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Introduction: The Idea of Green Building

Earth, upon which this moving, breathing life exists;
May she bestow on us the finest of her harvests!
Earth, the all-sustaining, treasure-bearing, resting-place;
Golden breasted Earth, home of all Life, Who bears the sacred fire.
...Set me, O Earth, amidst the nourishing strength
That emanates from thy body.
The Earth is my mother, her child am I.

— AtharvaVeda

India is on the path of massive urbanization. From 377 million urban population, living in 7936 cities and towns, it is projected that by the year 2030, 600 million people will live in urban areas and 68 cities in India will become metropolitan (million plus). Massive efforts and investments will be required for housing, however, the efficacy and haphazard development continue to scar our cities. Although the cities generate 60% of GDP and 70% jobs, the state of housing and basic infrastructure services remain awfully poor, impeding sustainability and economy.

Table 1.1: India's Urban Trajectory

Year	*2011*	*2030*
Population	1210 million	1440 million
Urban population	377 million	600 million
Million+ Cities	47	68
5 million+ Cities	6	10
Housing Shortage	18.78 million units	40 million units
Slum Population	75 million	200 million

Source : Census of India, 2011 & McKinsey Report, 2010.

Notwithstanding the fact that still many Indian cities are abysmally poor, they are the engines of productivity and wealth. The wealth created by urbanization and innovations in housing, services, utilities and technology lead to improvements in people's lives. Big cities are the vanguards of this change, where incomes and resources are available. Although some of the India's biggest cities still appear poor by world standards, many are now as rich as their counterparts in the developed world were 50 years ago. It is projected that by the year 2031,70 per cent GDP and 70 per cent of new jobs will come from the cities.

Cities and buildings are spatial manifestations of human and economic activities and exhibit a dynamic relationship between various elements. There is a considerable amount of resource use and environmental impact directly and indirectly associated with buildings. Estimates put construction alone responsible for approximately 40% of total energy use worldwide, most of which is sourced from fossil fuels. This energy consumption in buildings has been growing dramatically over the years with changing lifestyle.

India's urbanization as economic development is changing the lifestyles of its people. Increasing production, mobility, consumption and living in comfort, are enhancing the carbon emissions-and climate change. Models predict an average increase in temperature of 2.3 to 4.8°C in India for the benchmark doubling of carbon dioxide scenario. Although per capita carbon emissions in India at 1.2mt per year is one of the lowest in the world, it is predicted to become double within next 10 years. Already in the urban areas the people with cars and air conditioners emit 4.5 mt of CO_2 Green House Gases (GHG) per year, while the low income people without car and air conditioners, emit an average of 1.1mt of CO_2/GH gases. As per UN Climate Change Panel, a benchmark of 3.0 mt per capita per year should be the upper limit.

Table 1.2: Carbon Dioxide and Green House Gases Emissions

	Total emissions Billion metric tonnes	*Per capita (Metric tonnes)*
US	6.049	20.4
Canada	0.639	20.0
Russia	1.524	10.5
Japan	1.257	9.8
Germany	0.860	9.7
UK	0.587	9.7
China	5.010	3.8
India	1.342	1.2

Source: UNFCC. WRl. 2004

This warns us to change our urban development paradigm, which has to be low carbon and is compatible to local climate, culture and is passive and low-energy. Although bio-climatic principles are relatively well advanced, what is lacking is their practice. The cornerstone of a low carbon society is to adopt an integrated approach towards ecology and the conservation of the natural resources.

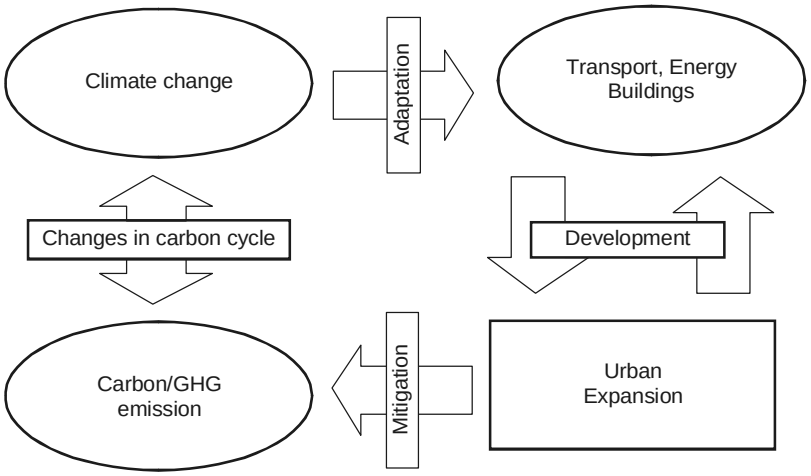

Fig. 1.1. The vicious cycle of climate change

Source : UN Habitat, 2011

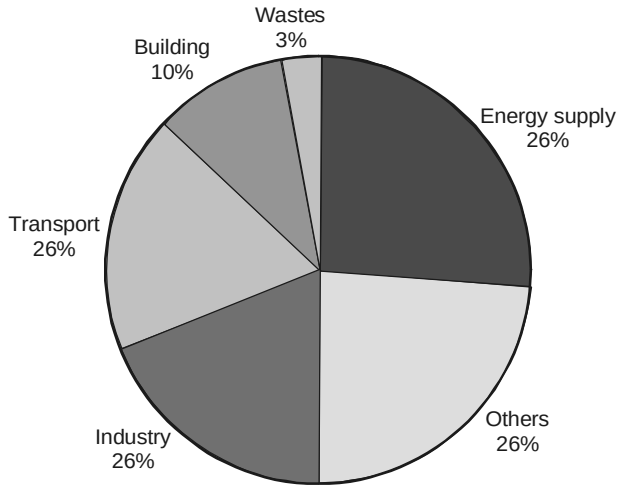

Fig. 1.2. Sources of GHG/equivalent carbon emissions.

Source : IPCC, 2007

Table 1.2 : Typical Greenhouse Gas Emissions

Activity	*Metric Tones (mt) per Capita per year*
Cooking Gas	0.1
Lighting	0.1
Electric appliances/fridge	0.6
Air-conditioning	1.5
Bus, Rail, Trams	0.1
Car	1.2
Air Travel	1.8
Other Direct Emissions	0.8

Source: Goodal, Christ, (2007) How to Live a Low Carbon Life, Earthscan, London

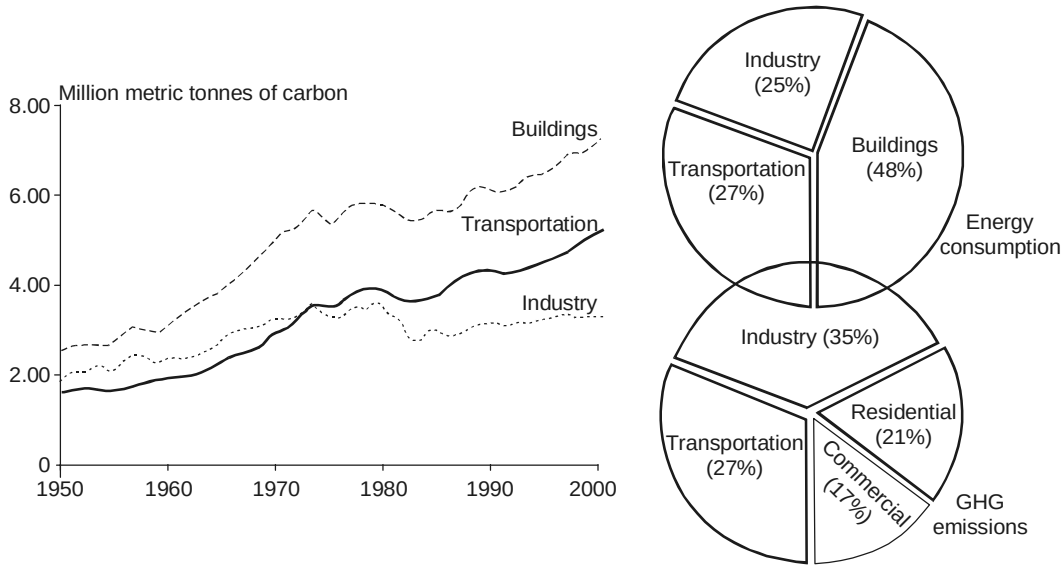

Fig.1.3 Annual energy consumption in various sectors, with buildings being the largest energy consuming and greenhouse gas emitting sector in the USA.

Source : USEIA, 2003.

The studies indicate wide variations in greenhouse gas emissions, which increase exponentially with the high end lifestyle, i.e. using air-conditioning, car-travel, air travel, etc.

The following standards are generally adopted to work out the greenhouse gas emissions:

Table 1.3 : Direct Greenhouse Gas Emission Standards

1 kwh (or unit) of electricity	0.43kg of CO_2/GHG
1 kwh of gas (approximately 11.5 kwh per cubic meter)	0.19 kg/CO_2/GHG
1 litre of petrol	2.3 kg/CO_2/GHG
1 km of rail or coach travel	0.049 kg/CO_2/GHG
1 km of long distance coach travel	0.028 kg/CO_2/GHG
1 km of bus travel	0.1 kg/CO_2/GHG
1 km of air travel	0.30kg/CO_2/GHG

Source: Goodall. Christ. (2007) How to Live a Low Carbon Life, Earthscan, London

Among the various cities of the world, India still has one of the lowest carbon emissions, however this is rapidly increasing and in absolute terms it is one of the highest.

