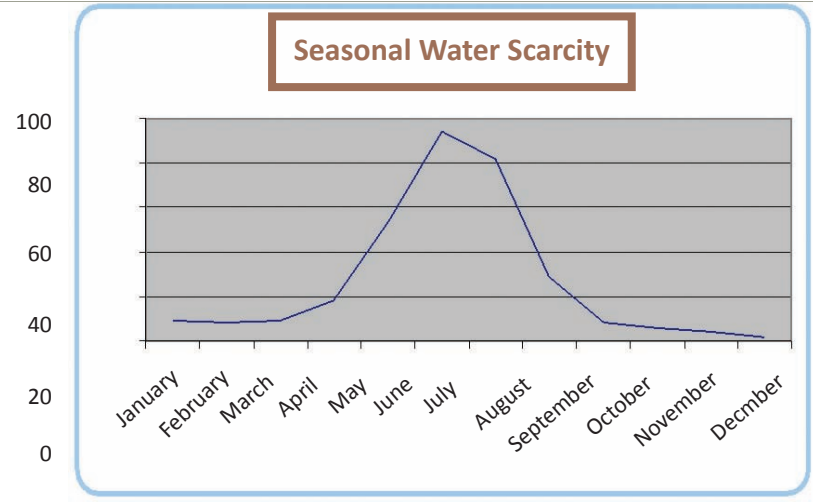
a *Citizen Report Card* (CRC) was conducted at the initiative of the *KW&SB* with the technical support of the *Water and Sanitation Program (WSP)* Pakistan office. Among other service delivery aspects and consumer coping mechanisms it also investigated the water consumption trends and a clear increase in water consumption (based on consumer input) was indicated during the warmer months of the year. Capacity constraints at different levels of the water utility to deal with the associated challenges of increased demand have already been discussed in detail earlier .

Weakening defences

Green spaces (parks/farmlands) reduce the urban heat island by reflecting more of the incoming solar energy than urban materials, as well as absorbing energy through photosynthesis and providing cooling through evaporative transpiration.As already discussed earlier in detail the green cover in the city is decreasing.

Fig. 37

Water Usage Profile – Annual Fluctuations



Source: *Water & Sewerage Services in Karachi – Citizen Report Card - Sustainable Service Delivery Improvements –2010 – KW&SB/WSP*

Critical Challenges

- Critical gaps in our 'understanding' of urban development trends overheating risks and target priority areas
  - Relation between population density and heat island effect
  - Contribution of anthropogenic factors in raising urban heat – traffic/air-condition use etc.)
  - Impact on infrastructure (E.g. power, water, transport)
  - Health impacts
- Shrinking green cover in the city
- Promote a green roof/rooftop garden program
- A transport infrastructure that discourages use of public transport and focuses on promoting use of 'private automobiles'
- Extremely high water and energy loss during transmission and distribution and no promotion of 'water' and 'energy' conservation measures – lack of focus on alternative and environment friendly 'energy sources'
- Critical gaps in the 'health emergency response systems – health/emergency/trauma facilities

End note

Lack of appropriate data and research again act as a constraining factor in determining the presence and extent of the relevant climate change impacts such as the *urban heat island effect*. However, possible contributing factors can be identified and mostly relate with the unplanned and unregulated growth that has now become the norm in Karachi's development scenario. Options for horizontal growth are now negligible if not already exhausted within the inner city and vertical growth scenarios are being considered – however, without proper consideration for the social, environmental safeguards necessary for making them a viable planning and development strategy to accommodate residential and commercial growth pressures.

An appalling lack of focus and priority on providing the city with socially, environmentally and financially viable public transport options has led to a phenomenal growth in the numbers of private vehicle usage that is now globally being discouraged as a sustainable mode of transport in terms of adverse impacts on the environment and sustainable growth of urban settlements. While there is much talk of investing in public transport options, it is a matter of grave concern that the present enhanced focus on specific transport infrastructure such as flyovers is geared to the benefit of the private vehicle user while at the same time acting as possible physical barriers and constraints to the development of a viable public transport system.

The issue of the ever existing and widening supply-demand gap in water supply, related cross cutting concerns and the grave institutional challenges being faced by the water utility – the *KW&SB* - has already been discussed. Yet again here the major cause of concern is on the *prioritization* of actions to tackle the challenges. Focus is largely on augmenting water supply. While such an action can provide benefits in the short run, it cannot on its own provide a viable and lasting solution to the crisis unless it is linked with measures to drastically reduce water loss and actively work to promote water conservation and waste water reclamation practices to lessen the pressure on the already stressed water supply resources. **A new paradigm in water resources management has to be envisioned by working with a basket of options for improved service provision and institutional reforms.**

Fig. 38

- Karachi City -
Cascading Consequences for 'Extreme Heat Events'

SEA LEVEL RISE

Sea-level rise refers to the increase in the mean level of the oceans. Within the context of extreme heat events, the following focus areas are being considered.

- Damage to bio-diversity/ecosystems
- Damage to sensitive government installations and residential/recreational and commercial properties
- Livelihoods loss – fishing communities

Sea level rise, by itself and in combination with other coastal hazards, such as intense storms and the effects of climate change, can have many interacting consequences. Possible hazards include:

- Rising water table
- Salt water intrusion
- Inundation and flooding
- Storm surge
- Coastal erosion

Sea Level Rise: Possible Impacts

- Damage to sensitive government installations and residential/recreational and commercial properties
- Damage to bio-diversity/ecosystems
- Livelihoods loss – fishing communities

Average sea levels have been rising around the world during recent decades, but with significant regional variation. The average rate of rise accelerated from 1.8mm per year between 1961 and 2003 to 3.1mm per year between 1993 and 2003.Sea-level rise is a serious concern for coastal cities as rising water levels and storm surges can cause property damage, displacement of residents, disruption of transportation and wetland loss.[28]

Tropical cyclones are weather systems that are being related with (though the science is not absolutely conclusive) possible rising of sea surface temperatures and consequent sea level rise. They are associated with thunderstorms and strong winds characterized by their wind circulation patterns and a well-

[28] Global Report on Human Settlements,2011,United Nations Human Settlements Programme

defined centre resulting in waves and storm surges (i.e. temporary offshore rise of water) that can damage property and threaten the safety of communities and bio-diversity in the affected area.

