URBAN ENERGY, CLIMATE RESILIENT AND SUSTAINABLE DEVELOPMENT: AN INTEGRATIVE DYNAMISM FOR PLANNING PERSPECTIVES OF MEGA CITIES, INDIA

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Abstract: Climate change is widely recognized as the most serious environmental threat facing mankind and has diverse local, regional and global consequences. Among the most significant environmental challenges of our time are global climate change, excessive fossil fuel dependency and the growing demand for urban energy, are being the major challenges of 21st century and one of the greatest problems facing humanity. In 1900 about 150 million people, or less than 10 per cent of the world's population at that time, lived in cities. By the year 2000, the number of urban residents had increased 20-fold and now in 2011, the planet holds 9 billion peoples, which represented more than half the world's population are now urban dwellers. The present rate and scale of urbanization has continued to increase, generating problems in both urban and rural areas. India is set for enormous urbanization. As per Census of India, 2011, Out of 1210 million masses, the urban India holds habitat for 350 million populations, living in 7936 cities and towns and supported by 47 million plus cities. The unprecedented population growth and urbanizing forces are like giant tidal waves, driving the present and future levels of urbanization, particularly in developing countries, have clear linkages to the global greenhouse gas (GHG) emissions. The global energy catastrophe coupled with the threats of climate change bring into sharp focus both opportunities and challenges for developing countries. Furthermore, have to tackle the increasing energy demands of growing economies, inclusive of global imperative to reduce carbon emissions to combat climate change.

One type of localized climate change is that of the Urban Heat Island (UHI). Though Urban Heat Island and climate change are distinct phenomena, they are strongly interconnected and indivisible. The presence of elevated urban temperatures does not directly imply the global climate change occurrence, but, is a result of urban development. The mechanism that connects the UHI effect to global climate change is that of increased energy demand. Megacities of world are longing for new forms of urban development that implies the community to thrive in a sustainable living and working environment. This development path is a low energy, low carbon and generally a resource efficient one. Increasing energy efficiency is an important tool for mitigating climate change. The range of activities that directly contribute to GHG emissions such as transportation, energy generation and industrial production are associated with cities and their functioning.

Having these knowledge in mind, urban system's concept has been proposed to employ in this study to understand the complexity and dynamic behavior of existing scenario of the system. This research paper will explore from India's perspectives, outline the prospects by developing synergies between urban energy, climate change and sustainable development to visualize their interactive dynamism. With the aforesaid knowledge, the authors have proposed an integrated planning approach to make an attempt to establish their functional linkages/causal relationships. Furthermore, the authors have proposed to examine the relevant policy instruments and planning tools towards the reduction of urban energy demand, with endeavor to develop a conceptualized framework which contributes to sustainable urban

development. Finally, concluding with plausible recommendations/guidelines for achieving sustainable and energy efficient urban development for the megacities of India.

Keywords: Climate Change, Energy Efficiency, Integrated Planning Approach, Sustainable Urban Development, Urban Energy, Urban System,

INTRODUCTION

Climate change is one of the greatest social, economic and environmental challenges prevailing across the globe of our time. Human activities stimulate the climate to change. In other words, there is overwhelming evidence for human-made global warming, due to the substantial increase in greenhouse gas (GHG) concentrations. Underlying causes of climate change implies the human activities, primarily energy-use and land-use practices are increasing the atmospheric concentrations of greenhouse gases and, in some regions, aerosols. The balance of scientific evidence suggests a discernible human influence on the Earth's climate. The main source of GHG emissions from urban areas related to the consumption of fossil fuels, which comprises of energy supply for electricity generation; energy use in residential and commercial buildings; transportation; industrial production; and waste. The world has seen an uncontrollable pace of urbanization, and a consequent rise in energy demand for private and public consumption and for economic activities leading on to greater emission of GHGs. This has led to an urgent need for the incorporation of energy efficiency issues to be included in urban planning and construction.

Urbanization is certainly one of the most prominent characteristics of our world today.During the last few decades, the accelerated pace of urbanbization and rapidly evolving human settlement forms have raised the issue of sustainability.Sustainability is a fundamental issue dogging human activities and progress.Sustainability of human settlements, particularly in urban areas of the developing world, is vulnerable and being severely threatened. According to National Geographic, March 2011[2], as Earth's population hits seven billion in 2011, the percentage of people with a decent standard of living is higher than it has ever been. By 2030, China will lose its top population status, and the most typical human face will be Indian. Yet before the era of explosive population growth ends by 2050, Earth will hold more than nine million people.The challenge: How to share and sustain the planet while lifting even more people into a better life?. Steering urbanization is a central challenge in the pursuit of the goal of global sustainable development. The formation of megacities and mega-urban regions are local processes with enormous global effects in all three dimensions of sustainability. They are closely interconnected with other global changes, i.e. land consumption, energy consumption, and the emission of greenhouse gases. Globally effective potential of energy efficiency and climate protection presents itself especially in fast growing urban growth centres, more specifically in developing and newly industrializing countries. The most important characteristic of this approach is its link to the concept of sustainable development.

The sustaianble development concept was brought to popular global attention by the report *Our Common Future*, prepared by the World Commission on Environment and Development(WCED) following its first meeting in 1984 (WCED 1987) [3]. It was then defined as "***development that meets the needs of the present without compromising the ability of the future generations to meet their own needs"***.The Rio Summit focused on environment and development (Rio de Janerio, 1992) responsible for Agenda 21, which marked a key milesstone as a comprehensive plan of action to be adopted globally, nationally and locally by organizations of the United Nations system, governments and major groups in every area concerned with the human impact on the environment [4, 5]. Also to be noted that some of the Millennium Development Goals (UNDP) have urged for ensuring environmental sustainability and reduction of the percentage of the population under extreme poverty. Similarly, explaining implications of climate change for sustainable development the Intergovernmental Panel on Climate Change notes (IPCC) the importance of social and environmental equity in development. Thus all the major world conferences and initiatives taken so far on environment and development have stressed on economically viable development, socially equitable development and protection of the environment for attaining sustainable development.

The share of world urban population 50.5 percent or 3.5 billion of the people lived in cities in 2010. By 2050, this will increase to 6.4 billion or 70 per cent of the global population [6].Thus, the present and future levels of urbanization, particularly the rapid urbanization of developing countries has clear linkages to the global greenhouse gas (GHG) emissions. The unprecedented population concentration in the urban system, consumes huge quantities of primary energy (Fossil fuels) such as, coal, oil and gas by various sectors namely, residential, commercial, industrial and transportation. Combustion of fossil fuels is chiefly responsible for urban air pollution, regional acidification and the risk of human-induced climate change .In twentieth century, it has been observed that rapid increase in the use of fossil fuels adversely affects the climate and urban environment by the emission of carbon

dioxide (CO_2) in to the atmosphere. The over consumption of urban energy is highly responsible for the climate change impacts and environment damage. While planning for sustainable urban development the factor of climate change along with urban heat island (UHI) effect need to be studied for understanding adverse impacts on urban environment.

Moreover, current trend of growing urban energy demand, the scarce non-renewable energy use could not be supplemented with renewable energy. The only possible solution is reduction of energy usage or efficient use of energy by minimizing CO_2 emission to safe guard the urban environment for present and future generations. Energy is central to socio-economic well being and also to meet environmental demand. Therefore, integrated planning approach in energy production and consumption of an urban system in sustainable way is indispensable for achieving energy efficient urban development. Energy plays vital role for improving human, social, economic, environmental conditions on one hand and the other hand, it pollute the environment and increase greenhouse gas emissions. Hence, energy for sustainable development must be visualized in three major dimensions, such as social, economic and environmental dimensions, which is very much essential to achieve sustainable and energy efficient urban development in the system. It is important to understand the forces that shaping the growing megacities of world in order to mitigate the climate change and its consequences, by the path way of energy efficient urban development through the guiding principles of sustainable development. Having the aforesaid knowledge, the authors have made an attempt to understand their dynamic behavior and functional integrity by developing synergies amongst urban energy, climate change and sustainable development to visualize their interactive dynamism. With this knowledge, the authors have proposed an integrated planning approach to make an attempt to establish their causal relationships by employing urban system's concept. Eventually, concluding with plausible recommendations/guidelines for achieving sustainable, energy efficient and climate resilient urban development in the context of Indian megacities.

EVOLUTION OF POPULATION DYNAMICS AND URBANIZATION OF WORLD

World population passed 7 billion persons in the last year (2011) of twenty-first century and it is currently growing at 1.2 percent annually. The population of the world is expected to increase by 2.1 billion during the next 40 years, from 7 billion today to 9.1 billion in 2050 [6]. This section of the article indicates a global overview of urban demographic trends and projections for selected developed, developing and least developed countries of the world, based on the United Nations: World Urbanization Prospects, 2009 Revision [8]. It reviews major population trends relating to population size and decadal growth, urban agglomeration trend across the globe are summarized. Decadal urban population growth and percentage of increase in urban area between the years 1950 to 2050 for selected developed, developing and least developed countries are presented in Table 01, 02, and 03 and Figures 01,02 and 03 respectively. The Table 01 and Figure 01 reveals that during the period from 1950 to 2050, the acceleration of population growth has been maintained in the same passion up to the projected year except Germany and Singapore, which are witnessing the negative growth between the years 2030 to 2050. It is interesting to note that some of the developed countries, the population growth has been soaked and it is expected to be decline between the year 2030 to 2050. In the case developing countries, the Table 02 and Figure 02 indicates that during the period from 1950 to 2050, the acceleration of population growth has been maintained with incremental increase up to the projected year excluding Russia and Poland, where they denote the negative growth between 2000 to 2050. It is to be pointed out here that some of the developing countries also attained the break-even point and has already been witnessed negative population growth / expected to be decline between the years 2030 to 2050. On the other hand, it has been observed from the Table 03 and Figure 03 that all the least developed countries have been maintained the acceleration of population growth with incremental increase from the base year 1950 to the projected year 2050.