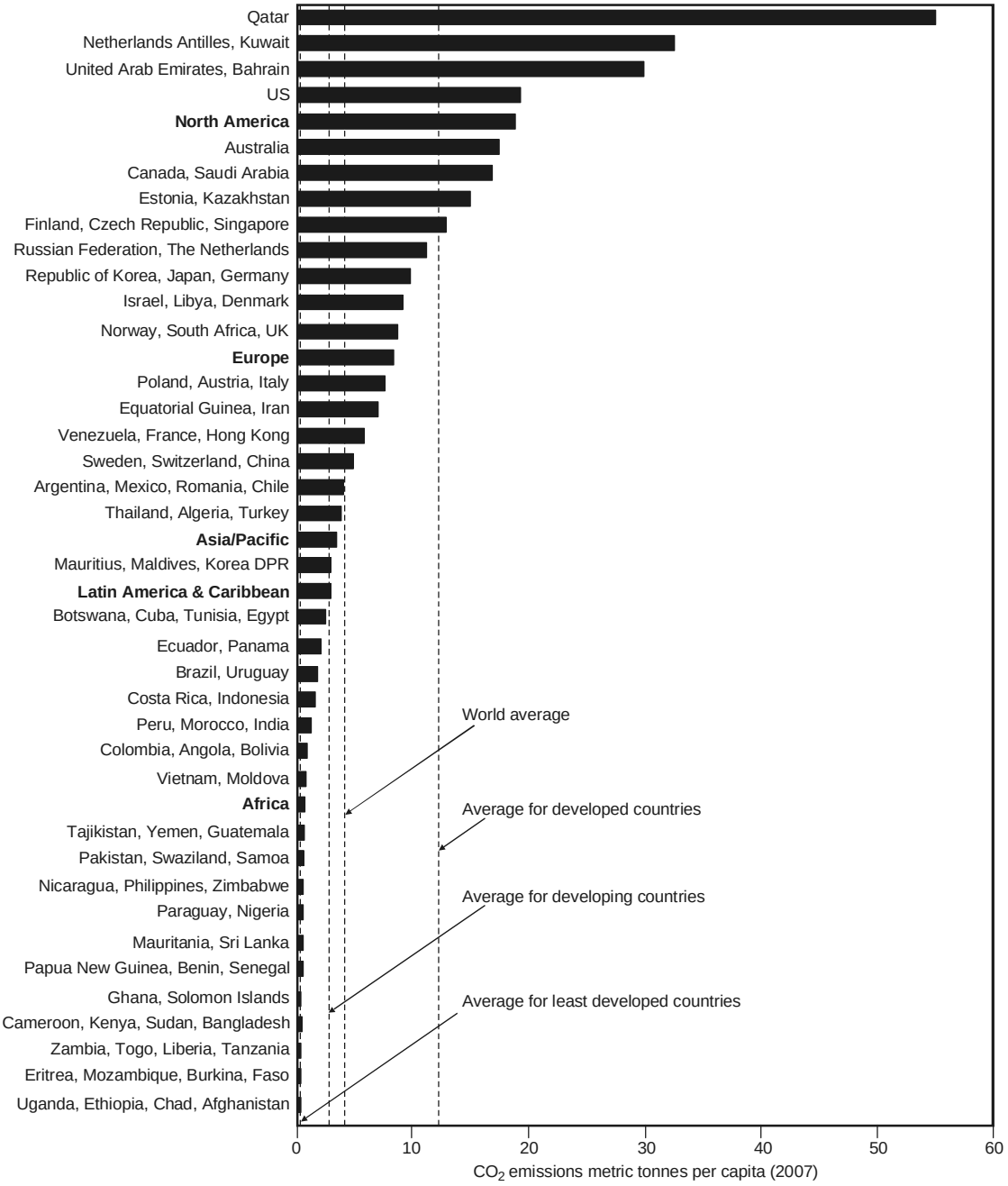

Fig.1.4. CO_2 Emissions per capita in selected countries and world regions (2007)

Source : IPCC

Without the greenhouse gases, including carbon dioxide, methane, nitrous oxide, and water vapour, earth would be too cold to inhabit. These gases in earth's, atmosphere absorb and emit heat energy, creating the greenhouse effect that keeps our planets temperature livable. Water vapour is the most plentiful greenhouse gas on the planet, accounting for about 60 percent of

the current greenhouse effect. Even ozone helps trap some of the heat that makes life on earth possible, but the 'ozone hole' is a separate issue not directly related to global warming.

Since the industrial revolution, people have burned vast amounts of coal, petroleum, and other fossil fuels to create heat and power. This releases carbon dioxide, the most plentiful human-produced greenhouse gas, into the atmosphere. The result more heat is trapped in Earth's atmosphere instead of radiating out into space.

Because carbon dioxide lasts more than a century in the atmosphere, it is well mixed around the globe. Measurements collected atop Hawaii's Mauna Loa since 1958 show a steady rise in global carbon dioxide concentrations. These have increased by 35 percent since preindustrial times, according to the World Meteorological Organisation. Other less prevalent greenhouse gases have increased at different rates. Methane, for example, has virtually levelled off since 1999 at 155 percent above its preindustrial level.

The relationship between earth's water cycle and global warming creates a well-known feedback loop. Warmer temperatures cause more evaporation from land and oceans, which produces more water vapour, which in turn contributes to warmer temperatures. This is just one of many feedbacks in the earth system that climate scientists are studying to improve projections of future climate change.

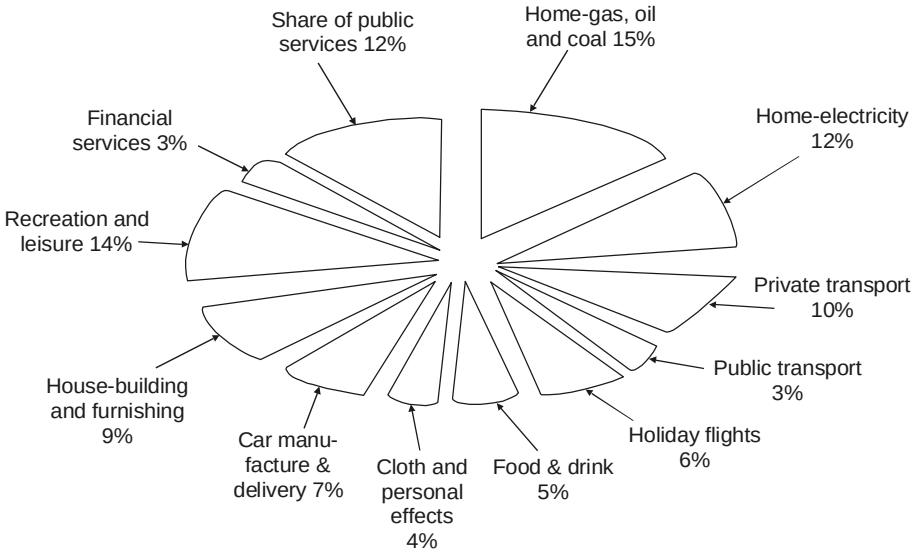

Fig.1.5 Main elements which make up a typical person's carbon footprint.

Climate Change and the United Nations/IPCC

1988	The world takes note of global warming. UN sets up Inter Governmental Panel on Climate Change (IPCC). Two years later, IPCC gives its First Report saying world is warming unnaturally.
1992	Rio Conference produces UN Framework Convention on Climate Change (UNFCC) which asks rich nations to cut emissions as they are responsible for it. Also tells them to financially and technologically help other countries improve. US opposes and blocks "polluter pays principle".

(*Contd....*)

1997	Kyoto Protocol adopted. Wants emissions to be brought down 5.2% below 1990 levels by 2012. Wants biggest emitters to commit to specific cuts. US Senate opposes proposal. US abstains at Kyoto. Protocol ratified in 2002.
2001	IPCC's 3rd Report says unprecedented global warming is "very likely". Scientists agree.
2007	IPCC gives its 4th Report, says effects of warming are already evident. Reiterates that cost of cutting emissions is less than cost of inaction. Still rich countries try to push burden of emission reduction on "emerging economies". At Bali, India leads fight back. In the same year Al Gore and IPCC get Nobel Peace Prize. Still there is no real action plan on which the world is agreed.
2008	Recession hits world giving rich countries case for not compensating the developing countries. India releases National Action Plan on Climate Change with eight missions.
2009	Climate Summit held at Copenhagen.

The Challenge of Climate Change

Climate change has become real and tangible, affecting people's lives worldwide. Over the past decade the earth has become warmer, rainfall is more erratic, polar ice caps and glaciers are melting, the sea level is rising and extreme weather events are becoming more frequent and more intense. Droughts and floods occur more often, and climatic zones are shifting. Development successes and the Millennium Development Goals are at risk. Greenhouse gas (GHG) emissions have been identified as the main cause for human induced climate change. Hence, decoupling of GHG emissions from economic growth to mitigate climate change, and adapting to its inevitable impacts have become global challenges.

India with its diverse agro-climatic and morphological zones is particularly affected by climate change. According to the initial national communication to the United Nations Framework on the Convention on Climate Change, the predicted impacts of climate change in India include a surface air temperature rise up to 4° Celsius by 2100, up to 30% decline in yield in rain-fed areas for some crops and an increase in incidences of extreme events, such as droughts, floods and cyclones. Since these impacts will strongly vary in its extent and form throughout the country, they require customised interventions in different states and regions to cope with these risks and to enhance the resilience of threatened population.

According to the Indian Network for Climate Change Assessment in 2010, 58 per cent of the total emissions in 2007 were caused by the energy sector, followed by the industrial sector at 22 per cent, agriculture at 17 per cent, waste at 3 per cent and land use, land use change and forestry at 1 per cent. Of the total carbon dioxide (CO_2) emissions 85% were contributed by activities of the energy sector. Of the total national methane (CH_4) and nitrous oxide (N_2O) emissions 78% were due to the agriculture sector.

Climate change can bring considerable changes in the hazard profile of the region by changing the type of hazards, changing the hazard intensities, magnitude and frequency. Many of these impacts may not be uniform across spatial and temporal scales. Devastating floods in Bangladesh, India, Nepal and Pakistan, typhoons in Philippines and a series of hurricanes in Florida are being associated with climate change. The intrinsic relationship of disasters and climate change are conceptually presented on next page :

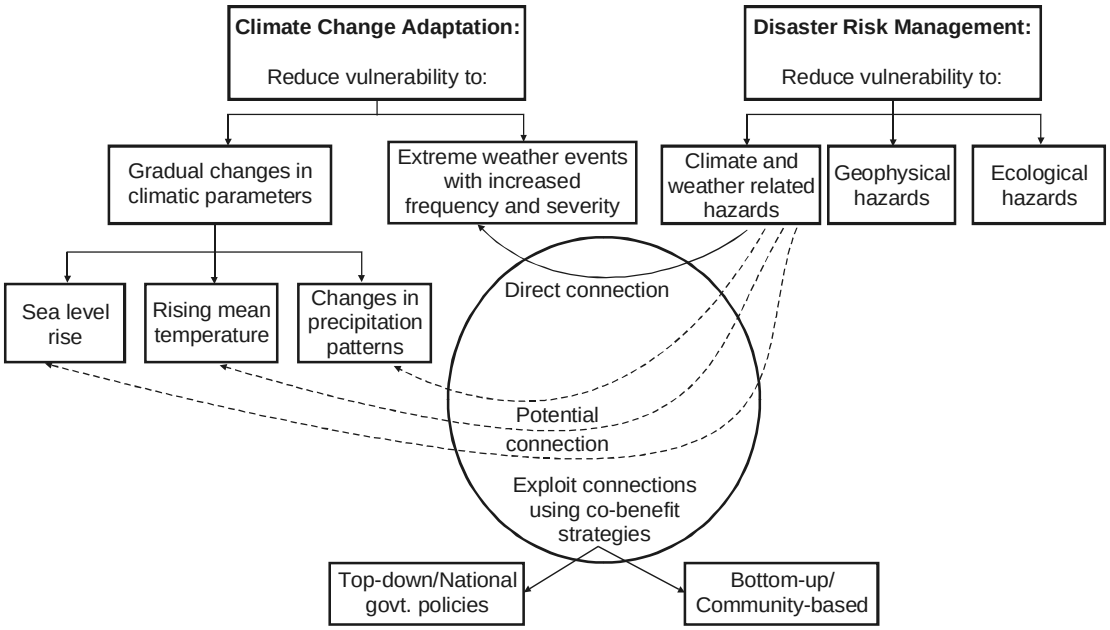

Fig.1.6 Conceptual linkages of climate change adaptation (CCA) & Disaster Risk Management (DRM)