Assessing risk

The risks posed by **sea level rise** itself for Karachi may be negligible in the short term and current timeframe but may become a cause for concern in a longer run. However, again, the science and related research is inconclusive but climate change then is all about considering possibilities and dealing with forecasts rather than certainties and *predictions.* The most viable and cost effective approach to minimizing the possible impacts of sea level rise in the longterm is the integration of measures into infrastructure design and development planning in the short term. Such an approach would translate the long term risks of sea level into an active policy and planning, management issue for today.

However, the implications of an extreme weather event such as cyclone have a greater urgency and intensity attached to them for Karachi. Major flooding associated with a major cyclonic event can result in serious damage to businesses and residential complexes, disruption of economic activity (e.g. at the Karachi Port and Fish Harbor) injuries and fatalities, environmental damage due to wetlands destruction, inundation of sewage and damage to low lying residential/ recreational areas and coastal fishing communities. Furthermore, inundation of water during storms can disrupt supply of potable water and contaminate water supplies with saltwater, chemicals and waterborne diseases.

Table 5

Sea Level Rise in Karachi
According to the Studies Carried Out at the National Institute of Oceanography (NIO), the Sea Level Along the Coast of Pakistan has Been Rising Approximately at 1.2 mm Per Year, in Agreement With the Average Global Rise of 1.5 mm Per Year Since 1960. Based on Karachi Tidal Station Records Projections for the Next 100 Years are Estimated at a Rate of 1.1mm/yr Rise

Tidal State	Present State (m)	Projected Level (m) after 100 years
Lowest Astronomical Tide	-0.49	+0.11
Mean Lower Low Water	+0.97	+1.57
Mean Higher Low Water	+1.43	+2.03
Mean Sea Level	+2.04	+2.64
Mean Lower High Water	+2.65	+3.25
Mean Higher High Water	+3.38	+3.98
Highest Astronomical Tide	+3.84	+4.44

Tropical Cyclone Impact

Cyclones are classified as 'storms' when sustained wind speeds reach between 63km to 118km per hour, while a hurricane is a tropical cyclone with sustained wind speeds exceeding 118km per hour

The implications of increased cyclone activity andintensity are far reaching for cities. Power outages duringstorms disrupt transportation, economic activity and supplyof potable water. Physical destruction caused by storms isoften extremely expensive to repair and results in fatalitiesand injuries to humans and wildlife. Furthermore, inundationof water during storms can contaminate water suppliieswith saltwater, chemicals and waterborne diseases

Source:*Global Report on Human Settlements 2011,United Nations Human Settlements Programme*

The National Institute of Oceanography (NIO) is of the view that the ground subsidence rates in the Indus deltaic region due to lack of sediment flux and excessive ground water extraction are probably in the range 2-4 mm per year. The ground subsidence has already resulted in the **sea water intrusion** upstream of the delta extending up to 80 km in the coastal areas of Thatta, Hyderabad and Badin districts (Panhwar 1999; Inam et al. 2007). The main factor considered responsible for intrusion of sea water into the Indus deltaic region is an insufficient flow of Indus water downstream Kotri barrage. An average of 35 maf went downstream Kotri during the period 1976-77 to 2002- 03; it varied between 0.8 maf in 2000-01 (when the IRS inflow was 103 maf) and 92 maf in 1994-95 (when the IRS inflow was 166 maf) (GoP-MoW&P 2005). However, possible scale and impacts of salt water intrusion along the Karachi coast are still not clear.

At risk – people and assets

Without having the facility of appropriate mapping and classification an effort nonetheless is being made to identify and classify areas of future impacts from ocean coastal flooding due to projected sea level rise and storms in order to reduce risk in those areas.

Table 6

Cyclones – Extreme Events

Name/Year	Impact	Losses
Yemyin (June 2007)	Sindh & Balochistan (coastal and adjoining regions)	2.5 million affected. 7 districts of Balochistan and 2 of Sindh severely affected
Onil Oct 2004	Sindh – Thatta and Badin	Localized impact. Cyclone impacted with a reduced impact resulting in heavy local precipitation
Cyclone of May 1999	Sindh coast - Thatta and Badin	202 deaths. Houses fully / partially damaged -138,719
15 Dec 1965	Karachi and Thatta	10,000 affected

***(Source:** Cyclone Contingency Plan for Karachi City 2008,NDMA)*

Table 7

Coastal Installations: Lifelines of 'National' Economy

The Facility	The Economic Importance
Karachi Port Trust	Karachi Port is now handling over 11.74 million tons of liquid cargo and 25.45 million tons of dry cargo, including 1,213,744 TEUs which constitute about 60% of import/export of the country
Port Qasim Authority	The port encompasses a total area of 12,000 acres (49 km2) wherein many industrial zones operate. In addition to the Pakistan Steel Mills and KESC Bin Qasim Power Plant (1260 MW) around 80% of the Pakistan's automotive industry is located at Port Qasim. The port also provides direct waterfront access to two major nearby industrial areas, Export Processing Zone (Landhi) and Korangi Industrial Area. Approximately 60% of country's export and import is originated from these areas
Karachi Fishing Industry	Karachi is the biggest fishery hub in Pakistan. Fisheries play an important role in Karachi's economy. They provide employment to about 300,000 fishermen directly. In addition, another 400,000 people are employed in ancillary industries. It is also a major source of export earning. The Karachi Fish Harbor (handles about 90% of fish and seafood catch in Pakistan and 95% of fish and seafood exports from Pakistan) and Korangi Fish Harbor are two major fish harbors in Karachi
KANUPP	KANUPP, Karachi is a single unit CANDU PHWR with a total gross capacity of 137 MW

People

In terms of communities located in the immediate risk zone, the most significant human settlements both in terms of their exposure and vulnerability are the fishing communities residing in fishing villages dotted along the Karachi coast.No detailed Sector Study has been done on the *fisheries* sector since 1986 and there has been no work on the estimation of fish stocks within the 12-200 mile zone for 20 years[29]. According to the *State Bank of Pakistan* (2005), the share of fisheries in GDP is only 0.3% while its share in agriculture is 1.3%. As such, fisheries though not being a high value contributor to the national wealth nevertheless supports significant human livelihoods and that too of extremely vulnerable communities.

Fishery is an export driven sector and the *Karachi port* and the *Karachi Fish Harbor* play a critical role in sustaining its functions. For exports, the major fishery is for prawns and the bulk of the catch is landed in Karachi where there are export facilities, which have been approved by the *European Union* (EU), and where the competent authority - the Federal Marine Fisheries Department is based.