Furthermore, the decadal population growth in the selected cities of developed and developing world have been analyzed between the year 1950 to 2025 (projected year), which are presented in the Tables 04 & 05 and Figures 04 & 05 respectively. The Table 04 reveals that there is constant surge in the decadal growth of population in all selected cities in the developed world, excluding the cities of London and Berlin. These cities shows phenomenal population growth, it is interesting to observe that the London city imply negative population growth between the year 1950 to 1990 i.e., from 8.36 to 7.65 million and gradual increase during 2000 to the projected year 2025 i.e., 8.22 to 8.78 million respectively. On the other hand the Berlin depicts the marginal decline between the year 1950 to 1980, i.e., 3.34 to 3.04 million and marginal increase over the period 1990 to 2010 i.e., 3.43 to 3.45 million, finally it is expected to reach saturation level of 3.60 million by the year

2025. Based on these analyses, one can make this as evident that impact of populism will differ within developed world. It has been observed from the Table 05 that all the selected cities of developing world show the constant surge in their population expansion between the same periods. However, among those selected cities the Mumbai and Mexico City imply predominant role with nearly seven fold increase, followed by Shanghai with nearly fivefold increase, during the same periods.

Eventually, the selected Indian cities and urban agglomerations of more than 5 million inhabitants, 2011 were analyzed between the years 1951to 2011, which are presented in the Table 06 and Figure 06 respectively. It has been observed from Table 6 that Delhi the capital city of India, shows phenomenal decadal population growth of more than 14 fold increase from 1951 to 2011, followed by the Bangalore city which has more than 11 fold increase. All the remaining cities have significant increase in population growth which ranges from 6 to 9 times increase between the same period 1951 to 2011, except the Kolkata city, which depicts the least among all the Indian cities with 3.50 times increase during the same period. The Figure 06 gives the clear idea about how the selected Indian cities represent their consistency towards the population accumulation. These detailed decadal analysis of population growth and urban agglomeration patterns across the world, demonstrates that developing and least developed countries well ahead of developed counties for their contribution to world population explosion. It is clear evident that the cities in the developing world depicted the unbeaten sprint and resembling athletic triple jump event champion of living field over the planet.

Urbanization principally refers to dynamics of the proportion of total population living in urban areas. Urbanization is a continuing process, which takes place in a vibrant manner in the developing countries, where as the intensity of urbanization is lesser in developed countries and it is further lesser in under developed countries. Urbanization is influenced by different factors, which includes geographical location, natural growth of population, rural-urban migration, cross country migration, availability of infrastructure, national policies, conducive atmosphere in connection with socio, economic, political and environmental development, corporate strategies, people's aspiration, attitudes, culture, etc. Urbanization has both *spread* and *backwash effects* in the system. As indicated in UN-Habitat's report 2008-09 [7], that the cities are engines of economic growth in any country, and it can be considered as spread effect, and simultaneously it has backwash effects too. The following activities emerged in the urban system, which can be considered as backwash effect of urbanization, including formation of slums, strengthening of the existing slums, squatter settlements, aggravating the problem of poverty, unemployment, under employment, disguised unemployment, and creation of all kinds of pollution, which lead to environmental degradation, damaging the cultural values that exists in the system, increase in heinous crimes, scarcity of infrastructure, and so on.

Urbanization and the phase of its acceleration is the foremost important aspect in deciding the level of the kinds of infrastructure requirement in the urban system, for its development. The features of urban population are changing not only as a result of its dynamism, but also the national development in which it belongs. Cities, towns, and urban agglomerations are expanding faster in most of the regions of the world, due to availability of infrastructure services in the particular system. Infrastructure is divided in to three types, which include *physical*, *economic* and *social* infrastructure. These entire three infrastructures are very much essential for the development of the urban system. In India, the urban system which has more infrastructure services developed further, and continuously growing with higher intensity, whereas the urban system has less infrastructure services grows with less intensity. Provision of required amount of infrastructure services to Indian urban system becomes a mirage, due to the functions of population explosion in the urban system on one hand, and the Government of India and the respective State Governments attitudes on the other. Further, it has been also observed from various studies that whatever infrastructure is made available in the urban system by the Government of India and by the respective State Governments, turning into a drop in the ocean, due to unprecedented growth of population in the urban system. Various studies proved that there is strong nexus between infrastructure services and economic development in the urban systems. According to the authors view, without required amount of infrastructure services in the urban system, the cities cannot be the engines of economic development. Provision of all kinds of infrastructure that can support the demand of current populism, which lead to vast transformation of natural resources into goods and services, eventually will consume enormous urban energy and end up with environmental chaos in the urban system. Therefore, there is pressing need of vital urban planning solutions that can lead the present and also upcoming generations to sustainable future of megacities in India.

Table 1: Decadal Urban Population Growth in the selected developed countries (1950-2050)

S.No	Country	Decadal Urban Population Growth (thousands) Years											Percentage Urban (%)				
		1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	1950	2000	2010	2030	2050
1	**Norway**	1647	1788	2536	2882	3052	3411	3856	4297	4700	5026	5296	50.50	76.10	79.40	85.20	89.10
2	**Qatar**	20	38	98	205	431	586	1445	1679	1891	2088	2261	79.20	94.90	95.80	96.90	97.60
3	**Italy**	25086	29390	34295	37523	38032	38395	41083	42840	44395	45679	46334	54.10	67.20	68.40	74.60	81.20
4	**Kuwait**	94	208	638	1303	2100	2188	3001	3637	4218	4752	5187	61.50	98.20	98.40	98.70	99.00
5	**Germany**	46558	51978	56496	57028	58080	59970	60598	60827	60993	60462	59089	68.10	73.10	73.80	78.30	83.80
6	**Singapore**	1016	1634	2075	2415	3016	4018	4837	5219	5460	5437	5221	99.40	100	100	100	100
7	**United States**	101242	130420	154171	169206	191914	227651	261375	293732	321698	345279	365093	64.20	79.10	82.30	87.00	90.40
8	**Ireland**	1190	1299	1528	1882	2000	2250	2842	3370	3889	4420	4909	40.10	59.10	61.90	69.80	78.00
9	**Netherlands**	5678	6864	8040	9161	10270	12222	13799	14824	15501	15863	15976	56.10	76.80	82.90	88.60	91.80
10	**United Kingdom**	39977	41083	42926	44196	44726	46331	49295	53001	56901	60309	63509	79.00	78.70	79.60	83.70	87.80

Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

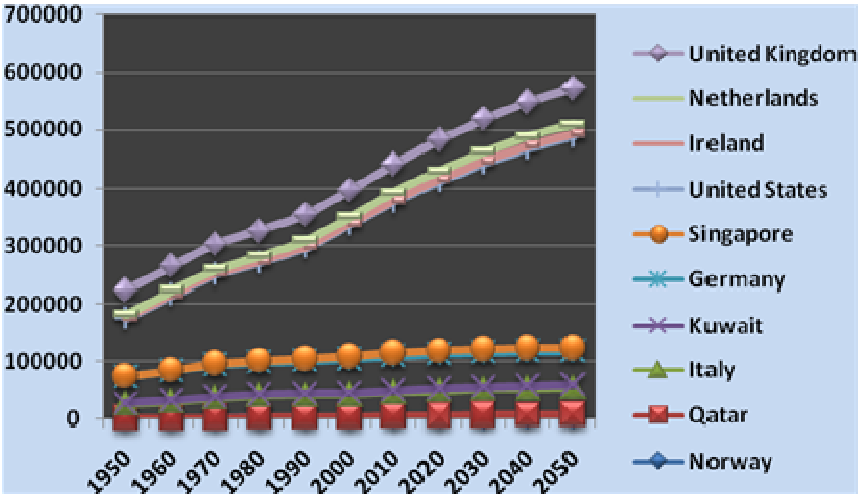

Figure 1 (Color): Decadal Urban Population Growth in the selected developed countries (1950-2050)
Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

Table 2: Decadal Urban Population Growth in the selected developing countries (1950-2050)

S. No	Country	Decadal Urban Population Growth (thousands) Years											Percentage Urban (%)				
		1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	1950	2000	2010	2030	2050
1	**Brazil**	19517	33563	53667	79621	110565	141416	169098	187104	197874	203495	204464	36.20	81.20	86.50	91.10	93.60
2	**Russia**	45278	64427	81458	96714	108670	107582	102702	100892	99153	97652	95978	44.10	73.40	73.20	76.90	82.70
3	**India**	63373	80357	109268	159984	220260	288430	364459	463328	590091	734264	875193	17.00	27.70	30.00	39.70	54.20
4	**China**	64319	104656	141975	189886	301995	453029	635839	786761	905449	987162	1037695	11.80	35.80	47.00	61.90	73.20
5	**South Africa**	5778	8110	10758	14080	19121	25528	31155	35060	39032	42415	45199	42.20	56.90	61.70	71.30	79.60
6	**Poland**	9517	14194	17026	20664	23351	23719	23187	23135	23481	23743	23567	38.30	61.70	61.00	64.90	73.60
7	**Mexico**	11833	19240	30638	45689	59566	74372	86113	96558	105300	111159	113012	42.70	74.70	77.80	83.30	87.60
8	**Argentina**	11206	15226	18933	23336	28268	33291	37572	41554	44726	47116	48882	65.30	90.10	92.40	94.60	96.00
9	**Turkey**	5322	8898	13844	20210	33204	43027	52728	62033	70247	76963	81812	24.80	64.70	69.60	77.70	84.00
10	**Indonesia**	9567	13573	19960	32401	54252	86219	102960	122257	145776	170041	190007	12.40	42.00	44.30	53.70	65.90

Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

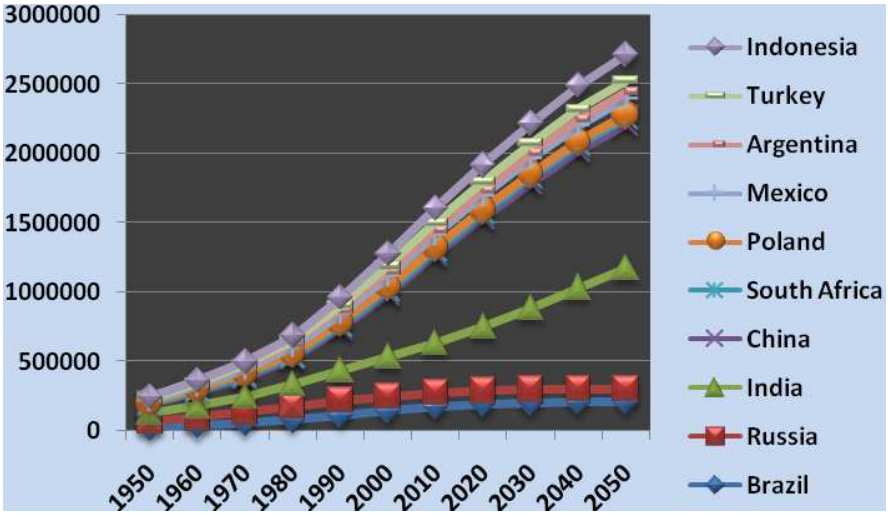

Figure 02(Color): Decadal Urban Population Growth in the selected developing countries (1950-2050)
Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