Source : www.planetaction.org/automne_modules_files

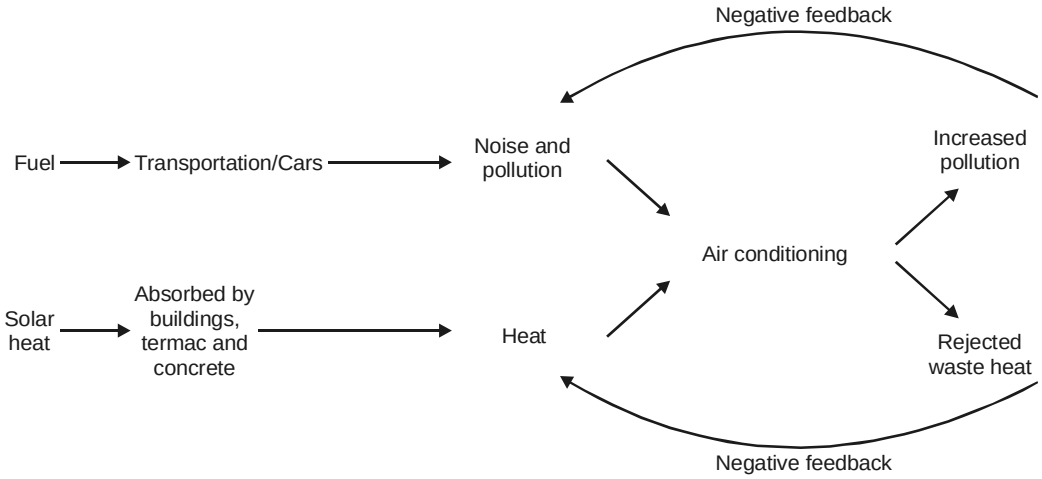

Fig. 1.7 The cycle of Urban pollution and rising temperature

National Action Plan on Climate Change

On 30 June 2008, the national action plan for climate change was released by the Prime Minister Dr. Manmohan Singh. It identifies measures that promote development, while also addresses climate change both adaptation as well as green house mitigation measures: The national action plan for climate change (NAPCC) is guided by the following principles:

- Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.

- Achieving national growth objectives through the quantitative change in direction that enhances ecological sustainability, leading to further mitigation of green house gases.
- Devise efficient and cost effective strategies for the demand side management.
- Developing appropriate measures for both adaptation and mitigation of green house gases emissions, extensively as well as at an accelerated place.
- Engineering new and innovative forms of market, regularity and voluntary mechanism to promote sustainable development.
- Effecting implementation of programmes through unique linkages, including civil society and local government institutions and through public private partnership.
- International cooperation for research, development, sharing and transfer of technologies enabled by additional funding.

The national action plan hinges on the development and use of new technologies. The implementation of the plan would be through appropriate institutional mechanism suited for effective delivery of each individual objectives and includes public private partnership and civil society action. The focus will be on promoting understanding climate change, adaptation and mitigation, energy efficiency and natural resource conservation. Eight national missions form the core of the National Action Plan, representing multi-programmed, long term and integrated strategies for achieving the goals in context of climate change.

- National Solar Mission
- National Mission to Enhance Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

The National Action Plan on Climate Change (NAPCC) and National Mission report on Sustainable Habitat are important landmarks on climate change debate in India. However, these reflect government response to the scale of the challenge. These need to link with the poverty issue and India's indigeneous and variety of climatic zones, spatial and cultural dimensions. There cannot be an easy plan to climate change. India faces its own peculiar challenges and there cannot be a uniform approach towards climate change. India's vast geography is contrasting in terms of its morphology and climate. A national level action plan has to be differentiated according to its geography, climate and its people.

Ecological Footprint

Environmental analyst Mathis Wackernagel developed the concept known as ecological footprint to measure the ecological capacity and impacts. Footprint analysis measures what an economy needs from nature: the inputs that fuel it and the wastes that emerge from it. It does so using a single matrix the number of global hectares of land and water needed by the economy. Global hectares are the area of biologically productive space (land and water with significant photosynthetic activity and biomass accumulation) with world average of productivity. Where a nation's footprint is larger than its bio–capacity, it indicates that its economy is consuming

more forests, crop lands and other resources than the country can supply and thus it is overtaxing the domestic environment's capacity to absorb wastes.

According to Mathis Wackernagel, the global footprint now exceeds global bio-capacity by 40 per cent. By importing resources and exporting wastes, particularly carbon dioxide, the United States, Europe, Japan, India and China all live well beyond their ecological means with footprints ranging from 200 per cent to nearly 600 per cent.

Footprints tend to grow larger as countries industrialise, but the bulk of footprint growth typically comes from a single source: the increase in area needed to absorb carbon dioxide. With per capita carbon emissions still modest compared with Japan and Western industrial nations, the carbon component of China and India's footprint is likely to grow dramatically in view of their faster growth and development.

In the context of growing footprints, the western countries are realising that they have carried their development too far. It is being debated whether development, which is called progress, has become a menace. Its implications on global warming are fearsome. If the sea level rose by just one meter it would make 20 million people homeless in Bangladesh and India alone with the coastlines being breached by rising seas, agriculture would fail, water would become scarce, and law and order would break down.

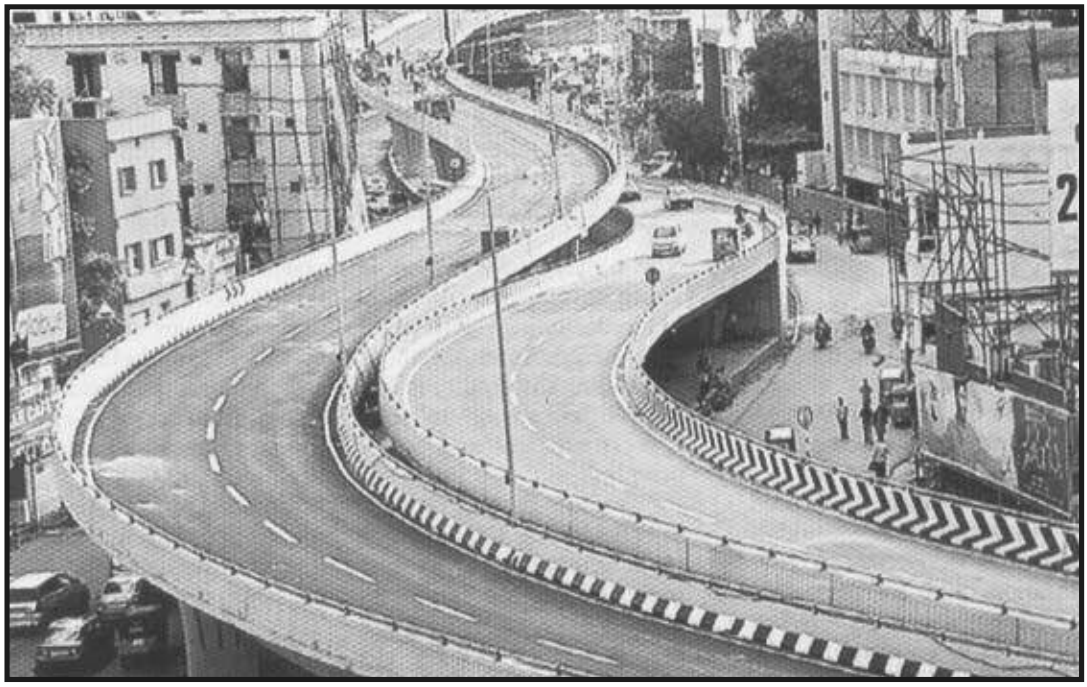

Fig 1.8. A double decked road (Hyderabad)– development footprint that is hurting environmental sustainability and severing human relationship with nature.

Urban Environment Issues

The problems of emissions, climate change and pollution are inextricably linked to poverty, productivity, and broad macroeconomic performance. Problem that crosses over to "green" or "social" issues typically involves inappropriate land use, precarious housing, deficient public

transportation, and road congestion. These are frequently manifested in overcrowding, noise pollution, the degradation of environmentally fragile lands, the occupation of areas prone to floods or landslides, and the degradation or loss of historical and cultural property and resources.

Environmental problems inflict a high human and health price as just 70 percent of urban dwellers are served by some form of sanitation, with only about 40 percent connected to sewers. Where there is sewerage, more than 90 percent of the wastewater is discharged without treatment. The costs of these and other pollution problems alone in some developing countries are estimated to exceed 5 percent of GDP. Poverty, economic development, and the environment have a close link. This linkage raises issues of equity (such as the willingness to pay for better environmental services and the issue of subsidizing basic urban services for the poor), and of the changing nature of environmental problems at different income levels.

The urban poor are affected disproportionately by environmental problems and their plight that exacerbates urban environmental crises. The survival of the urban poor is strongly linked to the functioning of urban labor markets and to the markets for land and housing. About a quarter of the world's urban population lives in absolute poverty—and many more live in substandard conditions. In many parts of the developing world, urban poverty has grown faster than rural poverty because of macroeconomic adjustment, inefficiencies in the urban economy, and misallocation of public resources.

The critical and most immediate problems facing cities are the health impacts of urban pollution that derive from inadequate water, sanitation, drainage and solid waste services, poor urban and industrial waste management, and air pollution, especially from particulates. Collectively dubbed the "brown agenda," this set of problems is closely linked to the poverty-environment nexus. Important underlying or related issues typically involve inappropriate land uses, precarious housing, deficient public transportation, and road congestion and accidents.

These pressing problems are also related to what may be considered more properly the "green" and the "social" issues of urban areas, such as the depletion of water and forest resources, the degradation of environmentally fragile lands, the occupation of areas prone to flooding or landslides, overcrowding, degradation or loss of historical and cultural property, noise pollution and other problems. Similarly, the emissions of cities resulting from energy use for cooking, heating, industry, and transport contribute significantly to climate change and public health.