It is estimated that 100,000 people (10,000 families) together with more than 30,000 (household heads) employed in the Karachi area from *Karachi Fish harbor, Ibrahim Hyderi* (most populace coastal fishing village) and other landing centers in *Korangi creek* and elsewhere near Karachi depend on fisheries.[30]

More than the inland coastal communities would be the inhabitants of the *twin islands of Babaand Bhit. Baba Bhit Island* is the smallest neighborhood of *Keamari Town in Karachi.* The approximated area of these islands is 4 km² and the population is about 12000.

Public and private infrastructure

Public and private infrastructure dominates large sections of Karachi's coastline. This infrastructure includes nuclear power plant, harbors and ports, sewage treatment plants along with the housing, businesses and recreational resources.

Public infrastructure -Some critical installations of national importance are located right along the coast. They include *Karachi Nuclear Power Plant* (KANUPP),the *Karachi harbor* (port and fisheries), *naval installations* (PNS Himalya) *and Port Qasim Authority* (PQA). Any disruption in their functions even for a day costs the nation in billions of rupees. The *TP-3 Mauripur Waste*

Fishing – an important livelihood source for coastal communities
Mohammad Arshad, Shehri-CBE

Livelihoods at risk from shifting sea levels
Mohammad Arshad, Shehri-CBE

Fishing – A family industry
Mohammad Arshad, Shehri-CBE

[29] Pakistan Coastal and Inland Community Development Project, 2005, ADB Technical Assistance Consultants Report (Financed by the Japan Special Fund) – Prepared by ANZDEC Limited Consultants, ANZDEC Limited, New Zealand – in cooperation with Resource Monitoring and Development Group, Pakistan and SEBCON (Pvt.) Limited Pakistan

[30] Pakistan Coastal and Inland Community Development Project, 2005, ADB Technical Assistance Consultants Report (Financed by the Japan Special Fund) – Prepared by ANZDEC Limited Consultants, ANZDEC Limited, New Zealand – in cooperation with Resource Monitoring and Development Group, Pakistan and SEBCON (Pvt.) Limited Pakistan

The Karachi harbor – a critical national economic lifeline
Mohammad Arshad, Shehri-CBE

Public recreation at Clifton beach
Mohammad Arshad, Shehri-CBE

Water Treatment Plant (54 MGD capacity) is also located close to the Lyari River estuary. Wastewater treatment plants in the coastal zone are at risk from flooding and the associated corrosion caused by salt water infiltration. In addition to the treatment facilities themselves, the substrate for sewer pipes could be damaged by erosion and a rising water table. The combined sewer outfall systems, such as the Lyari and Malir river outfalls and drainage channel outfalls already experiencing untreated discharges during high-rainfall events in Karachi, can be further compromised by backflow and/or gravity discharge problems as sea level rises.

Private infrastructure -A key area of concern for the Karachi City planners could be the major residential, business and recreation areas being constructed along the waterfront land – along the Clifton beach for example. Coastal land reclamation has also taken place in the process and the possible impacts on the coastal hydrology – erosion and deposition patterns -are uncertain.

Expanding commercial development along the coastline
Mohammad Arshad, Shehri-CBE

A viable planning document – the Karachi Coastal Recreation Development Plan, 1990-2000 –(Karachi Development Authority Master Plan & Environmental Control Department, UNDP, United Nations Center for Human Settlement, Doxiadis Associate International Group S.A Consultant on Development and Ekistics & Osmani and Company Private Limited) serves as the guideline for coastline recreation development as per the *Karachi Building and Town Planning Regulations where the entire 40 mile strip of Karachi coastline right from Hub River estuary passing through Paradise Point, Hawksbay, Manora and Western/eastern backwaters and Clifton, Gizri, Defence and Korangi right upto Gharo creek is an interim control area for the purpose and tourism.*

The guidelines are extensive in terms of identifying environmental

planning zones – conservation, utilization, restricted zones – however, firstly there are no provisions for dealing with any scenarios that might be related with climate change and secondly, the level to which the guidelines are being followed in terms of completed or planned coastal development is far from satisfactory.

Ecosystems

All the possible hazards associated with seal level rise scenario have the capacity of damaging, in cases irreversibly the exposed ecosystems viability. Following are highlighted some Karachi's critical coastal ecosystems that are likely to be impacted:

Mangroves – tidal wetlands

Wetland loss (mangrove forests) in coastal areas along the Indus delta and Karachi coast is a cause of serious concern. Wetlands are undergoing either rapid conversion to mudflats, or have been filled to create land for development. In addition to the loss of natural services caused by filling wetlands, the low-elevation communities or properties that come up at their cost can be at high risk from storm surge and sea level rise.Wetlands provide critical spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds and other wildlife. They also improve surface water quality by filtering, storing, and detoxifying wastes. The major export item in the fishery sector for Pakistan is shrimps/prawns and mangroves provide a nursery area for shrimp post larvae and juveniles.[31]

Recent studies suggest that storm surges superimposed on higher sea levels will increase the frequency and extent of flooding in coastal regions and estuaries, thus increasing the risk of damage to vulnerable wetlands.At the lower end of projected sea level rise rates, the slow deposition of water-borne sediment will enable some tidal wetlands to migrate into adjacent upland areas, mitigating their loss. Such migration will not be possible in areas where shoreline protective structures, development, or natural impediments (open water or steep slopes) prevent it (already we are altering the Karachi shoreline through development related land reclamation).[32]

Other than their bio-diversity and economic value, there are other reasons why coastal wetlands and marshes need to be protected. Such ecosystems are also an important form of natural infrastructure along the shore and are estimated to prevent approximately $23 billion dollars in coastal storm damage each year on the southeast and Gulf of Mexico coasts.[33] There is some evi-

The mangroves ecosystem – precious biodiversity
Mohammad Arshad, Shehri-CBE

[31] Pakistan Coastal and Inland Community Development Project, 2005, ADB Technical Assistance Consultants Report (Financed by the Japan Special Fund) – Prepared by ANZDEC Limited Consultants, ANZDEC Limited, New Zealand – in cooperation with Resource Monitoring and Development Group, Pakistan and SEBCON (Pvt.) Limited Pakistan

[32] New York State Sea Level Rise Task Force Report to the Legislature, December 2010

[33] Costanza, R., et al. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital: Part One, 3, http://www.nj.gov/dep/dsr/naturalcap/nat-cap-overview.pdf.