Table 03: Decadal Urban Population Growth in the selected least developed countries (1950-2050)

S.No	Country	Decadal Urban Population Growth (thousands) Years											Percentage Urban (%)				
		1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	1950	2000	2010	2030	2050
1	**Angola**	314	523	910	1908	3960	6995	11112	16184	21784	27784	34042	7.60	49.00	58.50	71.60	80.50
2	**Bangladesh**	1867	2780	5253	13425	22908	33208	46149	62886	83408	104857	125500	4.30	23.60	28.10	41.00	56.40
3	**Bhutan**	4	8	18	43	90	143	246	348	451	552	650	2.10	25.40	34.70	50.00	64.20
4	**Ethiopia**	848	1451	2486	3686	6095	9762	14158	20800	31383	46552	65149	4.60	14.90	16.70	23.90	37.50
5	**Mozambique**	153	280	546	1591	2857	5601	8996	13208	18199	23805	29750	2.40	30.70	38.40	53.70	67.40
6	**Nepal**	218	337	470	917	1692	3281	5559	8739	12902	17822	23319	2.70	13.40	18.60	31.70	47.60
7	**Senegal**	416	709	1251	2016	2932	3995	5450	7524	10269	13542	17003	17.20	40.30	42.40	52.50	65.10
8	**Sudan**	627	1256	2485	4093	7211	11661	17322	24804	33267	42322	51365	6.80	33.40	40.10	54.50	67.70
9	**Uganda**	145	300	629	953	1964	2952	4493	7381	12503	20215	30596	2.80	12.10	13.30	20.60	33.50
10	**Zambia**	269	552	1256	2299	3117	3643	4733	6584	9340	12859	16898	11.50	34.80	35.70	44.70	58.40

Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

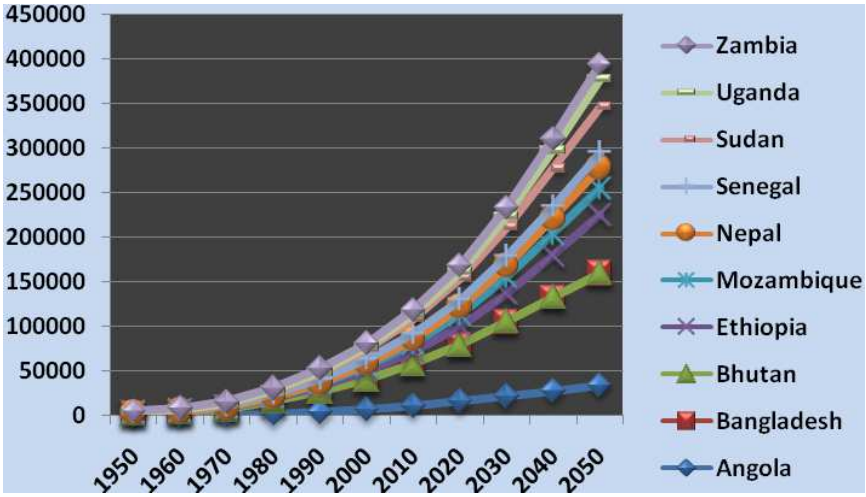

Figure 03(Color): Decadal Urban Population Growth in the selected least developed countries (1950-2050)
Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

Table 04: Decadal Urban Population Growth of selected cities in developed countries

S.No	Cities	Decadal Urban Population Growth (millions)								
		Years								
		1950	1960	1970	1980	1990	2000	2010	2020	2025
1	**New York**	12.34	14.16	16.19	15.60	16.09	17.85	19.43	20.37	20.64
2	**London**	8.36	8.20	7.51	7.66	7.65	8.22	8.63	8.78	8.78
3	**Chicago**	5.00	6.18	7.11	7.22	7.37	8.33	9.20	9.76	9.94
4	**Tokyo**	11.27	16.68	23.30	28.55	32.53	34.45	36.67	37.09	37.09
5	**Paris**	6.52	7.41	8.35	8.67	9.33	9.74	10.49	10.88	10.88
6	**Los Angeles**	4.05	6.53	8.38	9.51	10.88	11.81	12.76	13.46	13.68
7	**Berlin**	3.34	3.26	3.21	3.04	3.43	3.38	3.45	3.60	3.60

Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

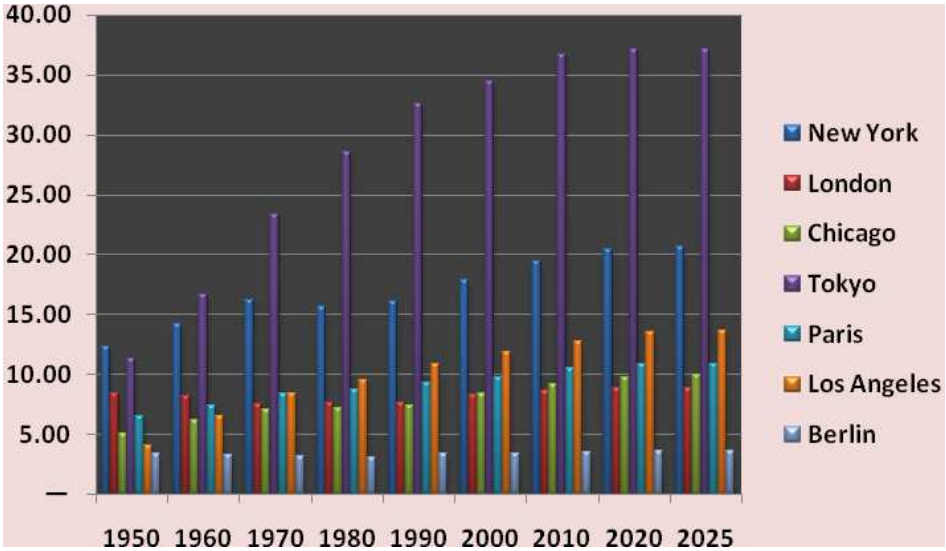

Figure 04 (Color): Decadal Urban Population Growth of selected cities in developed countries

Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

Table 05: Decadal Urban Population Growth of selected cities in developing countries

S.No	Cities	Decadal Urban Population Growth (millions)								
		Years								
		1950	1960	1970	1980	1990	2000	2010	2020	2025
1	**Mumbai (Bombay)**	2.86	4.06	5.81	8.66	12.31	16.09	20.04	23.72	25.81
2	**Shanghai**	4.30	6.82	6.04	5.97	7.82	13.22	16.58	19.09	20.02
3	**Rio de Janeiro**	2.95	4.37	6.64	8.58	9.59	10.80	11.95	12.62	12.65
4	**Buenos Aires**	5.10	6.60	8.10	9.42	10.51	11.85	13.07	13.61	13.71
5	**Moskva (Moscow)**	5.36	6.17	7.11	8.14	8.99	10.00	10.55	10.66	10.66
6	**Mexico City**	2.88	5.01	8.77	13.01	15.31	18.02	19.46	20.48	20.71
7	**Al-Qahirah (Cairo)**	2.49	3.68	5.58	7.35	9.06	10.17	11.00	12.54	13.53

Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

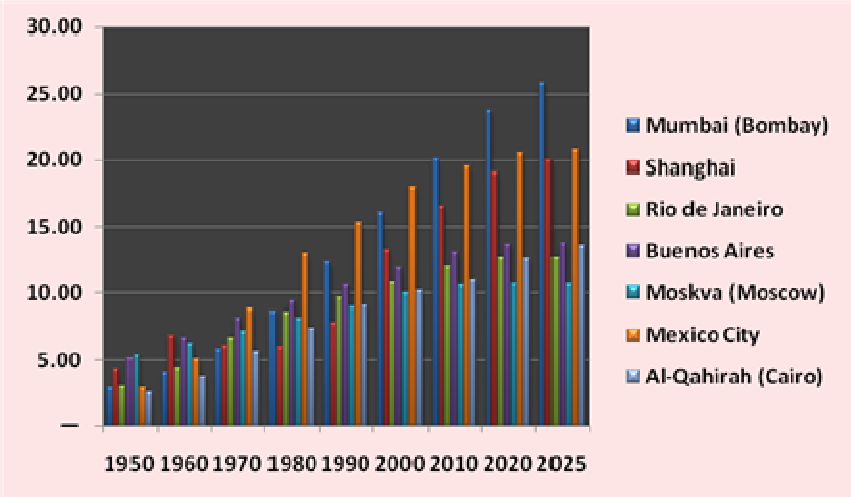

Figure 05 (Color): Decadal Urban Population Growth of selected cities in developing countries
Source: Compiled by the investigators based on the United Nations: World Urbanization Prospects, 2009 Revision

Table 06: Selected Indian Cities & Urban Agglomerations of more than 5 million inhabitants, 2011

S.No.	Name	YEAR (Population in thousands of inhabitants)								
		1872	1901	1951	1961	1971	1981	1991	2001	2011
	INDIA	**199199**	**238339**	**361089**	**439216**	**548161**	**683331**	**844272**	**1 028 610**	**1 210 193**
1	**Delhi**	162	240	1 537	2 527	3 941	5 783	8 723	15 725	21 753
2	**Mumbai**	652	813	2 967	4 152	6 592	9 422	12 572	16 434	20 748
3	**Kolkata**	1 093	1 503	4 761	5 903	7 421	9 914	10 916	13 206	16 509
4	**Chennai**	422	541	1 416	1 729	3 170	4 290	5 361	6 560	8 917
5	**Bangalore**	143	162	786	1 207	1 664	2 922	4 087	5 701	8 728
6	**Hyderabad**	368	449	1 130	1 251	1 815	2 562	4 280	5 742	7 749
7	**Ahmadabad**	120	186	877	1 206	1 752	2 558	3 298	4 525	6 352
8	**Pune**	132	164	600	738	1 135	1 686	2 485	3 761	5 049

Source: Compiled by the researcher based on the report of Census of India, 2011[1].