Table 1.4 : Climatic Change, Possible Impacts, and Potential Impacts on Cities

Climate Change	*Impact*		*Urban Consequences*
Increased Temperatures	Ground water	:	Depletion of Water and Shortage
	Water Shortage	:	Distress migration to cities/towns due to droughts in rural areas
	Drought	:	Interruption of food supply networks and higher food prices
	Degraded air Quality, smog	:	Potential energy price increases (e.g., from reduced hydro-electricity generation)
		:	Exaggerated urban heat island effect
		:	Increased energy demands for cooling
		:	Need for higher and/or additional wastewater treatment

		:	Population health impacts (e.g., increased mortality during heat waves, decreased access to food/nutrition)
Increased precipitation	Increased risk of landslides or mudslides on hazard slopes	:	Interruption of food supply networks Property damage (homes and businesses) Disruption of livelihoods and urban economies Damage to infrastructure not designed to standards of occurrences being experienced. Displacement and population movement from informal settlements built on steep slope, hazardous lands, etc. More favorable breeding grounds for pathogens (e.g., mosquitoes and malaria) Population health impacts (increased incidences of water-borne diseases like cholera)
Sea-level rise	Coastal flooding, Salt water intrusion into groundwater, increased storm surge hazard		Displacement and population movement from Property damage (homes and businesses), Damage to infrastructure not designed to standards of occurrences being experienced, Increased storm, disruption of livelihoods and economies Population health impacts (injuries, increased mortality and illness) Population health impacts (injuries, increased mortality, distress) Interruption of food supply networks Increased risk of landslides or mudslides on hazard slopes

Source: Adapted from Developing Local Climate Change Plans, UN-HABITAT/International Institute for Environment & Development (2010).

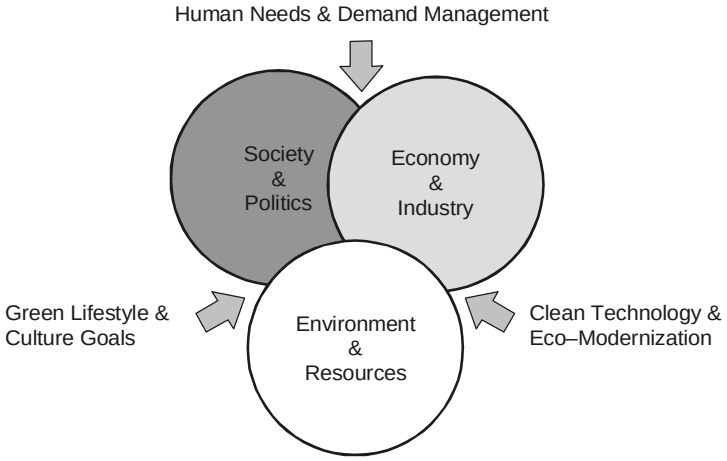

Fig. 1.9 Environment-Economy-Society Interface.

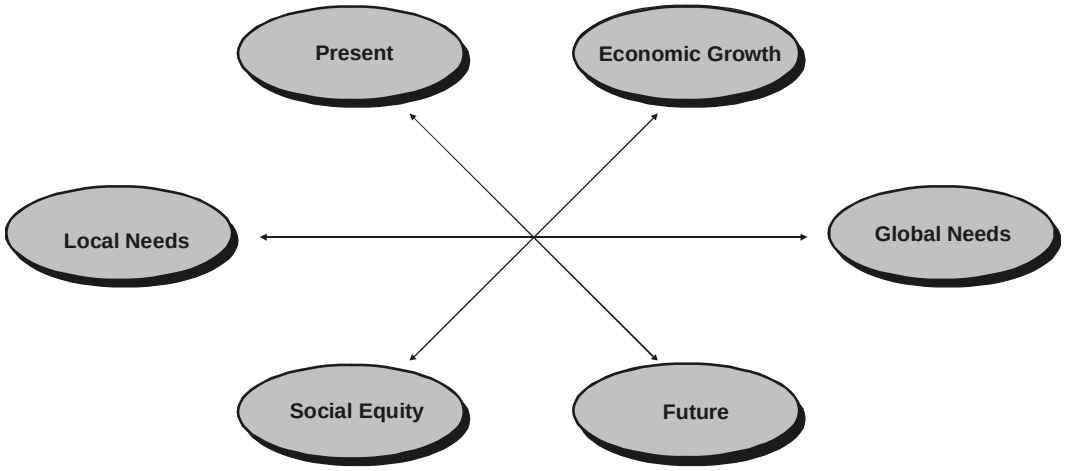

Fig. 1.10. Sustainable Balance.

The nature and severity of environmental problems as well as the character of potential intervention strategies depends on five factors:

- *The unique natural features of urban areas*—cities tend to take their form from the nature of their site, and their environmental problems are determined in large measure by regional ecosystem characteristics. Ecosystem features vary widely, for example, whether coastal or inland, mountainous or flat, arid or humid, temperate or tropical, or some combination of these features. Each characteristic can be associated with potential problems: for example, topology affects drainage; altitude and atmospheric stability are determinants of urban ventilation and air quality.
- *Population size and rate of growth*—the sheer magnitude and pace of population growth in cities directly affects the spatial concentration of people, industry, commerce, vehicles, energy consumption, water use, waste generation, and other environmental stresses, as well as placing pressure on the local managerial and operational capacity to respond.

- *The level of income and economic development*—as people rise out of poverty, the nature of their environmental problems changes. For example, a low level of economic development is associated with inadequate basic services, indoor air pollution, and land degradation, whereas cities with higher levels of income and economic development suffer more from industrial and energy related pollution of air and water, and the inability to manage hazardous and toxic wastes.
- *The diverse spatial dimensions of environmental problems* — spatial factors determine who is affected and how, the severity of impact, and the appropriate level of responsibility and decision making needed to solve problems. For example, access to basic environmental services is normally a household, neighbourhood, or community issue, while air and water pollution are city-wide or regional issues.
- *The roles of local actors*— the quality of the environment in a city is determined largely by the interaction of numerous public, private, and household actors who have an important effect on environmental problems and their solutions. The managerial and operational capacity and responsiveness of local and sectoral institutions is a critical determinant, as is the level of participation of local stakeholders.

The key policy approach centers around (*i*) public support and participation, (*ii*) policy interventions, (*iii*) service delivery, (*iv*) institutional capacity, (*v*) the gap between urban environment and planning. (*vi*) sustainable development, green building and a minimalist life style. UN Habitat provides a 8-step agenda in response to climate change integrating urban services in the cities (Table 1.5).

The challenge of urban planning is to identify the effects of environmental problems in terms of human health, productivity, amenity, ecological values, and other key indicators. By categorizing impacts in this way, emphasis can be placed in the following areas:

- *Health and Safety*. In examining health and safety effects, assessment criteria include health care costs, lost working days, and higher mortality rates.
- *Productivity*. Any assessment should judge the extent of losses in urban productivity, which is the result of poorly run cities and such external factors as spillover pollution from nearby industrial areas.
- *Equity*. Because the negative effects of urban environmental degradation fall disproportionately on the poor, issues of equity are of critical importance. Efforts to improve universal access to basic sanitation and other essential urban services and to include the poorest of the poor in urban improvement programs will go a long way toward mitigating urban environmental degradation.
- *Ecology*. Ecological effects can be judged by the availability and costs of fresh water, the extent of land subsidence from overdrawn ground water, the vulnerability to flooding, landslides and other natural disasters, and the loss of biological diversity.
- *Amenity*. Effects on amenity include air and water quality, noise levels, scenic beauty, and the presence of parks and open spaces.

Table 1.5 Policy Responses Integrating Ecosystem Services

Policy directions	*Examples of potential responses*
1. Renewable energy to reduce dependence on non–renewable sources	• Community energy systems in Freiburg (Germany) and travel management in Calgary (Canada)
2. Carbon–neutral cities to cut and offset carbon emissions	• Zero–carbon housing in Denmark • Urban tree and woodlands in Sacramento (USA)
3. Small–scale, distributed power and water systems with more energy-efficient service provision	• Water sensitive design that uses the complete water cycle in Hanoi (Vietnam) • Waste water agro-systems in Kolkata (India) • Local power systems and cooperatives in Malmo (Sweden)
4. Increasing photosynthetic spaces (as part of green infrastructure development) to expand renewable sources of energy and local food	• Local food provision in Devon (UK) • Biomass in Vaxjo (Sweden) • Green roofs and materials in Shanghai (China)
5. Eco–efficiency to enable the use of waste products to satisfy urban energy and material resource needs	• Industries reduce waste and resource requirements by sharing waste and resources in Kalundborg (Denmark)
6. Local strategies that increase 'pride in place' by enhancing the implementation and effectiveness of innovations	• Ambitious recycling targets in Cairo (Egypt) • Maximizing urban densities in Hammarby Sjostad (Sweden):
7. Sustainable transport that reduces the adverse impacts of dependence on fossil fuels	• Participatory system that localize energy, food, materials and local production in Medeilin (Colombia) • Planning systems that capture the value of ecosystem services and creating a 'local sustainability currency' in Curitiba (Brazil) • Urban form and density in Vancouver (Canada) Transit systems in London (UK) • Street planning and mobility management in Tokyo (Japan)
8. Development of 'cities without slums' to improve access to safe drinking water, sanitation and reduce environmental degradation	• Respecting community structure in slum resettlement in Kampung (Indonesia) • Planning for the informal economy in Somalia (UN–HABITAT initiative)

Source: Adapted from UN-HABITAT (2009)

Idean's Seven Branches

Peter Gotsch developed the concept of 'Idean' tree with seven branches which should be dealt with an integrated manner :

Inclusive Society. Social sustainability is one of the prime principles of sustainable urban development, that fosters minorities' needs, encourages inclusive and integrated development, and generats social capital. Neighbourhoods that work for weak groups such as children, handicapped people, the elderly, and other minorities feature the best quality of life for all and enhance social capital.

Balanced Economy. Idean values strive for a balanced security and opportunity and between growth and stability, while at the same time promoting affordability. Shared resources such as fresh and clean water, natural light, and public space, etc. need to be integrated into a new value system while affordable housing secure a basic mix and heterogeneity in the neighbour and open up perspectives for weaker sections of the population.