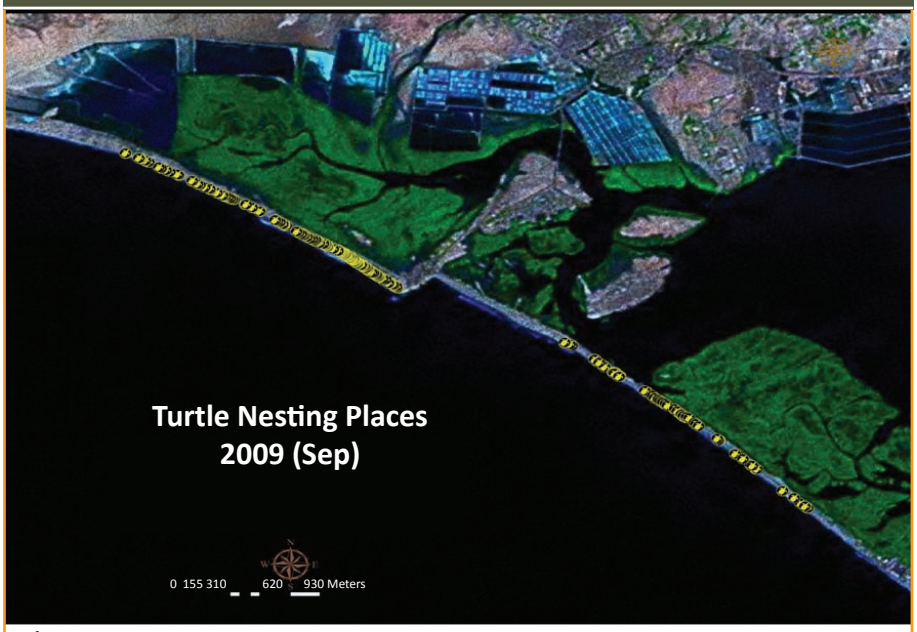
dence to suggest that as mangroves are able to absorb 70-90% of the energy from a normal wave, they acted as viable *buffers* during the 2006 Tsunami catastrophe.

The Sandspit/Hawksbay ecosystem- threatened habitat

To provide an idea of the ecological richness and sensitivity of the Karachi coastline a brief outline is being provided of the natural back-water habitat of the Sandspit/ Hawksbay beach ecosystem. Some of the main wetland sites on Karachi coast that have been identified as Wetlands of *International Importance* and include the Sandspit/ Hawksbay area. The area has already been included in the Directory of Asian *Wetlands*. A large area of Sandspit/Hawksbay back waters supports dense mangrove vegetation comprising Avicennia marina species of mangroves.The back waters contain a very rich and complex food web of algae, invertebrates living in the mud, such as worms, shrimps,crabs and juvenile fish. Many water birds are to be found in this area,especially herons,waders such as stints,sandpipers,redshanks,avocets and black winged stilts, and hawks such as ospreys, and brahminny kites.The ecosystem is one of the most important areas for wintering, passage and summering shorebirds in Pakistan,and also supports significant numbers of cormorants,flamingoes,ducks,gulls and terns.[34]

Fig. 39

The Green Turtle Nesting Habitat – Hawksbay/Sandspit Beach EcoSystem



***(Source:** SHEHRI-CBE)*

Sea Turtles enjoy a protected status in Pakistan. Virtually all the marine turtles nesting sites in Sindh occur on the Hawksbay/Sandspit beaches, concentrated along one 5 km stretch but extending in some degree along the entire beach strip of around 20 km. These two beaches represent the largest nesting habitat for marine turtles in Pakistan where the dominant resident turtle is the green turtle. Due to various human activities the habitat and green turtles are already threatened .

There is a direct link between possible climate change scenarios and sustainability of turtle nesting and breeding. Sea level rise can result in reducing the available beach habitat. In addition to rising sea levels, climate change is also likely to result in further increases in the temperature of the sand, which could alter

A nesting green turtle at the Sandspit beach *Shehri-CBE*

[34] Directory of Asian Wetlands

the sex ratio in sea turtle populations.As with some other reptile species, the sex of sea turtle hatchlings is determined by temperature.In the case of turtles, hatching when the sand is above the pivotal temperature produces a female; hatching below the temperature produces a male.Similarly, if the air and water temperatures rise, the time of year when sea turtle nesting occurs could be drastically changed.The major cause of sea level is expansion of the ocean due to raised temperatures(Since 1961, the world's oceans have been absorbing more than 80 per cent of the heat added to the climate, causing ocean water to expand and contributing to rising sea levels. Between 1993 and 2003, ocean expansion was the largest contributor to sea-level rise[35]). Evidence is growing that changes in temperature due to climate change shift critical life events in many species including their breeding, feeding and migration cycles.One recent study concludes that it is likely that southern populations of turtles in the United States will become "ultra-biased" towards female populations if temperatures increase by even 1˚C.3 [36]

A recent Study conducted by Shehri-Citizens for a Better Environment (funded by the office of WWF Pakistan) - *Assessing the habitat suitability for specie habitation- Case Study: Sandspit/Hawksbay Coastal Ecosystem as a Turtle Nesting Habitat, 2010*- already established a direct relationship between:

- *increasing elevation of the beach and the increasing numbers of successful turtle nests*
- *decreasing ground water level and increasing number of successful turtle nests*

Both favorable physical attributes are likely to change in case of a sea level rise scenario adversely impacting on the green turtle nesting patterns.