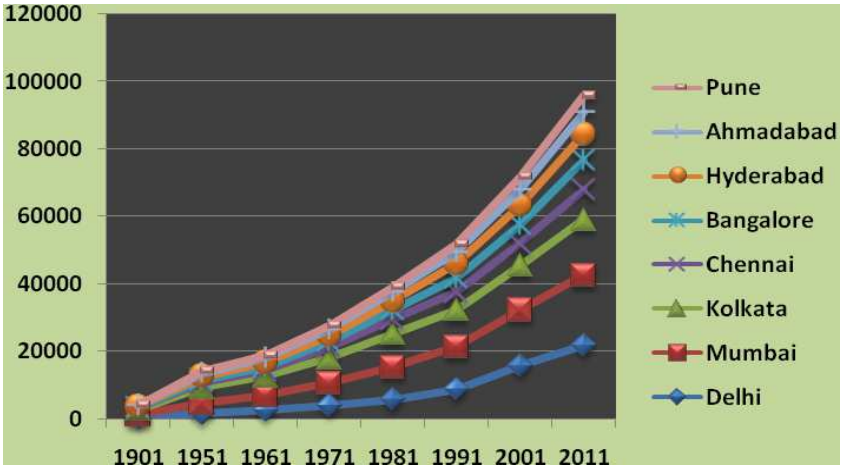

Figure 06 (Color): Selected Indian Cities & Urban Agglomerations of more than 5 million inhabitants, 2011

Source: Compiled by the researcher based on the report of Census of India, 2011[1].

PLANNING FOR SUSTAINABLE URBAN DEVELOPMENT: SOME ISSUES

Sustainable development means attaining a balance between environmental protection and human economic development and between the present and future needs. It means equity in development and sect-oral actions across space and time. It requires an integration of economic, social and environmental approaches towards development. Sustainable urban development refers to attaining social equity and environmental protection in urbanization while minimizing the costs of urbanization. Sustainable urban development specifically emphasis on achieving a balance between the development of the urban areas and protection of the environment with an eye to equity in employment, shelter, basic services, social infrastructure and transportation in the urban areas. Sustainable city planning should aim at achieving social and environmental equity while improving the lives of the people. For that to happen we need to have a sustainable city form as well as provision and proper management of the services. Thus, in order for a city or urban area to be sustainable it needs to produce and manage basic services like water, waste, energy, and transportation in a way that it conforms to the principles of sustainable development. In other words, the city should be able to produce and distribute the services in an economic, environment friendly and equitable way.

Asian cities face significant environmental degradation, including serious problems of air, water and land pollution, congestion, traffic, affordability,and other planning challenges. They have insufficient open space, and many have poor urban infrastructure. Automobile ownership and use are growing rapidly. Transit systems cannot meet demand. Many Asian countries have poorly developed public transit systems and are responsible for rapid shift to private automobile ownership.The rapid spread of private motorcycle and automobile ownership, which has quickly extended the land development frontier far from the original high-density metropolitan cores, creates mounting problems in urban fringe areas. For the last decade, Urban planners/ Urbanists have serached for ways to move cities towards sustainability.The untoward and unplanned growth pattern especially in these cities in developing countries bring with it consequences on ill health, ecology, environment, and the whole urban system. They account for most of the country's resource consumption and waste generation, besides being large-scale polluters of the living environment. In India, there is a mass migration of people from rural areas to cities and also from smaller to larger cities and then to metropolitan centres like Mumbai, Delhi, Kolkata, Bangalore, Hyderabad and Chennai. There has been large population of migration from North East India to other megacities of India in last one decade. Population moved in search for employment and better educational career. Over 314,850 populations migrated from North East India to other mega cities in search higher studies and employment during 2005 to 2009. Migration growth rate from 2008 to 2009 is 13.62 per cent and at this rate, approximate number of people migrated in 2010 is close to 100,000 populations, numbering total population over 414,850, which is 12 times higher in last six years. Delhi is most choice destiny with over 200,000 North East Indian populations, which holds 48.21per cent of total migrated population.[9]. This influx has created an increased demand for sharing the limited public resources and infrastructure available in the megacities of India. If such an exodus is not checked and corrected, it would lead to extreme urban decay and malice where urban sustainability would then become one big utopian vision.

The state of the urban environment of megacities of Mumbai, Delhi, Kolkata, Bangalore, Hyderabad, and Chennai and almost all over India is deteriorating so fast that the sustainability of the cities is threatened. This exponential population growth has wreaked havoc on human life in the city environment. The doubling and tripling of urban population in practically all major cities and towns and the consequent strain on existing systems has manifested in environmental chaos. Every mega city of India faces the proliferated typical planning problems of urban expansion, inadequate housing, poor transportation, poor sewerage, erratic electric supply, and insufficient water supplies. An increasing number of trucks, buses, cars, three-wheelers and motorcycles all spewing uncontrolled fumes, all competing for space on city streets already jammed with jaywalking pedestrians, rickshaws and cattle. The phenomena of rapid urban economic growth and urbanization are the main perpetrators, which besides bringing higher standards of living, has also brought problems related to the growth of dense and unplanned residential areas, environmental pollution, lack of services and amenities, solid waste generation, and growth of slums. Population growth and in-migration of poor people, industrial growth, inefficient and inadequate traffic corridors, and poor environmental infrastructure are the main factors that have deteriorated the overall quality of the city environment.

The transport sector is the major contributor to air pollution in urban India. The ambient air pollution in terms of Suspended Particulate Matter (SPM) in all metropolitan cities in India exceeds the limit set by the World Health Organization (WHO). With deteriorating levels of mass transport services and increasing use of personalized modes, vehicular

emission has reached an alarming level in most Indian cities. Indian cities also face severe traffic congestion. Growing traffic and limited road space have reduced peak-hour speeds to 5 to 10 kms per hour in the central areas of many major cities, which leads to higher levels of vehicular emission [16]. According to the Centre for Science and Environment (CSE) India, the quantity of all three major air pollutants (namely, CO, hydrocarbons, and nitrogen oxides) drastically increases with reduction in motor vehicle speeds. Thus, prevalent traffic congestion in Indian cities, particularly during peak hours, not only increases the delay but also increases the pollution level. The fast growing megacities of India, like Mumbai, Delhi, Kolkata, Bangalore, Hyderabad and Chennai are experiencing unsustainable pattern of urban development. All these concerns, questions and initiatives about sustainable environment and climate change have resulted in experiments and debates over city forms that are sustainable. Mega cities of India are longing for the urgent need and stressed the inevitable requirement of new forms of urban development in the system. Under these circumstances, sustainable and energy efficient urban development is very much essential to safeguard the interest of humanity and the nation.

CORRELATION AMONGST ENERGY AND SUSTAINABLE DEVELOPMENT

The relationship between energy and sustainable development is complex, both positive and negative. On the positive side, it is the services that energy enables, not the energy itself, that most directly advance sustainable development. Better cooking, lighting, space conditioning, transportation, communications, income generating processes and other services are the means by which energy improves human, social, economic and environmental conditions. On the negative side, energy can be produced and deployed in ways that pollute the environment and increase greenhouse gas emissions. Energy is vital to providing an array of necessary services, but the nature of its contribution is not fixed. It is possible to alter the end-use devices, methods, infrastructure and behavior that deliver these services to become more energy efficient or to use alternative types of energy. The strategy process offers an opportunity to build on the complementarities of programmes in the economic, environmental and social spheres to improve the long-term effectiveness of complex energy policies. An array of policy tools are needed to ensure that sufficient quantities of energy are delivered to end-users in an affordable, reliable and environmentally friendly manner. Still more policy approaches implemented in conjunction with sectoral policies are needed to advance end-use energy efficiency and CO_2 emissions reduction.

Energy is important to be able to measure a country's state of development and to monitor its progress or lack of progress towards sustainability. The purpose of the energy indicators for this research study will be addressing the important issues within three of the major dimensions of sustainable development: economic, social and environmental. These indicators give a clear picture of the whole system, including inter-linkages and trade-offs among various dimensions of sustainable development, as well as the longer-term implications of current decisions and behavior. Furthermore, the changes in the indicator values over time mark progress or lack of progress towards sustainable development. Some indicators focus on the delivery of essential energy services for reducing poverty and improving living conditions, while other indicators focus on environmental effects. The relative importance of different indicators for sustainable energy development will vary from country to country, depending on country-specific conditions, national energy priorities, and sustainability and development criteria and objectives. Every country has its own special economic circumstances and geography, its own range of energy resources and its own expertise and priorities. Therefore, each country will have its own way of using the energy indicators for sustainable development.

Dimensions of Sustainable Development

The energy indicators with relevance to sustainable urban development are discussed in this section. There are 27 energy indicators have been compiled with relevance to sustainable development, which are categorized into three dimensions: They are: Social, Economic and Environmental dimensions.

Social Dimension

Availability of energy has a direct impact on poverty, employment opportunities, education, demographic transition, indoor pollution and health, and has gender and age related implications. In rich countries, energy for lighting, heating and cooking is available at the flip of a switch. The energy is clean, safe, reliable and affordable. In poor countries, up to six hours a day is required to collect wood and dung for cooking and heating, and this task is usually done by women, who could be otherwise engaged in more productive activities. In areas where coal and charcoal are commercially available, these fuels take up a large portion of the monthly household income. Inadequate equipment and ventilation means that these fuels, burned inside the house, cause a high toll of disease and death through air pollution. The energy indicators identified under the social dimension are presented in Table 07. This table illustrates the two themes of the social dimension: *Equity and Health*. Social equity is one of the

principal values underlying sustainable development, involving the degree of fairness and inclusiveness with which energy resources are distributed, energy systems are made accessible and pricing schemes are formulated to ensure affordability. Energy should be available to all at a fair price.

Environmental Dimension

The production, distribution and use of energy create pressures on the environment in the household, workplace and city, and at the national, regional and global levels. The environmental impacts can depend greatly on how energy is produced and used, the fuel mix, the structure of the energy systems and related energy regulatory actions and pricing structures. Gaseous emissions from the burning of fossil fuels pollute the atmosphere. Large hydropower dams cause silting. Both the coal and nuclear fuel cycles emit some radiation and generate waste. Wind turbines can spoil pristine countryside. And gathering firewood can lead to deforestation and desertification. The Environmental indicators are divided into three themes: *Atmosphere, Water and Land* along with their sub-themes are presented in Table 08.