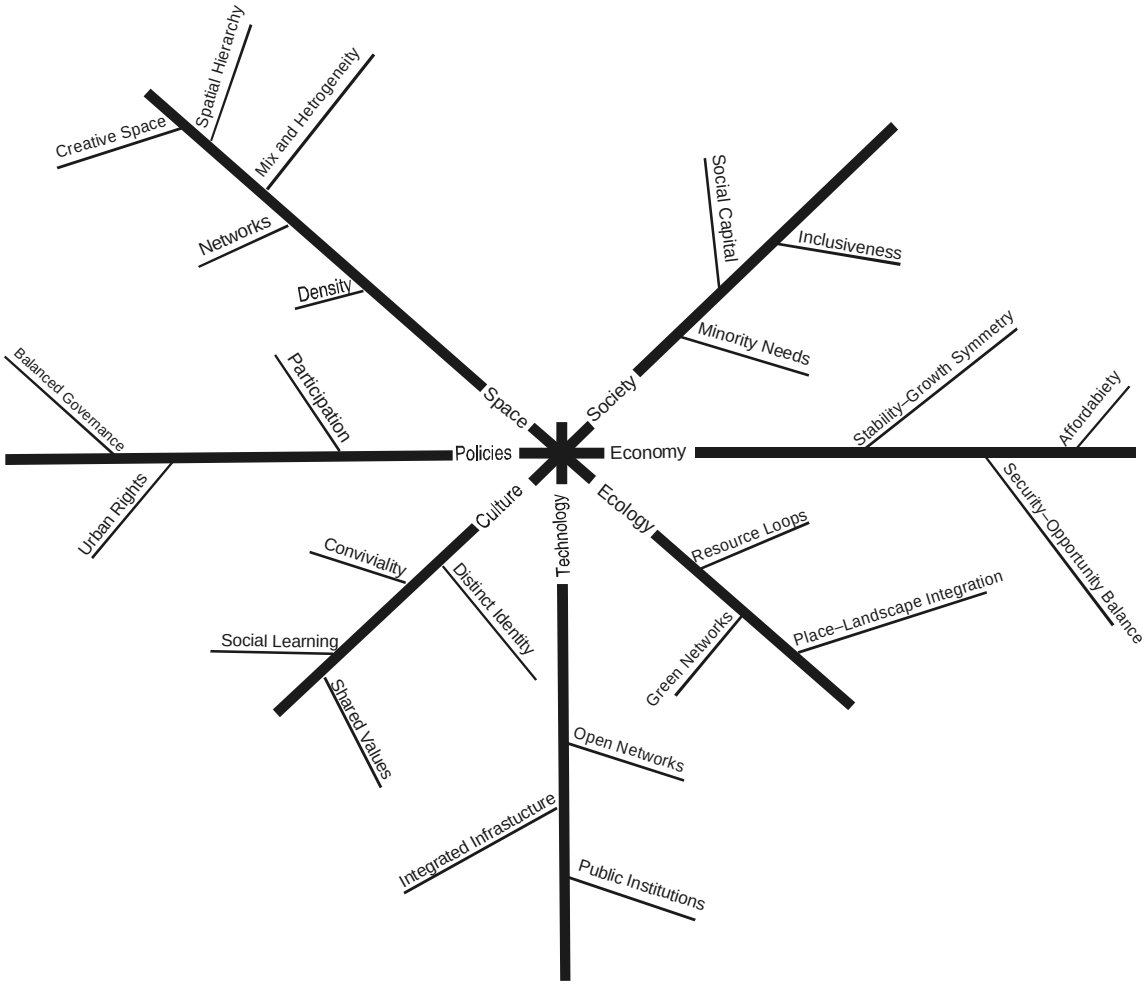

Fig 1.11 : The IDEAN Tree with 7 branches, social, ecological, economic components of sustainability are complemented by spatial, technical, political and cultural facets.

Source: Gotsch, Peter (2012).

Integrated Ecology. Promote Place–Landscape integration. Green Networks and Resource Loops should be comprehensively planned that interweave the natural assets and ecological systems of a specific location as the best means of promoting a neighborhood's profile, authenticity, and identity.

Enabling Technology. The three pillars of IDEAN'S enabling technology dimension are integrated infrastructure, open networks, and public institutions. Idean's infrastructure promotes principles of integration, accessibility, human scale, and security. It promotes education and media skills for the maximum number of people beyond the physical backbones of networks.

Open Culture. The agglomerated activities and outcomes resulting from the application of the shared values generate a distinct identity and trigger change. Distinct Identity, Shared Values, Social Learning and Conviviality encourage synergies between different cultures.

Equitable politics. Co–creation, open access and participation are the benchmarks. As a basis, the approach aims to guarantee basic services and rights to all. Participation implies that political and administrative power is generated from bottom-up, with equal citizenship and independent of class or possession. Policy is the art of consensus and negotiation, and urban rights and participation are the main elements of its architecture of power.

Open Space. Optimal densities need to be correlated with social, economic, cultural and environmental parameters. Open space puts into practice the principle of mixture and heterogeneity and transforms these into distinct urban cultures. IDEAN sectors promote a distinct spatial hierarchy based on the human scale. Open spaces serve as active generators of creativity and innovation.

Source: Gotsch, Peter, 2012. IDEAN Principles–Ingredients of Sustainable and Resilient Neighborhoods, TRILOG 108, Aug 2012

A Case Study — Recovery of a River in Seoul (Korea)

Fig. 1.12. Elevated Expressway before demolition

Fig. 1.13 Recovery of river by dismantling elevated expressway in Seoul, Korea

Cheonggyecheon, a stream that marks the feng–shui origins of Seoul in 1392, used to run through central Seoul until the mid–1970s, it was originally a brook, and then developed into a stream with 14 waterways at the time of King Taejongin 1412 at the beginning of the Joseon Dynasty. The covering of the stream for military, sanitary and flood management purposes started early in the 20th century and was finally completed in 1958. The elevated Cheonggye expressway was opened in 1976. The Cheonggye expressway became one of the most important inner city highways with up to 168,000 vehicles a day, and the surrounding areas became the most important clothing clusters in the 1970s and 1980s. Removal of the expressway started on July 2003 and the rest of the stream restoration work was completed by October 2005. In total, the restoration took one year of urban planning processes and two years and three months of construction time. The successful implementation of the project paved the way of Lee Myung-bak, then the mayor of Seoul, to become the president of South Korea in February 2008.

Source: Erpenstein, Annette, 2012, Back in the Future: The Rebirth of Public Space in Seoul, Trialog, 108, August 2012.

The Challenges

The unprecedented challenge is to re–establish the uterine relationship between nature and man, between human consumption and production. The ecological cycle, which has been disrupted by indiscriminate economic and physical demands of development needs to be revived. Looking at the damage which our cities and development have inflicted upon the environment, one of the prime agenda is to explore the possibility of creating a living environment which is self sufficient, ecologically balanced and culturally stimulating. We need to relook at the fundamentals of human settlements and evolve a sustainable system whereby harmony and interrelationship between nature and life can be re–established.

What is Sustainability? The first question that needs to be asked is what is meant by sustainability? Why Sustainability? What are the attributes of sustainable human settlements? The report 'Our Common Future' states that the basis of sustainable development is to promote harmony among human beings and between humanity and nature. The pursuit of sustainable

development requires striving for a balance between economic goals, human (social, cultural, livability and health) and environmental needs. This involves a process of effective citizen participation in decision-making. An economic system that is self reliant and securing ecological basis for development are the prerequisites of sustainable development.

To translate sustainability principles in terms of city planning, the following six critical areas can be identified:

- **Jobs:** Job sites located within communities reduce time spent traveling to work.
- **Corridors:** High density commercial and residential corridors focus growth along transit routes.
- **Walkability:** Interconnected pathways and street systems link residents with the services they need.
- **Green Space:** Green spaces provide recreation opportunities and connect people with natural systems.
- **Infrastructure:** Integrating natural systems that reduces infrastructure costs and environmental impact.
- **Housing:** A range of housing types allows residents of differing economic situations to live in the same neighborhood and have access to the same services.

Sustainable development requires a holistic approach. As stated by Alien and You of the DPU, London, there are five aspects of sustainability that impinge on the development of human settlements:

Economic Sustainability relates to the capacity to put local and regional resources to productive use for the long-term benefit of the community without damaging or depleting the natural resource base on which it depends and without increasing the city's ecological footprint. This implies taking into consideration the full impact of production cycles.

Social sustainability refers to the fairness, inclusiveness and cultural adequacy of an intervention to promote equitable rights over the natural, physical and economic capital that support the livelihoods of communities, with particular emphasis on the poor and traditionally marginalized groups. Cultural adequacy means the extent to which a practice respects cultural heritage and cultural diversity.

Table 1.6: Conventional Versus Sustainable Urban Development Models

Conventional Model	*Sustainable Model*
The Urban System	
* Urban concentrated industrial complexes	* Regionally dispersed industrial complexes
* Manufacturing oriented	* Community oriented
* Short–term economic growth emphasized	* Long–term development emphasized
* Commodity oriented	* Conservation oriented
* Consumption driven	* Balance sought between consumption and conservation
* Resources seen as inputs to production system	* Resources seen as limited, vulnerable requiring stewardship
* Resource–intensive, governed by economic priorities	* Resource conserving, governed by multiple priorities