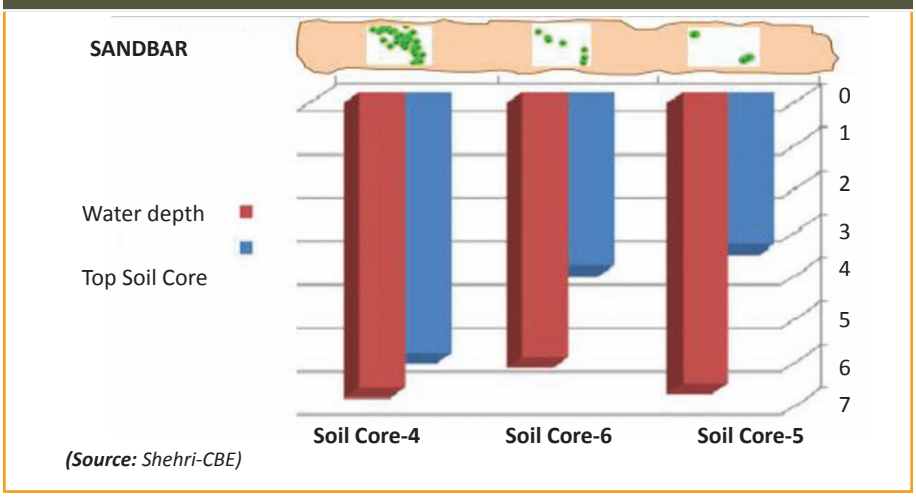
Tropical cyclone in Karachi – likely scenario

Not much has been done to simulate or think in a quantitative or tangible manner on the possible impacts of any climate change scenario. However, despite absence of historical data of cyclone impact on Karach,i two scenarios have been identified by the *Pakistan Meteorological Department* (PMD) that have been documented in the *Cyclone Contingency Plan for Karachi City,* prepared by the *National Disaster Management Authority* (NMDA) *Government of Pakistan* in 2008. The *worst case scenario* is highlighted below:

Scenario 1 – Cyclone category III or above (Worst cases scenario) depicts a *World Meteorological Department* (WMO) defined *Category III* cyclone storm or above making landfall in Karachi City. Its key impacts are summarized below: -

Fig. 40

Higher Ground Water Level – Less Nesting



***(Source:** Shehri-CBE)*

[35] Global Report on Human Settlements,2011,United Nations Human SettlementsProgramme
[36] Elizabeth Griffin, Emily Frost, Lisa White, David Allison. Climate Change and Commercial Fishing: A One-twoPunch for Sea Turtles. November, 2007

Storm surge wave

- It would start to impact Karachi City with increasing velocity when the cyclone is 25-30 kilometers from the coast
- It reaches peak about 2 kilometres from the coast with maximum speed
- Height of the surge wave could range between 12-15 feet or above
- The wave is likely to travel up to 5 km inland
- The topography of Karachi City adjoining the coast does not offer any natural resistance to the tidal wave - Impediments would be in the shape of city infrastructure or built up area
- Depending on the point of impact the water inflows would be regulated along the road network and along *Malir* and *Lyari* rivers plus other storm water drains
- Immediate impact would be total paralysis within 3-5 kilometres of the coastal region depending on the point of the impact of storm surge wave
- However communications paralysis can occur in low lying areas located much deeper from the point of impact

Conclusion

City authorities would have to evacuate population within a minimum of 2 kilometers along the coast

Storm wind

- Wind speed up to 64 – 120 knots (118-222 kmh) is expected
- Wind impact would commence when the cyclone is 25-30 kilometres from the coast
- Its impact is most likely to be severe along the centre / eye of the cyclone
- Wind impact would vary depending on the direction / axis of the cyclone movement
- Wind pressure decreases as cyclone passes certain point

Rainfall

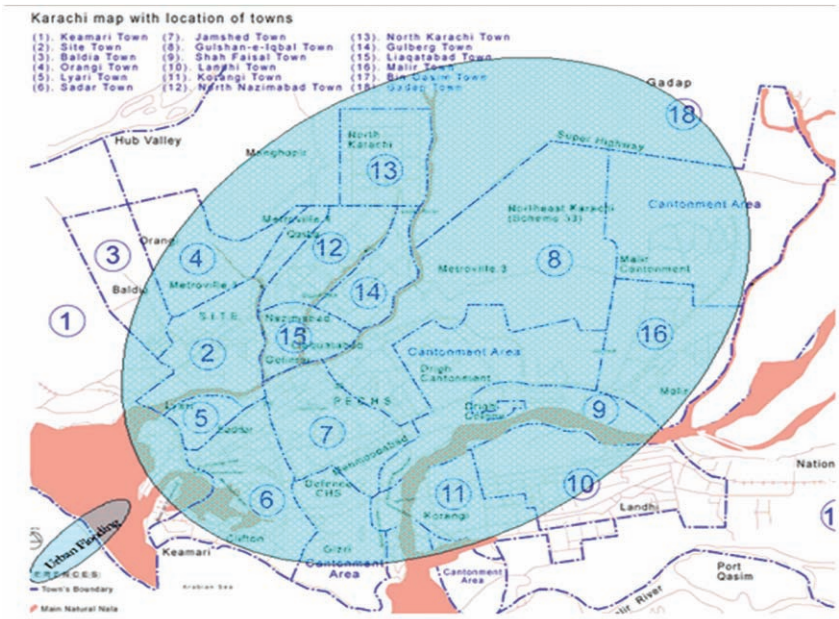
- Approximately 200 -225 mm rainfall (9-10 inches) is expected over a period of 36 hours in the City
- Its intensity is likely to be more pronounced along the centre / eye of the cyclone

End note

As with the case of other climate change scenarios, here again, there is a desperate need for research, filling of data gaps and working with data to inform appropriate decision making, starting with the outlining of areas of greatest vulnerability to

Fig. 41

Potential Scale of Urban Flooding



***(Source:** Cyclone Contingency Plan for Karachi City 2008,NDMA)*

Table 8		
Likely Humanitarian Impact – Scenario 1		
Towns	**Population**	**Affected population**
Worst affected towns (5 towns)	3,651,791	2,395,368
Moderately affected towns (2 towns)	1,730,957	407,864
Towns affected by rain and winds (13 towns)	9,737,082	1,864,641
Grand Total	**15,119,830**	**4,667,873**
Affected Pop / Relief Caseload in Worst Affected Towns		
Korangi	829,813	622,360 (75%)
DHA	379,596	303,677 (80%)
Saddar	935,566	654,897 (70%)
Keamri	583,640	583,640 (100)
Lyari	923,176	230,794 (25%)
Total	**3,651,791**	**2,395,368**
50% of the entire population in the worst affected towns would need to be evacuated		

***(Source**: Cyclone Contingency Plan for Karachi City 2008,NDMA)*

coastal hazards. Shoreline inventories should be completed for public and private infrastructure and assets in addition to the status of the threatened bio-diversity and supporting ecosystems. The relevant agencies and authorities must continue to monitor coastal processes and improve understanding of how they will be affected by sea level rise.