Economic Dimension

Modern economies depend on a reliable and adequate energy supply, and developing countries need to secure this as a prerequisite for industrialization. All sectors of the economy, residential, commercial, transport, service demand modern energy services. These services in turn foster economic and social development at the local level by raising productivity and enabling local income generation. Energy supply affects jobs, productivity and development. Electricity is the dominant form of energy for communications, information technology, manufacturing and services. The economic indicators have two themes: *Consumption and Production Patterns, and Security.* The first has the sub-themes of Overall Use, Overall Productivity, Supply Efficiency, Production, End Use, Diversification and Prices. The second has the subthemes of Imports and Strategic Fuel Stocks which are presented in Table 09.

Institutional Dimension

Energy Indicator for Sustainable Development does not include institutional indicators. These indicators are the most difficult to define for two reasons. First, they tend to address issues that are by nature, difficult to measure in quantitative terms. Many of these issues relate to the future and require dynamic analysis based on projections of energy production, consumption and investment. Second, the variables measured by institutional indicators tend to be structural or policy responses to sustainable development needs. Countries need to monitor the state of their major energy infrastructures to ensure a sustainable energy future.

URBAN SYSTEM CONCEPT

The following sub-systems are linked together and form an urban system. They are ***physical, social, economic, ecology, environment, infrastructure, and institutions.*** All these subsystems are interlinked and interdependent to each other functioning as a whole. Urban system is purely a dynamic system since it is always functioning. “A system functions as a whole with the interaction of several sub system. All the subsystems of the systems are interlinked and inter dependent on each other”. If one of the sub systems of the system defunct its effect can be seen in the whole system. Similarly, if one of the subsystems takes a lead role or has advanced functions in the system, its effects can also be observed in the whole system". In this present investigation the whole region is considered as system, since it has several subsystems and all the sub-systems are interlinked and interdependent to each other, and function as a whole. Urban system has different subsystems, such as, physical, social, economic, ecology, environment, infrastructure, and institutions. These all subsystems are interlinked and interdependent on each other and functions as a whole. Functions of Urban system along with its subsystems are presented in Figure 07

URBAN ENERGY INDICATORS FOR SUSTAINABLE DEVLOPMENT AND FUNCTIONAL LINKAGES WITH SUB-SYSTEMS OF AN URBAN SYSTEM

Social Indicators (Equity and Health)

From a sustainable development perspective, it is important to examine income, wealth and in particular affordability of modern energy services across the population. A country may have a high per capita gross domestic product (GDP), but its income distribution may be so skewed that a large percentage of the population has no possibility to meet their needs for commercial household energy at current energy prices and private income levels. Therefore, there is a need to decrease the burden of expenditure on fuel and electricity in household budgets for the lower-income groups of the population in developing countries, so as to promote social and economic development.

The social sub-system comprises the main themes of Equity and Health along with corresponding energy indicators. These indicators of social sub-system are linked to the use of noncommercial fuels, to energy prices and to several indicators of the economic sub-system, such as income inequality, share of household income spent on fuel and electricity, energy use relative to income level, urbanization, etc. The indicator might indirectly reflect a related use of forest resources as fuel wood, which in turn could

cause deforestation, will have impact on ecology and environmental sub-systems. The indicator of energy prices is linked to several indicators of the social sub-systems, such as income inequality, shares of households without access to electricity or heavily dependent on non-commercial energy services and energy use relative to income level and in turn will have functional linkages to some indicators of the economic sub-systems, such as the level of energy use, production, fuel mix, etc. The lack of access to modern energy services will have direct impact on health of well beings and would deteriorate environmental sub-system. The provision of modern energy services which lies under infrastructure sub-system would depend on proper fiscal instruments devised from the economic sub-system, physical sub-system and appropriate institutional mechanism of institutional sub-system of an urban system. Thus, the energy indicators of social sub-system are inter-reliant to each indicator of all other sub-systems of an urban system.

Environmental Indicators (Atmosphere, Water and Land)

During the 20th Century, the Earth's average surface temperature rose by around 0.6°C and evidence is growing that most of this warming is attributable to increasing concentrations of GHGs in the atmosphere. The quantity of CO_2, for example, has increased by more than 30 percent since preindustrial times and is currently increasing at an unprecedented rate of about 0.4 percent per year, mainly due to the combustion of fossil fuels and deforestation. [10].The resulting effect has been predicted to lead to more extreme weather events than in the past, with some areas experiencing increased storms and rainfall, and others suffering drought. An increasing percentage of the world's population lives in urban areas. High population density and the concentration of industry and traffic exert great pressures on local environments. Air pollution from energy use in households, industry, power stations and transportation (motor vehicles) is often a major problem. As a result, the greatest potential for human exposure to ambient air pollution and subsequent health problems occurs in urban areas. Improving air quality is a significant aspect of promoting sustainable human settlements. On the one hand, fresh water is a scarce resource in many parts of the world and needs to be used wisely to ensure and maintain sustainable quantities of good-quality supplies, when both sulphur and nitrogen compounds settle out of the atmosphere in the form of wet deposition (acid rain) or dry deposition, the resulting acidification of soils and surface waters can have serious consequences for both plant life and water fauna. When the soil becomes acidified, its essential nutrients are leached out, which reduces the fertility of the soil.

The environmental sub-system implies the main themes such as Atmosphere, Water and Land, along with relevant energy indicators. These indicators are closely linked to many other economic and environmental sub-systems indicators, including energy consumption per capita, per unit of GDP, primary, final energy consumption and electricity generation, fuel mix, atmospheric emissions, etc. In addition to annual air pollutant emissions and their percentage changes, emission intensities i.e., *expressed as quantities of pollutant emitted per unit of gross energy used* should be presented in order to assess sustainability [17]. These indicators of energy production and electricity generation are having functional linkages with other Physical, social, economic and environmental sub-systems indicators such as discharges of oil into coastal waters, greenhouse gas emissions, air pollutant emissions, etc. The solid waste generation and management system, including indigenous energy production, energy use, energy intensity, energy mix, energy supply efficiency, accumulated quantity of solid wastes to be managed, land area taken up by waste dumping, etc. are having casual relationship with the functions of physical, social, economic, environmental, ecology, infrastructure and institutional sub-systems of an urban system

Economic Indicators (Consumption and Production Patterns, Security)

Energy is a key factor in economic development and in providing vital services that improve quality of life. Although energy is a key requirement for economic progress, its production, use and byproducts have resulted in major pressures on the environment, both by depleting resources and by creating pollution. Energy is essential for economic and social development. However, energy use affects resource availability and the environment. In particular, fossil fuel use is a major cause of air pollution and climate change. Improving energy efficiency and decoupling economic development from energy use are important sustainable development objectives. Improvements in the efficiency of energy supply systems translate into more effective utilization of energy resources and into reductions of negative environmental impacts. In general, sustainable development requires increases in energy efficiency in all sectors in order to reduce overall energy use and to diminish negative environmental impacts. The economic sub-system comprises the main themes of Consumption and Production Patterns and, Security along with associated energy indicators. These economic sub-systems indicators such as energy use per unit of

gross domestic product (GDP), energy prices, energy intensities and energy net imports; are functional interconnected with other physical, ecology and environmental sub-systems indicators which implies the GHG emissions, air quality, waste generation; and with social indicators such as household energy use for each income group. The ratio of energy use to GDP is an aggregate energy intensity indicator and thus it linked to indicators of the energy intensities of the manufacturing, transport, service/commercial and residential sectors. Furthermore, it is also linked to indicators for total energy use, greenhouse gas emissions and air pollution emissions. Thus it shows the functional integration with the other sub-system such as, physical, social, infrastructure, environmental and institutional sub-systems of an urban system. Eventually, these indicators are also linked to indicators of final and primary energy use, electricity use, greenhouse gas emissions, air pollutant emissions and depletion of energy resources with relevance to all the seven sub-system of an urban system. Related indicators of the economic dimension are annual energy use per capita, intensity of energy use, energy mix are associated with emissions of greenhouse gases relevance to environmental sub-system. These indicators are also associated to social indicators such as share of household income spent on fuel and electricity of the social sub-system. The above discussion reveal that energy indicator of economic sub-system is interlinked or interdependent with the functions of several sub-systems, such as physical, social, economic, environment, ecology, infrastructure and institutional sub-systems of an urban system.

By linking these indicators and monitoring changes in their values, one should be able to visualize integrative dynamism effects in the whole urban system that shifts in energy production or consumption have on the economy, society and the environment. Out of 27 energy indicators for sustainable development under the social, economic and environmental dimensions, the change, lead role or defunct of any one indicator of a sub-system, its casual effects can be visualized in the entire system [10]. Therefore, systematic examination is very much essential to understand its dynamic behavior and complexity in nature. The authors captivating perspective after employing urban system's concept is that we the urban planners and policy makers need to think 'out of box'; the key is to think a bit differently which imply *systems thinking, relational thinking, ecological thinking, holistic thinking, and integrative thinking* to understand common connections and functional integrity of various sub-systems of urban system. Therefore, the 'Systems Thinking' is inevitable prerequisite to understand the interconnections /interdependency between the environment, economy and society. Eventually, this would help to resolve plausible recommendations/guidelines for navigating towards the sustainable and energy efficient urban development in the system.

SUSTAINABLE AND ENERGY EFFICIENT URBAN DEVELOPMENT: AN INTEGRATED PLANNING APPROACH

It clear evident from the above discussions, based on the available literature one can easily conclude that energy is the central core for human comfort and societal uplift of all sections of the people, in terms its production, consumption, activities, end users and also for polluting the urban environment by the emission of green house gases. Among the most significant environmental challenges of our time are global climate change, excessive fossil fuel dependency and the growing demand for energy, all likely to be major challenges of the 21st century and one of the greatest problems facing humanity. Infrastructure is the backbone of any national energy system. Countries need to examine the situation of their chief energy infrastructures to guarantee a sustainable energy future. Many countries now depend on major energy infrastructures that are obsolete, inefficient, insufficient or environmentally unacceptable.