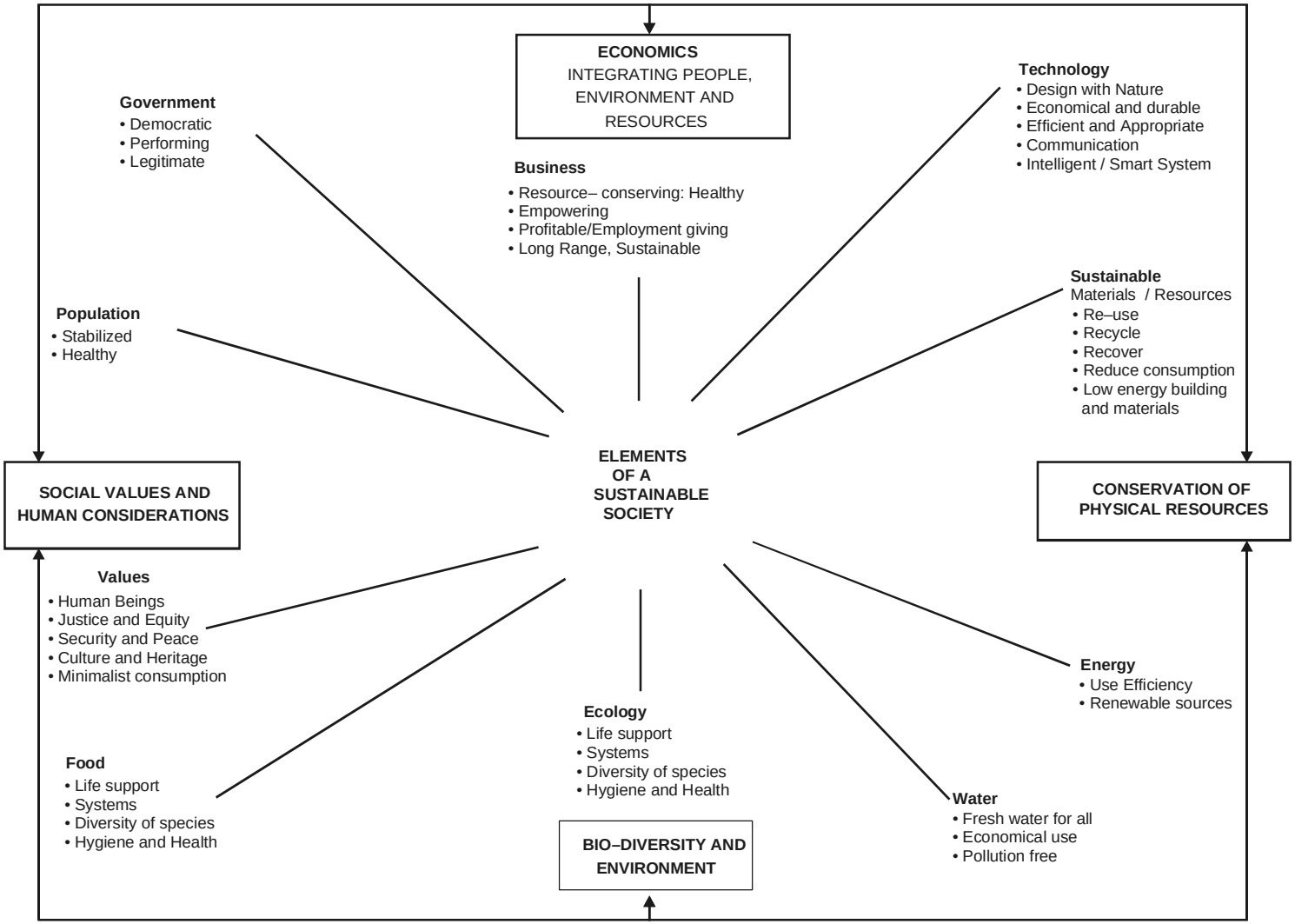

Fig.1.14: Elements of a Sustainable Society

* Economic costs are primary	* Economic costs balanced by social/environ mental costs
The Energy System	
* Fossil fuel based	* Renewable energy
* Energy abundance and cheap supplies emphasized	* Conservation and renewability emphasized
* Diversify sources of supply	* Reduce energy intensity
* Market based prices not reflecting social/ environmental costs	* Social/environmental cost based prices
* Technology focused	* Conservation focused
* Efficiency in economic production emphasized	* Efficiency in end-uses emphasized
* Scale economies and technological centralization emphasized	* Modularity and technological decentralization sought
The Environmental System	
* Humans dominate the environment	* Humans and environment are seen as mutually dependent
* Environment as an abundant source of commodities	* Exhaustibility of natural resources recognized
* Environmental impacts external to economic choice	* Environmental impacts internal to economic choice
* Rehabilitation oriented	* Prevention oriented
The Technology System	
* Large-scale economies sought	* Moderate-scale economies preferred
* Centralized system emphasized	* Decentralized system emphasized
* Infrastructure driven technology choices	* User-driven technology choices
* Technical decisions governed by economic costs	* Technical decisions governed by social/environmental costs
* Environmental impacts ignored	* Environment sensitive designs promoted

Source : Adapted from Byrne, J., et al(1992), "Energy and environmental sustainability in East and South-East Asia", in IEEE Technology and Society, Vol. 10, No. 4, page 26. Environment and Urbanization, Vol. 6, No.1, April 1994

Ecological sustainability pertains to the impact of urban production and consumption on the integrity and health of the city region and global carrying capacity. This demands long term consideration between the state, dynamics of environmental resources and services, and the demands exerted over them.

Physical sustainability concerns the capacity of an intervention to enhance the livability of buildings and urban infrastructures for all city dwellers, without damaging or disrupting the urban region environment. It also includes a concern for the efficiency of the built environment in supporting the local economy.

Political sustainability is concerned with the quality of governance systems guiding the relationship and actions of different actors among the previous four dimensions. It implies the democratization and participation of local civil society in all areas of decision making.

Physical planning attempts to bind together all these facets of sustainable development. However, as has been practiced for last few decades, planning has to undergo mutations including advocacy planning, participatory planning and budgeting, and community design. Planning in a myriad of ways has to respond to the challenge of and the quest for sustainable urbanization. These initiatives have to share a common ethical commitment to participatory governance and social inclusion, for reducing the poverty and promoting environmental justice. Effective participatory planning among all the stakeholders, mediation between competing or conflicting interests would help in. bringing about change and lasting improvements to the living environment.

Sustainable City

The cornerstone of making a city sustainable is to adopt an integrated approach towards ecology and the conservation of the natural resources which should form the basis of city planning and development. The composite built environment includes the environmental infrastructure - water supply, sewerage, solid waste disposal and transportation network. Planning attempts to interface the regional, physical, environmental, transport, social, legal, management, financial and other aspects into a composite whole. It should strike a balance between conflicting demands - citizen freedom versus safeguarding community interests, commercial opportunity versus environmental sustainability, public service versus mandatory procedures. Most important is to develop a vision and ideas as the basis of urban planning. The vision for the future requires a radical transformation of infrastructure systems. Land, water, air, bio–diversity, energy and resource management should be the basis of sustainable growth along with appropriate technology, use of IT and biotechnology. The spatial scale of environmental issues needs to be segregated at global/city/community and local/household levels. Accordingly, the issues can be addressed and networked to the surrounding ecosystems.

Land is a non–renewable resource, which is consumed to accommodate the growing population. Once converted to use for habitation it becomes non-retrievable. A study of the present land use pattern in India indicates shortfall in land under forests and pasture. Lands under agricultural use have been and are increasingly getting converted and annexed for uses like expansion of settlements for human habitation. The rate of conversion shows that an additional 2 to 3 million hectares would be required for human settlements in during 2013–2031. Sacrificing agricultural land for habitation implies reduction of land for producing food for the ever growing population. Thus agricultural lands need to be protected from the process of conversion. Moreover lands that sustain biodiversity, water quality and groundwater recharge, fragile areas, sensitive areas, coastal zones, etc. need protection and conservation. Land for development is thus scarce and needs to be judiciously utilized for various uses according to the inherent capacity or the suitability of the land for the particular land use.

Water scarcity has become a persisting problem in Indian cities due to rapid population growth, haphazard and unplanned development. The average annual availability of per capita water supply in the country has gone down from 5,236 cubic meters in 1951 to 1800 cubic meters in 1991. Only 18% of the renewable water resource is being used. India, though endowed with a good monsoon and ample rainfall uses only 10% of the annual rainfall. Thus there is a

need to augment our water resources in the context of the increasing demand through recharging of groundwater resources and rainwater harvesting.

Disposal of wastewater due to the ever expanding urban growth causes pollution of water sources, both surface water and groundwater sources. Studies conducted by the Central Pollution Control Board (CPCB) show that all the 13 major rivers of the country, which are major sources of water for the settlements are polluted to various degrees causing health hazards in urban areas. Surveys of Indian cities revealed that though approximately 60% of the population is not covered by sewerage system and treatment facilities are grossly inadequate. The parameters of concern are increasing coliform levels and Bio-chemical Oxygen demand (BOD) in surface waters and increased concentration of nitrate in the groundwater. To overcome the health problems, water sources need to be protected by interception and treatment of wastewater through appropriate technologies.

Air quality in Indian cities is deteriorating due to vehicular and industrial emissions. Though the emissions of air pollutants in urban areas, on per capita basis, is much lower than the Asian average, the pollutant levels of SPM, CO, Pb, PAH, NOX, etc. in many cities have exceeded the permitted maximum limits. This has led to increase in respiratory diseases. According to a survey conducted by the CPCB ambient air quality, the national capital of Delhi has reached a very critical situation of air pollution. Relatively high frequency of suspended particulate matter SPM, SO_2, NO_2, CO_2 and heavy metals, including lead content in the exhaust by number of automobiles and scooters have been observed. However the recent changes in the fuel, adoption of clean technologies, and enforcement of emission norms, traffic management measures and development of mass rapid transport system have reduced the alarming pollutant levels caused due to vehicular emissions. Proper industrial location would also reduce the adverse impacts on air quality.

Biodiversity is the sum total of living organisms in all types of habitats. India, being a tropical country, is one of the regions of high diversity. India is also one of the few countries in the world which have enshrined in their constitution a commitment to protect the flora and fauna. Being a signatory to the Convention on Biological Diversity, (1992) India has made a commitment to inventories and protect its biodiversity. In the pre independence years protection of flora and fauna was limited to providing protection through legislation to a few game species. This was followed by demarcating sensitive ecosystems within forest areas for conservation - Reserved and Protected forests, as per Forest Conservation Act 1927 and 1980 and demarcating areas as National Parks and sanctuaries was the next step. Setting up of Biosphere Reserves was the final step in the Protected Area Network in the Country. These efforts were targeted to protect the floral and faunal resources in areas of sparse human settlements. It is only now that it is being recognized that a wealth of living resources exist within human settlements that play a critical role in combating pollution, recharging water, and need to be protected and judiciously utilized to ensure sustainable development. The Biodiversity Action Plan, initiated in January 2000, is a step in this direction.

Energy scenario in India is characterised by increasing demand for energy growing at the rate of about three times in the last two decades making the country the fifth largest energy consumer. The post independence era of the country has experienced a shift in the bias towards commercial energy sources, which is slated to be the predominant energy source in the future. Coal, oil and gas are the primary commercial sources with coal dominating the energy supply of the country. The actual production of coal is the highest as compared to other primary energy sources. However, higher reserve-production ratios of oil and gas over decades show

that the rate of growth in production are higher than that of the production of coal. Power generation capacity has also increased in order to meet the rising demands. The energy consumption sectors include industrial, transport, commercial, agriculture and domestic sectors. The pressing problem facing the country today is increased oil imports in order to meet the rising consumption levels.

Resource Management

Protection of the environmental resource base of human settlements is vital for sustainability. Starting with the Stockholm Conference (1972), the concern for the environment of settlements has been discussed in all major international and national conferences. The strategies and directives that have emerged out of these deliberations started with adopting measures of pollution control, waste minimization, judicious utilization of resources. With the rapid growth of settlements, both in number and size, alternate methods to assess the environmental status of settlements have been evolved. Assessment of the biodiversity and the energy consumption pattern and their judicious disposition and utilization are emerging strategies for resource conservation.

To address to ecological sustainability and climatic changes there is an urgent need to focus upon the improvement in planning process and development. Despite a containment of user demand using' Factor 4' technologies and decentralized generation, alternative and renewable energy sources, such as solar energy, offshore wind turbines, biomass-based energy generation, gas and clean coal for thermal power, the grid and hydrogen as the major energy carriers, need to be explored. The concept of energy efficiency begins with Zero–fossil Energy Development (ZED), which should be incorporated in city planning. For water a range of technical and institutional options ranging from centralized surface storage to decentralized rainwater harvesting and re–cycling, together with design of water management options can be explored.