Protective measures against flooding say from a cyclonic event need to be considered, such as constructing flood protection barriers, sea walls, beach nourishment or diverting and concentrating flood waters to more confined locations. However, another long term threat for which consideration can be given now is within the context of what is termed as residual damage – where irreversible damage takes place from a climate change scenario. This is more relevant in the case of sea level rise as rising sea level and resulting erosion may result in loss of coastal land.

Critical Challenges

- Critical assets and vulnerable communities at potential flood risk
- High potential for residual damage in case infrastructure changes to protect areas from property damage from storm surge/flood water (diverting and concentrating flood waters to more confined locations) are not initiated
- No focus on assessing needs for development of structural and non-structural flood protection projects
- More extensive storm water capture infrastructure to decrease the potential of flooding impacts
- No habitat management plan in placefor critical bio-diversity and habitats within the context of climate change risk
- Urgent need to build capacity among exposed and vulnerable communities for reducing vulnerabilities

Over the long term, non-structural measures, such as elevation of at-risk structures and planned relocation away from the coastal shoreline, may prove more cost effective, as structural solutions, other than being more costly also may limit public access to beaches and prevent natural systems from migrating inland as water levels increase owing to barriers created by coastal structures and changes in shoreline configuration, leaving them to drown in place. However a strategy adopting mixed approaches of structural and non-structural solutions may offer the best solutions..

A critical priority is to build capacity in the exposed and vulnerable communities through raising awareness about the risks so that they can act to reduce the vulnerability of high-risk areas. Community-based organizations need to be engaged with for mobilizing public opinion and building the required adaptive capacity and resilience.

Since a large number of federal and private entities own land and assets along the coast, a larger and more holistic framework around a comprehensive climate change adaptation strategy would have to be worked out so that the city government can mediate and negotiate the required actions and responses.

Fig. 42

Karachi City - Cascading Consequences for 'Sea Level Rise'

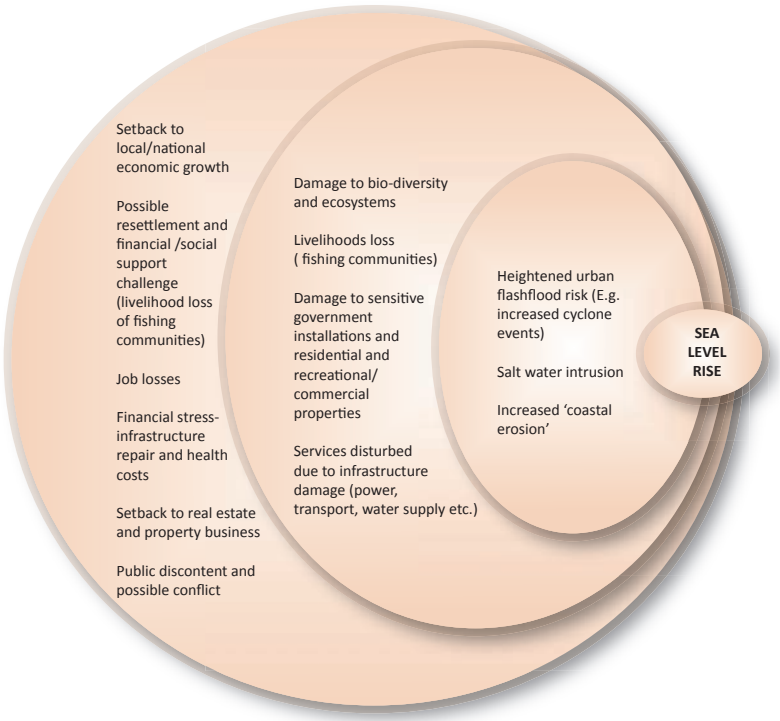
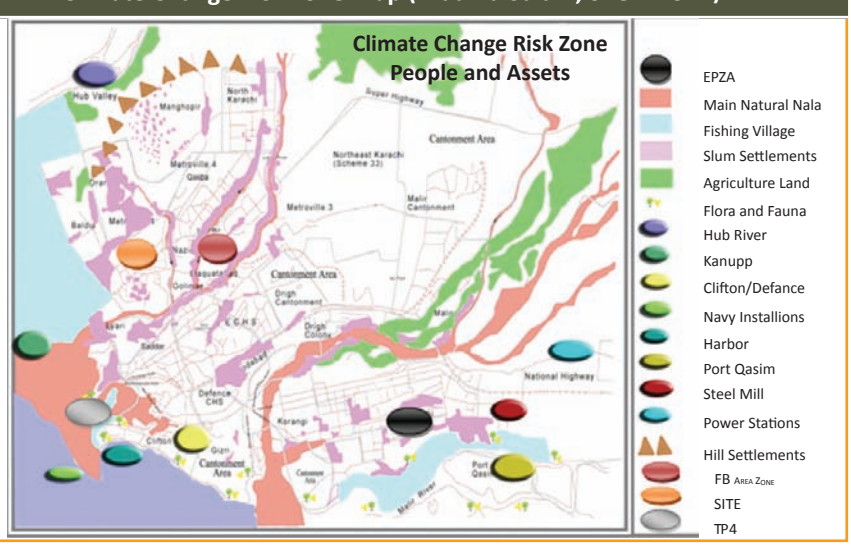


Fig. 43

Climate Change Risk Zone Map (Madiha Salam, Shehri-CBE)



Section 3 : Managing the Impacts

In a country like Pakistan where there are crisis a plenty with the economy and critical institutions of the state struggling to find relevance within a viable governance framework, where the social sector is stressed and heightened security concerns a matter of daily routine it is difficult to imagine that an issue like climate change and possible long term projections laced with uncertainties would create a sense of urgency and need for immediate action. Mobilizing people and institutions for action would then require placing the issue in a context that can find both relevance and urgency within our larger planning priorities.

A discussion on climate change adaptation should therefore start with a discussion on how the climate change-related risks fit within other existing risks and priority challenges rather than on the risks that climate change is bringing or may bring. Climate change adaptation is all about promoting *good development* and *good governance* and on bringing all relevant stakeholders under a common platform for action and coordination. The strategic framework that binds climate change adaptation actions are geared to meet already existing gaps and deficits in key urban services such as provision for water, sanitation, drainage, energy efficiency, housing and healthcare, emphasis on sustainable public transport, and improving the financial well being of marginalized communities – within which measures for climate change adaptation are integrated. This is what constitutes as making a city resilient not just to meet a climate change impact but to cope with the everyday risks and urban growth challenges generally. The context therefore is of making a city vibrant and well governed with preparedness to meet likely climate change scenarios accruing as a co-benefit.This understanding can lead to a strategically important shift of not considering climate change adaptation as something separate rather incorporating the relevant policy and strategies in the overall development framework as they relate to specific sectors and institutions.