With above knowledge, the authors have been motivated to work towards the sustainable, energy efficient and climate resilient urban development of Indian megacities. Man consumes energy and community, the basic unit of urban development along with the subsystems of an urban system, is also an integrated energy -consuming unit which is presented in Figure 08. Energy divides energy users into four groups: residential, commercial, industrial, transportation, and energy lose. (For every one unit of "useful energy" received more than two units of energy are wasted as heat). These groups are called the sectors of the economy. The principle of sustainable development implies the three dimensional concept for improving quality of life in sustained path, socially, economically and environmentally, over a long term. Urban system comprises of seven sub-systems, such as physical, social, economic, environment, ecology, infrastructure, and institutional respectively. The functions of these sub-systems are interconnected and interdependent with each other. i.e., a subsystem's output is one or more other subsystem's input. In an urban system, if one of the subsystems defunct, or partially function or takes lead role in its function over a period of time its effects would be visualized in the whole system. The urban energy is a central basic unit and its functions/activities are having direct/indirect relationship with one way or other

with all the sub-systems of an urban system. Therefore, an integrated planning approach is very much essential to achieve the state of sustainable and energy efficient urban development in the system.

Urban Energy Consumption Along With Influential Factors For Low Carbon Development

Energy is central to improve social and economic well-being .It is important to be able to measure a country's state of development and to monitor its progress or lack of progress towards sustainability. First, policymakers need to know their country's current status concerning energy and economic sustainability, what needs to be improved and how these improvements can be achieved. Second, it is important for policymakers to understand the implications of selected energy, environmental and economic programmes, policies and plans, and their impacts on the shaping of development and on the feasibility of making this development sustainable. Third, inevitably there will be trade-offs. Policymakers need methods for measuring and assessing the current and future effects of energy use on human health, human society, air, soil and water. They need to determine whether current energy use is sustainable and, if not, how to change it, so that it is sustainable. This is the purpose of the energy indicators which address the important issues within three of the major dimensions of sustainable development: economic, social and environmental. Changes in intensities are affected by factors other than energy efficiency; therefore, analyzing intensity trends provides important insights into how energy efficiency and other factors affect energy use. There are three main components affecting energy use: activity levels, structure (the mix of activities within a sector) and energy intensities (energy use per unit of sub-sectoral activity). Depending on the sector, *activity* is measured either as value added, passenger-kilometres (km), tonne-km, and population or built area. *Structure* divides activity further into industry sub-sectors, transportation modes or measures of residential end-use activity.

The Figure 09 illustrates the integrated model concept developed by the authors which gives clear idea about the sectoral distribution of total energy consumption along with its potential influencing factors for energy reduction in the urban system. Based on the study of extensive literature and discussion, the authors decided to disaggregate the total final energy consumption in to six sectors in Indian context: They are: *household, manufacturing industry, other industry, passenger transport, freight transport, and services* respectively. It is understood that there are four influencing factors which are highly responsible for urban energy reduction, they are: *Energy production, Mobility, Urban form, and Building,* respectively. These factors are not only responsible for energy reduction and also having great influence in minimizing the CO_2 emissions, associated with traffic related problems by paving the way for low carbon urban development in the system.

Climate Resilient and Sustainable Development

Climate change is a major environmental problem that represents social and economic threats to everyone in the globe. Risks have become higher from the natural disasters that loom to almost unmanageable extent, longer periods of rain, harsher storms, prolonged dry spells, extreme heat and cold temperatures, more frequent hot days and nights, flash floods, forest fires, rising sea level, tsunamis, volcanic eruptions, earthquakes, and the warming global temperature are being experienced by the 'mother earth' and implies serious threat to humanity. Urban resource consumption and waste disposal is widely seen as the root cause of many of the world's environmental problems. Because so much damage has already been done to the world's ecosystems, and solutions need to be found to reverse it, we need to start resilient thinking rather than just sustainable urban development. Resilience thinking for the 21st century is inevitable for generating sustainable community and preserving the living environment. Resilience is the ability of a system to respond to change without altering the structure and function of the system. In the past decade concepts that capture the idea of how to future-proof our cities have arisen worldwide: *smart cities, liveable cities, sustainable cities, intelligent cities, resilient cities.*

According to Intergovernmental Panel on Climate Change (IPCC), *"Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" [14].*

The authors have devised the climate change adaptation framework for India, which recognises the importance addressing climate change adaptation along with actions to reduce emissions. However, the actions of the adaptation framework will focus on achieving climate change adaptation rather than emissions reduction. The suggested conceptual framework has been presented in Figure 10 and this will assist decision makers by focusing action on the following four areas, eventually, the outcome would be increased resilience to a climate change.

Table 07: Selected Energy Indicators on Social Dimension

SOCIAL (Equity and Health)				
S.No	**Sub-Theme**	**Energy Indicator**		**Components**
1	**Accessibility**	**SOC1**	Share of households without electricity or commercial energy or heavily dependent on non-commercial energy	▪ Share of households without electricity or commercial energy or heavily dependent on non-commercial energy ▪ Total number of households or population
2	**Affordability**	**SOC2**	Share of household income spent on fuel and electricity	▪ Share of household income spent on fuel and electricity ▪ Household income(total and poorest 25% of population
3	**Disparities**	**SOC3**	Household energy use for each income group and corresponding fuel mix	▪ Energy use per household for each income group ▪ Household income for each income group ▪ Corresponding fuel mix for each income group
4	**Safety**	**SOC4**	Accident fatalities per energy produced by fuel chain	▪ Annual fatalities by fuel chain ▪ Annual energy produced

Source: Compiled by the investigators based on the report on Energy Indicators for Sustainable Development, IAEA, 2005 & IEHB, 2011 [10,11].

Table 08: Selected Energy Indicators on Environmental Dimension

ENVIRONMENTAL (Atmosphere, Water and Land)				
S.No	**Sub-Theme**	**Energy Indicator**		**Components**
1	Climate Change	**ENV1**	GHG emissions from energy production and use per capita and per unit of GDP	▪ GHG emissions from energy production and use ▪ Population and GDP
2	Air Quality	**ENV2**	Ambient concentrations of air pollutants in urban areas	▪ Concentrations of pollutants in air
		ENV3	Air pollutant emissions from energy systems	▪ Air pollutants emissions
3	Water Quality	**ENV4**	Contaminant discharges in liquid effluents from energy systems	▪ Contaminant discharges in liquid effluents
4	Soil Quality	**ENV5**	Soil area where acidification exceeds critical load	▪ Affected soil area ▪ Critical load
5	Forest	**ENV6**	Rate of deforestation attributed to energy use	▪ Forest area at two different times ▪ Biomass utilization

6	Solid Waste Generation and Management	**ENV7**	Ratio of solid waste generation to units of energy produced	▪ Amount of solid waste ▪ Energy produced
7	do	**ENV8**	Ratio of solid waste properly disposed of to total generated to total generated solid waste	▪ Amount of solid waste properly disposed of ▪ Total amount of solid waste

Source: Compiled by the investigators based on Energy Indicators for Sustainable Development, IAEA, 2005 & IEHB 2011[10, 11].

Table 09: Selected Energy Indicators on Economic Dimension

ECONOMIC (Consumption and Production patterns, Security)				
S.No	**Sub-Theme**	**Energy Indicators**		**Components**
1	**Overall Use**	**ECO1**	Energy use per capita	▪ Energy use (total primary energy supply, total final consumption and electricity use ▪ Total population
2	**Overall Productivity**	**ECO2**	Energy use per unit of GDP	▪ Energy use (total primary energy supply, total final consumption and electricity use Total population ▪ GDP
3	**Supply Efficiency**	**ECO3**	Efficiency of energy conversion and distribution	▪ Losses in transmission systems including losses in electricity generation, transmission and distribution
4	**Production**	**ECO4**	Reserves-to-production ratio	▪ Proven recoverable reserves ▪ Total energy production
		ECO5	Resources -to- production ratio	▪ Total estimated resources ▪ Total energy production
5	**End Use**	**ECO6**	Industrial Energy intensities	▪ Energy use in industrial sector (Manufacturing branch) ▪ Corresponding value added
		ECO7	Service/Commercial energy intensities	▪ Energy use in service/commercial sector ▪ Corresponding value added
		ECO8	Household energy intensities	▪ Energy use in households and by key end use ▪ Number of households, floor area, persons per household, appliance ownership
		ECO9	Transport energy intensities	▪ Energy use in passenger travel and freight sectors and by mode ▪ Passenger-km travel and tonne-km freight and by mode

ECONOMIC (cont.,) (Consumption and Production patterns, Security)			
S.No.	**Sub-Theme**	**Energy Indicator**	**Components**

6	**Diversification (Fuel Mix)**	**ECO10**	Fuel shares in energy and electricity	▪ Primary energy supply and final consumption electricity, electricity generation and generating capacity by fuel type. ▪ Total primary energy supply, total final consumption, total electricity generation and total generating capacity
		ECO11	Non-carbon energy share in energy and electricity	▪ Primary supply, electricity generation and generating capacity by non-carbon energy ▪ Total primary energy supply, total electricity generation and total generating capacity
		ECO12	Renewable energy share in energy and electricity	▪ Primary energy supply, Final consumption and electricity generation and generating capacity by renewable energy ▪ Total primary energy supply, total final consumption, total electricity generation and total generating capacity
7	**Prices**	**ECO13**	End-use energy prices by fuel and by sector	▪ Energy prices (with and without tax/subsidy
8	**Imports**	**ECO14**	Net energy import dependency	▪ Energy imports ▪ Total primary energy supply
9	**Strategic Fuel Stocks**	**ECO15**	Stocks of critical fuels per corresponding fuel consumption	▪ Stocks of critical fuel (such as oil, gas, etc.,) ▪ Critical fuel consumption

Source: Compiled by the investigators based on Energy Indicators for Sustainable Development, IAEA, 2005& IEHB, 2011 [10, 11]

(a) Exposure: the degree to which Indian cities are exposed to change such as increases in annual temperature**.** This will be addressed by developing a better understanding of the consequences of a changing climate and the challenges and opportunities it presents; (b) **Adaptive Capacity:** the ability of organisations and stakeholders to identify risks and take appropriate action. This will be addressed by working to equip stakeholders with the skills and tools needed to adapt to a changing climate; and (c) **Competing pressures:** the degree to which organisations are restricted in how much they can do to adapt to a changing climate by other, competing pressures and constraints. This will be addressed by work to provide wider public policy and regulation that, wherever possible, is a help, not a hindrance, to addressing climate change issues. (d) **Communication to Indigenous People:** The building capacity of indigenous people which includes the cultural integration, organizing community, resources allocation, knowledge management, and developing skills and technology respectively. The communication which implies the following questions adaptation impact and mitigation for the changing climate towards indigenous people for achieving coherent social development.