Sustaining ecosystem is not just an environmental goal. It is necessary to ensure the conditions for sound economic and social development. Therefore two key principles need to be applied if we are to integrate an ecosystem services approach into spatial planning:

- Planning must be undertaken for the functional spaces within which people live and work rather than the administrative boundaries of a single municipality or region. Ecosystems and the scales on which they deliver services should therefore be understood as the key building blocks for spatial analysis.
- It is essential to integrate ecosystem services into socio-economic decision making, rather than addressing them separately. For this reason, planners can develop a multi-scale approach to decision making that accounts for both 'horizontal' and vertical' collaboration.

The potential of ecosystem services is increasingly taken into account in regional and national land use planning. At the local scale, the Global Report on Human Settlements (UN-HABITAT 2009) has identified eight potential planning responses for urban zoning. These responses provide opportunities to incorporate the above principles into ecosystem oriented planning. Furthermore, assumptions that are based on historical experience no longer hold under climate change. Therefore, new tools and guidance is needed that include sophisticated methods like climate models for local and regional planning, which integrate ecosystem services.

Table 1.8. Key Environmental Issues and Action Areas in Spatial Scale.

SPATIAL SCALE	*CITY/REGION POLICY LEVEL*	*COMMUNITY LOCAL LEVEL*	*HOUSEHOLD BUILDING LEVEL*
KEY CHARACTERISTICS AND ISSUES	• Acid Rain, Global Warming, Heat Island, Ozone Layer • Sprawl • Air Pollution • Water Sources, River Pollution • Power Plants & Energy • Natural Resource Management • Health • Poverty • Industry • Highways, Roads & Transport • Waste Treatment • Landfills/Toxic Dumps • Land Use • Governance and Participation	• Water • Sewerage • Wastes management • Drainage and Floods • Streets/Roads/Transport • Noise/Stress • Natural Disasters • Micro–climate • Energy • Safely/Security/Health • Informal sector (jobs, slums etc.) • Common Services	• Buildings • Water supply, • Air Pollution/Indoor Pollution, • Drainage, Sewage/Sanitation • Waste disposal/recycling/ segregation • Ventilation • Disease Vectors • Energy/fuels • Safety/security • Affordability • Equity • Gender security and justice
KEY ACTION AREAS	• Urban Metabolism • Zero Carbon City • Zero Fossil Energy Development • Smart Growth & Mixed Use • Public Transport • Minimum Urban Footprints • Energy Efficiency/Renewable Energy • Regulatory and Legal Framework • Decentralised and Participatory Planning	• Organisation of Space • Urban Transport & Fuels • Decentralised Services • Recycle/Reuse • Energy Efficiency / Audit • Water Conservation/ Harvesting • Conservation of Greens and Bio-diversity • Mixed Use • Zero-Run Off Drainage • Planning Standards & Controls • New Technology	• Green Building • Passive Design, Micro-climatic, day lighting, Recycled Materials • Water Conservation & Harvesting • Building resources • Energy Efficiency, Renewable Energy • Shelter • Jobs and livelihood • Bldg. Bye Laws & Standards • Services & Maintenance • Affordable and sustainable services, shelter and work places • Reservations rights and security genders empowerment entitlements • Social justice, equity and community engagement

For spatial planning to effectively use an ecosystem approach, municipalities and other agencies are advised to establish:

1. Legal Framework: This provides a statutory basis for local plans to guide both development and the powers that enforce it. Without a legal framework, the adverse impacts of proposals on ecosystem services cannot be fully controlled or remediated. Planning systems can be made more effective if local communities can design (and redesign) regulatory and legal systems to support effective development.

2. Regional or national planning frameworks: In most countries, spatial planning takes place only at the local level, making it difficult for municipalities to draw up strategies for entire ecosystems (such as water catchments). Developing a regional or national planning framework helps to implement plans that incorporate entire ecosystems

3. Technical Resources: Planners need data and tools to draw up effective plans. This is a particular challenge in developing countries, where there is often negligible information, for instance, about slum neighbourhoods and informal settlements.

4. Processes for engaging local communities: Participatory planning is at the core of spatial planning. Community support is essential for an effective plan. This depends on the political will and the resources of the community, particularly in areas where civic society does not have a democratic culture or institutions.

Table 1.9. Green and Brown Agendas for Urban Planning

Green agenda (ecological systems)	*Brown agenda (human systems)*
Ecosystems that provide green/recreation space and biodiversity protection	Waste systems that recycle and remove (solid, liquid, air) wastes from cities.
Water systems that provide a natural flow water supply and waste disposal	Energy systems that provide power, heating, cooling and lighting for city functions.
Climate and air systems that provide cities with a healthy environment	Transport systems (including fuel) that enable mobility in the city.
Agricultural and forestry systems (and that ecological services) that provide food	Building and materials systems that provide resources and physical infrastructure of cities.

Source: Adapted from UN-HABITAT (2009).

A village with 54 millionaires: Agricultural revolution in an Indian village

Hiware Bazaar, an agrarian village in an arid district in the state of Maharashtra, has turned from abject *-poverty* to become home to more than 50 millionaires (in Rupees) and boasts one of the highest average rural incomes in India. In the 1970s, problems from low rainfall (400 mm annually) were exacerbated by increasing run–off during monsoons, leading to a decline in water levels and acute water shortages. The cause was deforestation and vegetation loss in the surrounding catchment. By 1989 barely 12% of the arable land could be farmed and this crisis had already triggered a trend of out–migration.

Village elders and leaders realised that the way out of this vicious poverty cycle was better management of water and forests. They drew up and implemented an integrated natural resource management plan which was helped by the emergence of the Indian government's Employment Guarantee Scheme (EGS) in the mid-1990s. With additional resources, and good coordination between government departments supporting the EGS, the village members regenerated 70 ha of degraded forests and built 40,000 contour bunds around the hills to conserve rainwater and recharge groundwater.

The number of active wells doubled, the area under irrigation expanded from 120 to 260 ha between 1999 and 2006, while grass production went up from 100 to 6,000 tonnes. Consequently, livestock increased dramatically, as did milk production from 150 liters to 4,000 liters per day. Income from agriculture alone amounted to 25 million Rupees in 2005. In less than a decade, poverty reduced by 73% and there was an overall increase in the quality of life with people returning to the village. Hiware Bazaar is a striking example of an integrated approach to natural resource management.

Source: Enhancing agriculture by ecosystem management, India-TEEB, 2011

As given above, the planning framework is ecologically based, when it integrates and balances the ecosystems and local development in a participatory manner with the following key action areas:

Seeing the forest for the trees: The overriding benefit of spatial planning is that it can encompass the cumulative impacts of incremental decisions on ecosystems and their services. It examines the 'parts' to make decisions that affect the 'whole.'

Knowledge is power: An effective planning framework can make the policy and planing process transparent and inclusive, assessing who benefits from which ecosystem service, helping to avoid conflicts,; especially if different stakeholder groups are part of the planning process.

Early thinking enables opportunities and management of change: Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) can contribute to the integration of biodiversity issues and ecosystem services in local and regional planning. This safeguards livelihoods, illuminates impacts on ecosystem services and highlights the risks and opportunities associated with changes. Start locally to think globally. A good strategy considers both local and global systems and stakeholders. Spatial planning, supported by ElA and SEA

may form a basis for sustainable, economically and socially appropriate responses, for example, to climate change.

Getting more than you bargained for can be a good thing. The proactive inclusion of ecosystem services allows environmental assessment to identify the economic potentials, rather than simply the constraints, associated with development that supports biodiversity.

Source: TEEB : For Local and Regional Policy Makers,2011

Reducing Energy Use and Green House Gases/CO_2 Emissions

The ways to reduce CO_2 emissions and energy use include:

Design and building fabric:

- Exploration of passive design measures such as proper orientation, good daylight and natural ventilation, thermal mass and controlling solar gain.
- Adequate insulation and airtight construction.

Building services and controls:

- Efficient building services and equipment for heating, cooling, lighting.
- Simple and effective controls such as window blinds, occupancy and daylight sensors

Low carbon and zero carbon technologies:

- Combined heat and power, ground source heat pumps
- Renewable sources – Solar thermal for hot water, solar photovoltaic and wind energy.

Table 1.10: Reducing Direct Greenhouse Gas Emissions to 3 Tonnes (from 6.0 Tonnes per capita per year)

		Average (Tonnes)	*Target (Tonnes)*	*Primary Means of Reduction to meet Target*
House	Lighting	0.1	Less than 0.1	Replace all bulbs with Energy–efficient variety
	Electric Appliances	0.6	0.4	Efficient fridge; no tumble dryer; small TV; Switch off appliances at wall
	Heating	1.2	0.9	New boiler better Insulation lower winter temperatures
	Water Heating	0.3	0.2	Shorter showers lower temperatures; 'air-mix' shower heads
	Cooking	0.1 (gas)	< 0.1	Use pressure cooker and microwave rather than gas oven or hob
Car*		1.2	0.9	Small car; fewer miles

Bus, Rail**	0.1	0.1	No reduction
Air travel	1.8	0.0	No air travel
Allowance for other emissions	0.6	0.3	
Total	6.0	3.0	

*A total of 27 million private cars driven an average of 14,500 km (9000 miles) a year and, on average, emit 180g (0.18kg) of carbon dioxide per kilometer. This equates to 1.2 tonnes per person per year.

**Bus and rail: Total emissions per person are under 0.1 tonnes per year.

Source : How to live a Low-Carbon Life-the individual's guide to stopping climate change by Chris Goodall Earthscan Publications Ltd., UK, 2007.

Resource Efficiency

Natural resource efficiency and saving is the starting point for environmentally responsive planning. As a rule of thumb, if a certain level of resource use is defined as a baseline, reduction of use by a factor x (say half) implies a reduction of the load on ecosystems by the same factor. At the same time enhancing the efficiency factor for technology and operations (say twice) gives 'Factor-4' efficiency. A specific efficiency factor may be an abstract target, but successfully increasing efficiency requires knowledge of local ecology on which to base the technologies and processes used. Planning along the lines of Factor-4 produces tangible results and improves the limited carrying capacity of urban land and conservation of natural resources. It is essential that the services and utilities are planned with flexibility to keep with fast changing technology. These should incorporate intelligent controls, and 'state of art' maintenance systems.

The spatial model impacts the sustainability (less travel time and thus energy saving). A compact city structure should be developed to achieve the following:

- **Urban Form:** (*i*) High dense settlements (*ii*) Less dependence on automobile, (mixed land use) (*iii*) Clear boundary from surrounding areas;
- **Spatial Characteristics:** (*i*) Social fairness (high dense settlements) (*ii*) Self-sufficiency of daily life (*iii*) Territory (clear boundary); and
- **Social Functions:** There is close relationship between compact urban form and the sustainability by reduction of automobile dependence, efficient supply of social infrastructure and public services, active community relationship by high-dense habitation, and revitalization of inner city.