If we focus on Karachi than there are some fundamental challenges related to the larger governance and institutional framework that need to be addressed first. Understanding the political economy is the first step in moving towards devising a viable strategy for reforms. While developing and implementing a climate change adaptation strategy has to be a participatory process, the main responsibility for implementing policies to address the impacts of climate change in cities rests with local governments. For us this consideration offers the most critical challenge of all. Over the years, the capacity and writ of local government entities in Karachi have steadily eroded. Karachi in effect is a highly decentralized city in terms of control over land and provision of services. This decentralization is manifested both officially and unofficially.

Nearly 90% of city land is under public ownership, where housing facilities cannot be extended without the consent of owning agency, of which there are 17 major institutions (ADB 2005). The city government owns only 30.9% of the land.[37] While decentralization may be one challenge, the greater challenge is the complete absence of a coordinating legislative or administrative mechanism binding these decentralized entities. Due to a variety of reasons, mostly political, the mandate and relevance of the local government development authorities has been minimized to a level that most development taking place along the peripheral areas is informal in nature mostly through land grabs. Provision of services is not sanctioned for these settlements rather are accessed illegally accessing tapping civic infrastructure. Conflicts, basically political in nature with ethnic, financial and social underpinnings are making the city and the associated policy formulation and development processes more divisive and complicated. So the first challenge is to resolve conflicts and place the city government in a rightful place of adopting the role of the guardians of the city with the requi-

[37] Karachi Strategic Development Plan (KSDP) 2020

Managing the Impacts			
Flooding	**Drought**	**Extreme Heat Events**	**Sea Level Rise**
Develop a 'Flood Risk Zone' (E.g. 'Flood Plain' identification of Lyari/Malir Rivers) Develop 'Flood Risk Maps' Identify critical 'assets' and 'vulnerable communities' at flood risk Develop a 'surface water management plan' Evaluate and improve the design (designed for an appropriate rainfall intensity and probability) and maintenance of the city 'drainage network' Create an integrated 'flood reporting and response mechanism' Strict 'policy/regulation' to prevent settlements in the 'river bed', 'hills' and encroachments of drainage channels and land use changes impacting adversely on the flood prevention and management capacity Increase the 'green cover' in the city to facilitate improved drainage (surface water flooding) and provide protection against tidal flooding - Green urban	Develop a 'ground water profile' Prepare a 'ground water policy' with identification of 'priority use' and 'water zoning' Implement projects to improve the 'recharge' and 'storage capacity' of river basins/aquifers (E.g. Infiltration basins, check/storage dams etc.) – sustainability of farming practices and bio-diversity Implement measures to promote 'sustainable water use' in farming/agricultural practices – cropping patterns/preventing water loss in irrigation etc. Strict policy/regulation to prevent unsustainable 'sand extraction' from river basins/aquifers Enhance technical, management and financial capacity of the water service provider (Karachi Water & Sewerage Board) to better cope with crisis situations Promote 'water conservation' practices (reduce use - E.g. metering of water sup-	Improve our 'understanding' of urban development trends overheating risks and target priority areas. • Relation between 'population density' and 'heat island effect' • Contribution of 'anthropogenic' factors in raising urban heat – traffic/air-condition use etc.) • Impact on infrastructure (E.g. power, water, transport) • Health impacts Increase the 'green cover' in the city Promote a 'green roof/rooftop garden' program Implement a 'transport policy' and 'program' that discourages use of private vehicles and focuses on sustainable 'public transport options' Reduce 'water' and 'energy' loss during transmission and distribution and promote 'water' and 'energy' conservation measures – focus on 'alternative' and environment friendly 'energy sources' *The City Government* in col-	Revised 'planning guidelines' for 'development' along the coastline – (E.g. reassessment of the 'high water mark') Identify critical 'assets' and 'vulnerable communities' at flood risk Application of 'infrastructure changes' to protect areas from property damage from storm surge/flood water (diverting and concentrating flood waters to more confined locations) Assess need for development of 'flood protection' projects such 'barriers' against tidal flooding at appropriate locations (Lyari/Malir barriers?) More extensive 'storm water capture' infrastructure to decrease the potential of flooding impacts Develop a 'habitat management plan' for critical 'biodiversity' and 'habitats' within the context of climate change risk High focus on preparing a comprehensive assessment of the possible

spaces (parks/playgrounds) Rural/farming land/Mangrove forests Increase awareness and capacity of vulnerable communities to improve coping and response mechanisms – recommended at least one model 'community flood plan' each for settlements in slums/coastal fishing villages/rural land Evaluate requirements for 'flood protection' projects such 'embankments'/tidal surge barriers Assess gaps and develop comprehensive implementation plans for strengthening the 'emergency response' systems – health/emergency/trauma facilities, fire services, law and order services (E.g. 'safe shelters') etc. – 'evacuation plans' and required procedures and facilities	ply - water harvesting etc.) Implement policies/programs to initiate 'waste water recycling' and 'reuse' practices	laboration with technical bodies like the *Pakistan Council of Architects and Town Planners (PCATP*) and the *Institute of Engineers Pakistan (IEP)* publish 'design guidance' for architects and developers to reduce the risk of overheating and formulate relevant policies and procedures Assess gaps and develop comprehensive implementation plans for strengthening the 'health emergency response' systems – health/emergency/trauma facilities	'economic/livelihoods' impacts of sea level rise on the 'fishing communities' in particular and the 'fishing industry' at large

site capacity and willingness to assume that role effectively. An overwhelming task but a requirement that is both imperative and urgent.

When we progress to the technical and procedural aspects of climate change adaptation than the first step is of mapping the tasks at hand starting with a mapping of exposed and vulnerable people and assets. It would be a task that would require working with probabilities, trends and translating them into marking physical jurisdictions (risk zones) and assessing risks to the people and assets located within. This would require a willingness and capacity to invest in research and generate and work with data on a regular basis. Sector based approaches is one way of tackling the task as has been done for example in London (UK) and Bangkok (Thailand).