(a) What are the means to communicate climate change adaptation?*(Adaptation)* (b) How is it best to communicate the message of climate change to a segment? *(Impact)* (c) What is the role of communication to mitigate impact of climate change?*(Mitigation)*

RECOMMENDATIONS AND GUIDELINES

Urban planning can enhance the ability of cities to meet climate change goals in mitigating, adaptation and resilience if they are strategically and systematically planned. The concern surrounding climate change and its impact on cities demonstrates the importance of maintaining and improving the sustainability of cities, worldwide. Urban planners can play a lead role in considering and anticipating the environment and health of different subsystems within an urban environment.

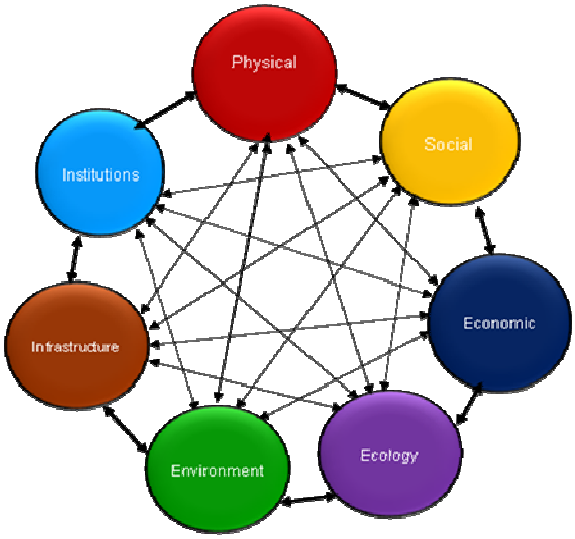

Figure 07(Color): Functions of Urban system along with its subsystems

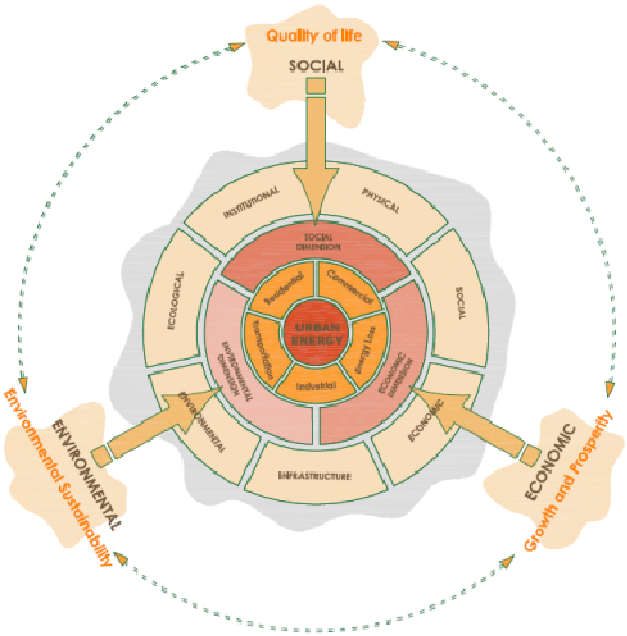

Figure 08(Color): Urban Energy: a central basic unit of an Urban System
Source: Compiled by the investigators based on IEA, 2001 and India Energy Hand Book, 2011[11, 13].

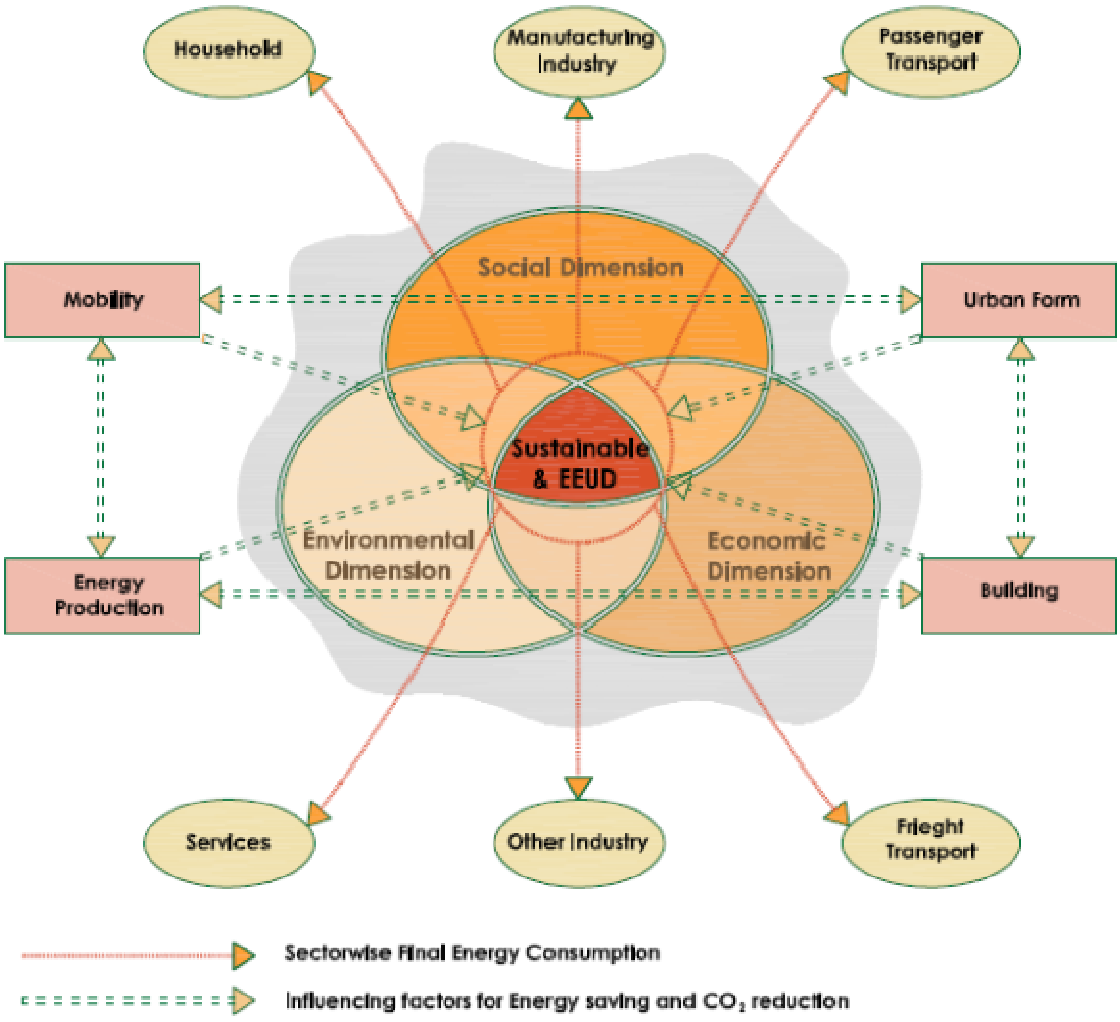

Figure 09(Color): Integrated Model Concept for energy reduction: Sector wise disaggregation of energy consumption along with influencing factors of an urban system
Source: Compiled by the investigators based on the report of IAEA, 2005 & WEC,2000 [10,18].

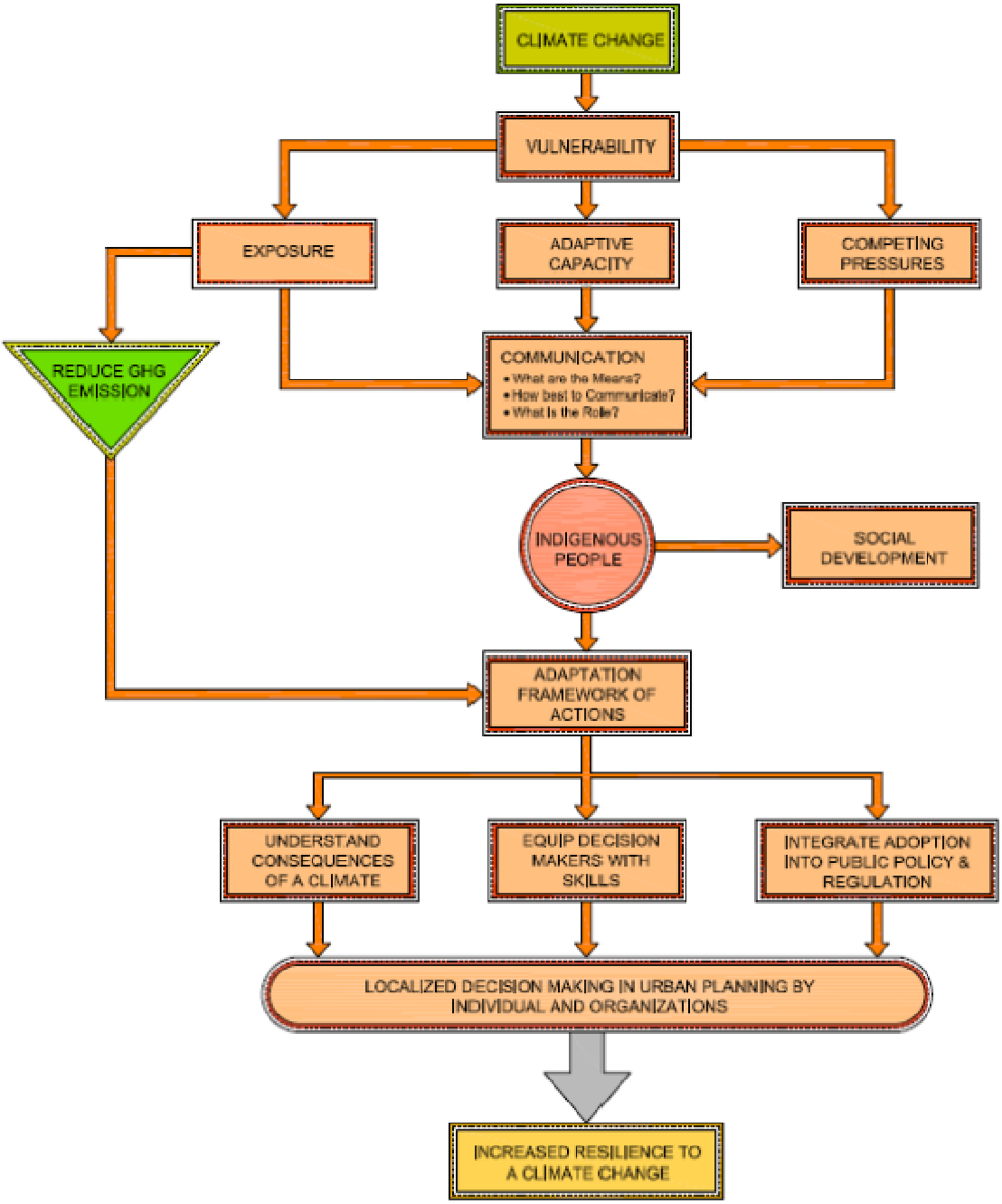

Figure 10(Color): A Conceptual Framework to promote Resilience for the Changing Climate
Source: Compiled by the investigators based on Sustainable Development in India, 2011[14, 15].