The approach to climate change adaptationplanningin London and Bangkok has been to identify particular sectors that are at risk and develop plans to address each of these, and withthe delegation of responsibility to appropriate agencies. Thisrequires an effective system of oversight and control, andrelies on these agents having sufficient financial and technicalcapacity to make the appropriate investments andinterventions. However this again

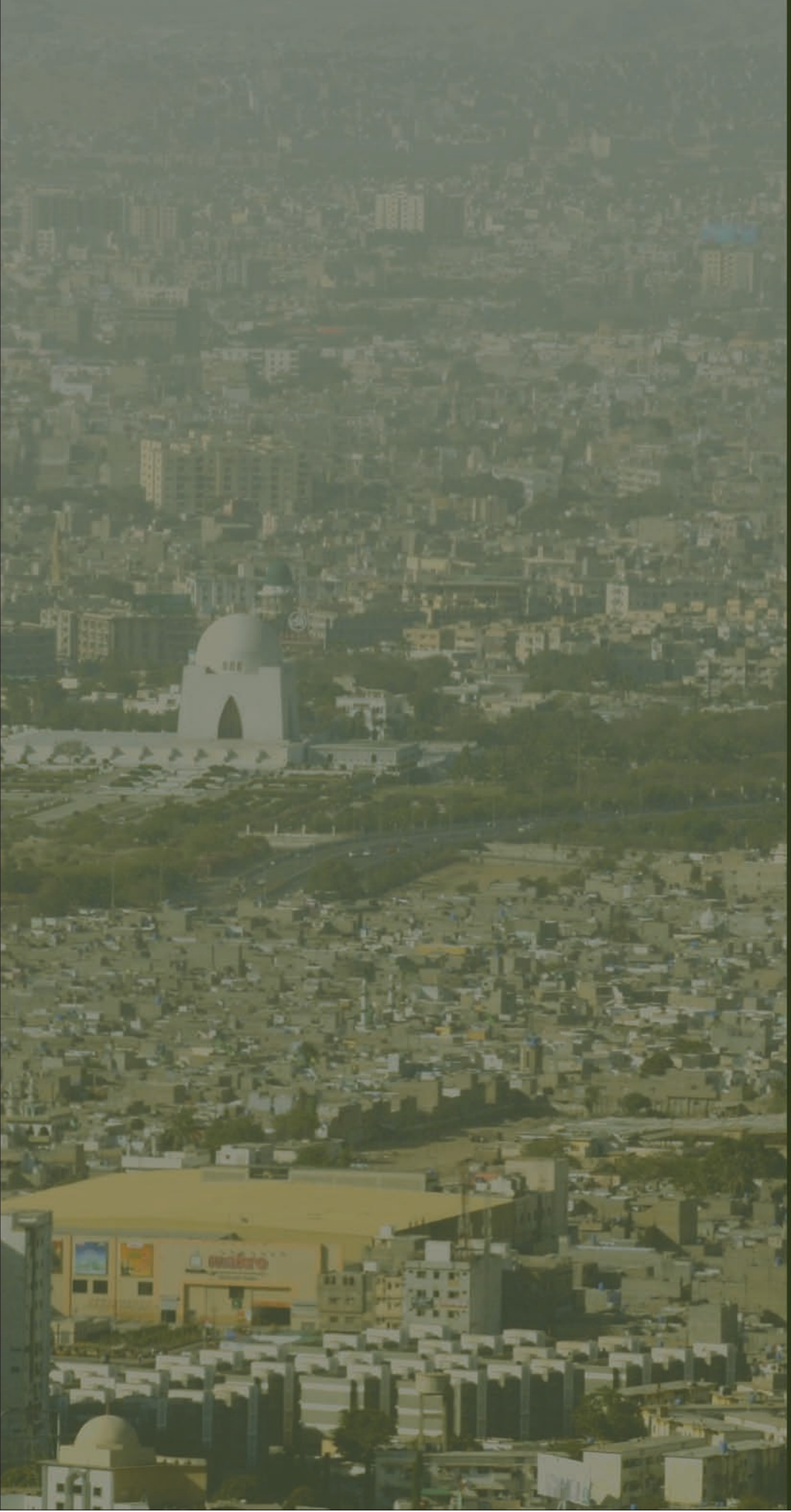
brings us to the fundamental challenge facing Karachi City and that is of a disorganized, ill-coordinated institutional and governance framework with substantial capacity deficits.

Some key sectors that can be identified in Karachi may include water and sanitation, drainage, housing and land use, transportation and emergency response – emergency medicine, health care, fire services, law and order etc. What is needed is the initiation of a process of institutional reforms within these sectors where a new paradigm requires to be considered that accommodates sharing of roles and responsibilities in terms of financing and provisioning of critical civic services between the public and private sectors and communities.

While a leading role has to be played by government institutions in implementing strategies for climate change adaptation, success and resilience can only be achieved if all sectors of the urban sphere right down to the household level are involved and have a role mapped out for them. While the city government should ideally be taking the lead coordinating role, important responsibilities in providing critical research, administration and service provision support will have to be provide by agencies such as NDMA, PDMA, SUPARCO, NIO, Met Department, academic institutions, KW&SB, SEPA, emergency response agencies etc. At the other level, initiatives at the city level for obtaining optimal results have to dovetail with a clearly mapped out *National Adaptation Program for Action* (NAPA). Here again, an opportunity exists to plug the gaps in the *Climate Change Policy* as it relates to the urban context and shift focus on a vitally important national growth priority – promoting and sustaining vibrant urban growth in Pakistan. Critically important would be provision of financing options for implementing actions.

The challenges are many but more delayed the action, the more difficult it will get. Developing a *climate change adaptation strategy* is not an end in itself. It is more in the nature of a journey that would evolve as the science around it evolves, new technological innovations surface and the capacities and responses of governments and communities adapt to changing scenarios. We need to take the first step. The scope of this Study could not allow going into the deeper strategic aspects such as a detailed insight into critical vulnerabilities, the larger policy and governance aspects as they relate to climate change adaptation and identification of key stakeholder, institutions and their possible roles and responsibilities. That work can be left for a Strategy document. The list of actions identified can be considered as some end goals – for us the most critical aspect relates more to developing willingness, a consensus and a strategy to achieve the end goalsand that can be the focus of hopefully a comprehensive climate change adaptation strategy for Karachi City.

Sunset at Karachi coast
Mohammad Arshad, Shehri-CBE



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