While planning livable cities, environmental sustainability is increasingly being considered in urban development plans. For climate change policies to be city wide and integrated requires urban planning interventions. Strong urban planning can promote resilience by ensuring optimal use of space, energy and natural resources.

Building Climate Resilience and Low Carbon Development

(i).Comprehensive city planning and integrated approaches, which involve all departments and sectors as well as expertise from various stakeholders. It would be useful to integrate one common component / aspect into all planning and processes at the urban level. (ii).The element of uncertainty associated with climate change impacts would require flexibility and adaptability within the planning processes. Ensuring sustainability as one of the key outputs of urban planning mechanisms is also a key feature. (iii). Engagement, education and awareness raising campaigns are a useful element within planning for development because each behavior or activity can contribute to climate change, wasting electricity, driving cars, not recycling or reusing man-made waste. (iv). Decentralized and improved local / urban governance is important for practical implementation of resilience and sustainability strategies. Cities contribute to and can reduce climate impacts caused by carbonemissions. Municipal governments are responsible for making sure that in their own administration and their governance role move towards climate-neutrality. (v). Public-private partnerships (PPPs) are an important and effective means of leveraging stakeholder expertise and forming partnerships for greater community benefits. Setting standards and regulations is possible only by the municipal governments for sustainable urban development, but the private sector needs to be involved and reigned in. (vi). Involving stakeholders and organizations to educate and facilitate informative processes that would address climate change and its effects. (vii).Awareness generation towards sustainability and climate change issues would also help generate demand from the general public for efficient and timely systems to support adaptation and mitigation. (viii). Timely action and leadership commitment is also a crucial component for urban resilience to climate change. Livable and resilience cities hinge upon ensuring appropriate actions and strategies are taken at the right time in anticipation of the diverse impacts of climate change. (ix). Information Technology (IT) tools like various data visualization techniques can help better inform the municipal bodies, utilities and others as well as the general citizens of the impacts and likely responses of climate change (x). Advanced Mapping, visual and spatial technologies can promote effective resource allocation and resilience strategies in cities. (xii) 'Systemic risk analysis of cities to climate change induced extreme events' is needed. Although there is macro level assessments on assessing the impacts of climate change induced extremes, there is a need for more city specific bottom up studies for all hydro meteorological disasters. (xiii).There is need for stricter implementation of existing rules and regulations. There are flood zone regulations, land use guidelines, cyclone guidelines, coastal regulation zone (CRZ) notifications that detail out a set of actions for development activities in the vulnerable regions. (xiv). It is important for governments to support scientific research on risk assessments, disaster prediction, modeling and monitoring methods, early warning systems and communication tools. (xv). To ensure disaster resilient development in cities, there is a need for 'better inter-agency coordination' across Ministries and departments such as urban affairs, housing, water resources, environment, transport, power, communications, municipal governance amongst others at national, state and local levels along with the support of NGOs and civil society.

Promotion of Green Building and Sustainable Building Policies

Energy consumption in buildings gives rise, directly and indirectly, to as much as 40 percent of CO_2 emissions and represents more than a third of global consumption. The demand for energy to run appliances such as televisions, air conditioning and refrigerators are also increasing substantially with rise in living standards. Climate change will further increase site energy demand as people shall seek to maintain comfort levels in more extreme conditions Green buildings entail promotion of energy efficiency, land sustainability, water efficiency, resources efficiency and better building environment. Such buildings have minimal adverse impacts on the built and natural environment. Building policies that regularly demonstrate GHG emissions reductions aim to: (i). A National Green Building policy which can be made a part of the National Urban Policy by the Ministry of Urban Development, India. This will serve as the guiding document for all the states to build their own state specific Green Building policy and model legislation. (ii). Each State should prepare a state specific Green Building policy and to legislate the preparation of Building bye laws incorporating principles of Green Buildings by each Development Authority. (iii). The State should also issue a statutory order to make a mandatory provision that all public buildings to be built in future will be green buildings. (iv). Each Development authority should amend the Building bye laws of municipalities and

Corporation coming under their respective jurisdiction in a defined time frame. (v). Building byelaws and codes need to be revised and rewritten at ULB level integrating aspects of Green buildings and Energy Conservation and Building code and various policies at the federal level. (vi). Increase building energy efficiency through design, placement and retrofitting with energy-saving devices. (vii). Increase local share of renewable and captured energy generation. (viii).Reduce Urban Heat Island effects by requiring or encouraging "green roofs". (ix). Discourage more use of Air-conditioning in buildings. (x). Cool roof and cool pavements use materials with higher albedos than traditional asphalt and are a viable technology for mitigating the urban heat island

Mitigating Emissions from Urban Transport Sector

Transport sector in most developing countries, the cities are experiencing an increasing share of personal motorized traffic, which has had impacts in terms of increasing traffic congestions, travel times, road accidents, pollution and most of all increasing dependence on fossil energy. They need to plan appropriate interventions to reduce reliance on personal vehicles, make them more fuel-efficient and increase the share of public transport and non-motorized transport that will lead to a significant reduction in energy consumption. Way forward for transport sector in Indian cities is recommended below: (i). The focus of development in urban transport should be on increasing shares of public transport trips as they are more clean, energy efficient and socially integrating. (ii). Integrated transport planning needs to be practiced in the cities and there is urgent need of state governments to discourage the use of personal vehicles and increase the share of public transport. (iii). All safety concerns of cyclists and pedestrians have to be addressed by encouraging the construction of segregated rights of way for bicycles and pedestrians. (iv).There is a need to establish fuel economy standards in the country as many studies have shown that the introduction of fuel economy standards will result in a significant reduction in energy consumption. (v). Promotion of clean alternative fuels and technologies like bio-fuels, hybrid vehicles, electric vehicles etc. by subsidizing the introduction of these technologies. (vi). Private investment in public transport should be encouraged by amending the laws relating to public transport. (vi). There is urgent need to develop a detailed and integrated strategy for urban transport sector, which is in line with National Urban Transport Policy (NUTP) and National Action Plan on Climate Change (NAPCC) and other sustainable mobility principles. (vii). Increase use of public transportation systems by discouraging personal dependency on personal vehicles and also support non-motorized means of travel. (viii). Encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved. (ix). Introducing Intelligent Transport Systems for traffic management. (x). Establishing institutional mechanisms for enhanced coordination in the planning and management of transport systems.

General recommendations for Sustainable and Energy Efficient Urban Development

(i). Encourage Compact City development to curtail urban sprawl effect in the system. (ii). Reducing Citywide Energy Demand to encounter the localized effect of Urban Heat Island. (iii). Increase more vegetative cover and must identify the specific use or range of uses appropriate for each area tree-cover development under urban planning process. (iv). Discourage fossil fuel dependency on cities functions and other associated activities. (v). Incentivizing walking, cycling and using public transport of the City. (vi). Municipal energy efficiency projects can be coordinated by a Citywide Energy Strategy. (vii).The consumption of renewable energy potentials should be extended in the system. (viii).Public utilities and services are considered as important municipal steering tools. (ix). Car pooling techniques should be introduced to decrease energy demand and to ease the traffic congestion. (x). Discouraging city-ward migration.

CONCLUSION

The review of literatures and discussions in the section (2) of this research paper reveals that urban population growth in the developed countries with moderate and lesser intensities, where as developing and least developed countries characterize with constant and higher intensities. The authors conclude that the unprecedented population growth and urbanizing forces are driving the present and future levels of urbanization, particularly in developing countries, have clear linkages to the global greenhouse gas (GHG) emissions.' Dynamism' of a city, denotes "something which is alive" is not a physical structure but dynamism evident in the incessant movement of physical components. Living being has no fixed, static mass (it grows), no fixed, static shape, no fixed, static composition, no fixed, static structural organization at a particular saturation point, likewise the 'City growth' is limited to certain level, but 'City development' cannot be limited, which indicates the dynamic process in the system. The word "integration" denotes a complex network of dependencies and correlations between these distinct activities [12]. In this research paper the term

'integration' implies a kind of indivisibility among the functions of sub-system of an urban system. 'Integrative dynamism' demonstrates that within the life-cycle, even a common man can easily distinguish several distinct, regular, repetitive, pattern-like forms of dynamism, for instance: *Utilization of Urban Energy:* it is a highly selective exploitation of raw materials and random portions of energy present in the environment. Every form of life cycle reveals a capacity to find and ingest a particular kind of raw material, and a particular form of energy to satisfy the needs of the humanity. It is also recognized that anthropogenic activities stimulate the raise of urban energy demand, which is highly influential for surplus GHGs emission and being the root cause for the environmental chaos in the system.

The current urbanizing world of 21st century the new form of city development that earth's need is 'Sustainable, Energy Efficient and Climate Resilient Urban development'. With increasing population and growing pollution, we can't ignore the ill effects of planning on the environment. These can be achieved through deploying appropriate policy measures by reducing urban energy demand in energy production and consumption sectors towards localized strategic planning. Integrated Model Concept for energy reduction has been developed by authors, considering urban energy as central basic unit by employing urban system's concept, which would realize its functional linkages and complex nature. System's thinking a way forward to understand interconnections between the environment, economy and society. Furthermore, the authors have also suggested a conceptual adaptation framework to encounter the changing climate along with actions to reduce emissions and expected outcome would be increased resilience to a climate change. This integrated planning approach is indispensable to understand the integrative dynamism effects amongst the Urban Energy, Climate Resiliency and Sustainable Development, which are indivisible to achieve eco-responsible future. This synergetic approach would pave the way for present and incipient megacities of India and may support in decision making for sustainable and energy efficient urban futures.

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