Compact cities can have significant implications to climate change and environment. Critical instruments for this policy option include coordination with public transport, infrastructure development, mixed land use, urban boundary, and coordination of different levels of government. Data from international cities indicates correlation of urban density with less transport energy use and car use per capita. Smart growth land use practices aim to create more accessible land use patterns, which reduce the amount of travel needed to reach goods and services.

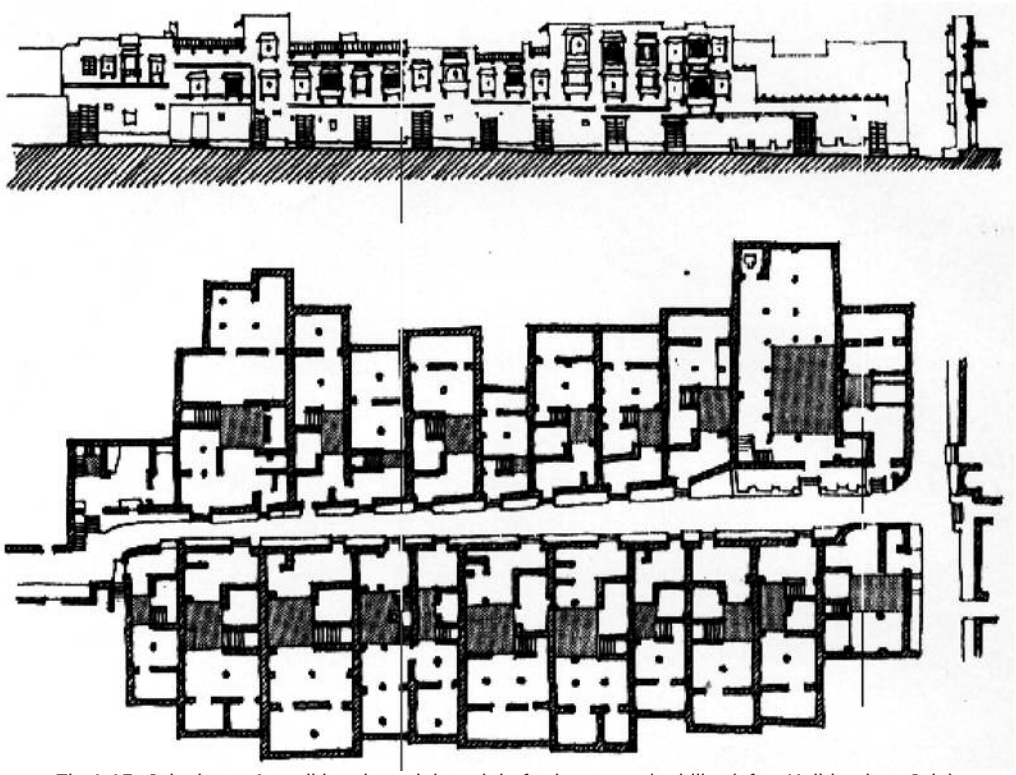

Fig.1.15: Jaisalmer: A traditional spatial model of urban sustainability (after Kulbhushan Jain)

Fig.1.16: Levitown, Long Island, NY, A Typical American Suburb - In contrast to Indian city, It has a car–centric, high energy urban form.

Source : after M.T. Kaufman

Infrastructure and Public Health

The performance of present urban services and systems needs to be reassessed with reference to environment, hygiene and public health. About 50 to 60 percent areas in Indian cities do not have clean drinking water supply, drainage, effluent treatment, wastewater recycling, sanitation, sewerage and solid waste management facilities, leading to serious issues of public health. Widespread method of land filling for solid waste disposal is an environmental disaster. In order to safeguard public health the urban society have to adopt re–cycling (e.g. water, solid waste, land), regeneration (dilapidated, old areas), recovery (wastelands, encroached areas), restructuring (networks, land use, transport), and rejuvenation (river, water bodies, parks, etc.). Instead of conventional drainage, the concepts of micro–runoff, bio–swales and bio–drainage can be adopted. Ponds/reservoirs and sediments traps can be planned in the catchment zones on low-lying grounds. The concepts of watershed development, rainwater harvesting and conservation and recharging of groundwater need to be institutionalized and legalised. Various options can be explored for augmentation of physical infrastructure, such as technology upgradation, dual piping system, rain water harvesting, energy audit and exploring alternative sources of energy. Several technologies, such as decentralized and compact water treatment units, solar/aerobic/oxidation and root zone systems can be employed to purify potable water from the natural sources. Various alternative technologies, like Extended Aeration Technique, Biogas production, Bubble Diffusion process, Floatation, Anaerobic Reactors, etc., are already available, which can be adapted for urban sanitation. Decentralized systems based on recycling, energy generation and organic decomposing can be explored for solid waste treatment. Bio–reactor composting and vassel system (Tunnel Reactor) are new generation technologies which can be employed for treatment of urban solid waste. All the public buildings, slums, roadsides and parks, etc. can be provided with public toilets, garbage bins, water points/public taps, etc.

Urban drains and waterfront can be landscaped in the form of interconnected parkways. There is no need for elaborate gardening of the greenways, but wild, simple and natural stretch by itself would be ecologically important. Such trails could be one of the cheapest forms of drainage and recreation. Drainage should be linked with the ecology and green network that is "bio-drainage". Regular de-silting of drains and control of dumping of solid waste into the drains should be taken up. Public awareness programmme need to be taken up in association with local community to make the society aware about the consequences of dumping the solid waste in the drains and rivers.

Making Cities Smart

Cities are complex systems, which generally involve multiple agencies, departments and organizations. To meet citizen expectations, city leaders must innovate across key areas. It is necessary to design and implement a city plan to realize its full potential, while efficiently running daily operations. It must provide services that support the social, health and educational needs of citizens. A city provides the infrastructure services such as water, energy and transportation. Cities contain intelligent networks, sustainable buildings, and mobility systems. A blueprint for smart cities focus on intelligent computing infrastructures with cutting–edge advances in cyber–physical systems, and innovation support the cities of tomorrow. Since a city is composed of numerous buildings these also need to be smart and green. By proper design and review of existing design and operations it may be possible to reduce energy consumption. Integration of major building systems on a common network helps optimize use assignment and space configurations, eliminating unused or underperforming space, as well

as raising user satisfaction. LEED and Energy Star–compliant buildings typically have higher occupancy rates, with less turnover. A variety of studies have demonstrated significant productivity increase in smarter buildings. A smart building strives to achieve infrastructure efficiency, conservation of water, energy and resources, economical operation of services and lesser maintenance problems by preventative maintenance. It is possible to plug the Non–Revenue Water (NRW) losses, which amount to 30 to 40 percent by following measures:

- Identify leaks in water network using non-invasive techniques
- Gather information regarding most likely location of leak, using advanced analytics and optimization techniques
- Control and manage the pressure in the network at pumps and valves
- Reduce access energy (power) consumption at pump motors

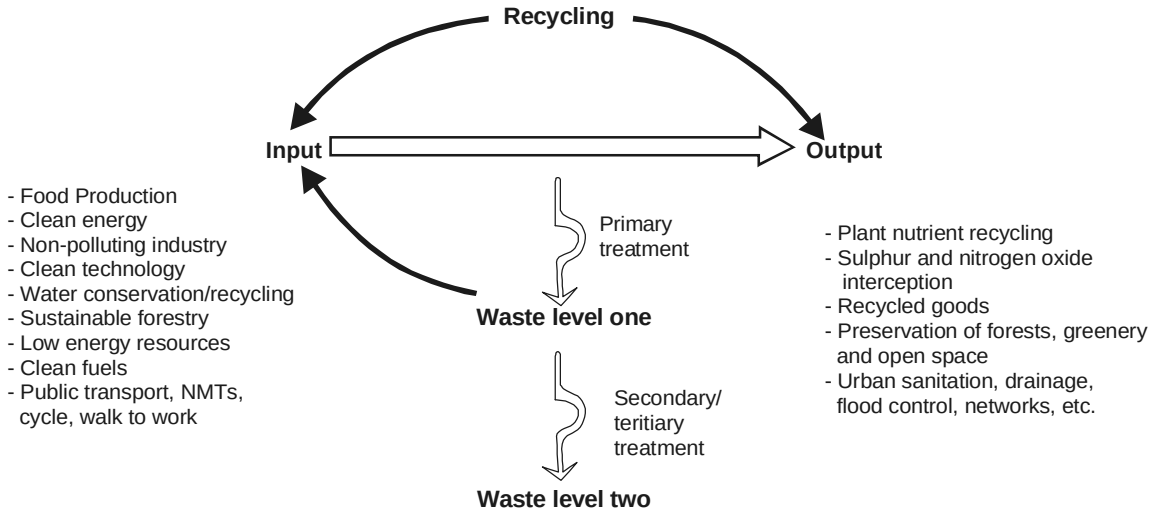

Fig.1.17: Circular Metabolism

Local capacity is intrinsically linked to that of the knowledge-based economy where innovation and technology are main drivers of growth, and the collective community intelligence, which underlines capacity and networks as main drivers of a community's success. This requires a planning paradigm pertinent for urban-regional development and innovation management, similar to the related concept of 'intelligent cities' (or communities, clusters, districts and multi-cluster territories). By developing sector–focused, cluster–based or more complex intelligent city strategies, territories can set in motion innovation mechanisms of global dimensions and enhance substantially their innovation systems. The critical factors those affect resource use and CO_2 emissions, such as energy use, transportation, waste prevention air quality, water quality, affordable housing, green space and transit. This implies the need to rethink and reshape the urban environment comprising transportation infrastructure, zoning, building codes, waste management, open space and greens, etc. which make the city more efficient, sustainable, and smarter.

The move towards social sustainability can be seen in the integration of e–participation techniques such as online consultation and deliberation over proposed service changes to support the participation of users in the democratisation of decisions about cities and development. Environmental sustainability is important in a world where resources are scarce, and where cities increasingly base their development and wealth on natural resources their exploitation must guarantee a safe and renewable use of natural resources.

The availability and quality of the ICT infrastructure is not the only definition of a smart or intelligent city. Other definitions stress the role of human capital and education and learning in urban development. It has been shown, for example, that the most rapid urban and economic growth rates have been achieved in cities where a high share of educated labour force is available. Innovation is driven by entrepreneurs who innovate in industries and products which require an increasingly more skilled labour force. Because not all cities are equally successful in investing in human capital, an educated labour force - 'the creative class'–is spatially clustering over time. This tendency for cities to diverge in terms of human capital has attracted the attention of researchers and policy makers. It turns out that some cities, which were in the past better endowed with a skilled labour force, have managed to achieve spatial homogeneity by progressive clustering of urban human capital.

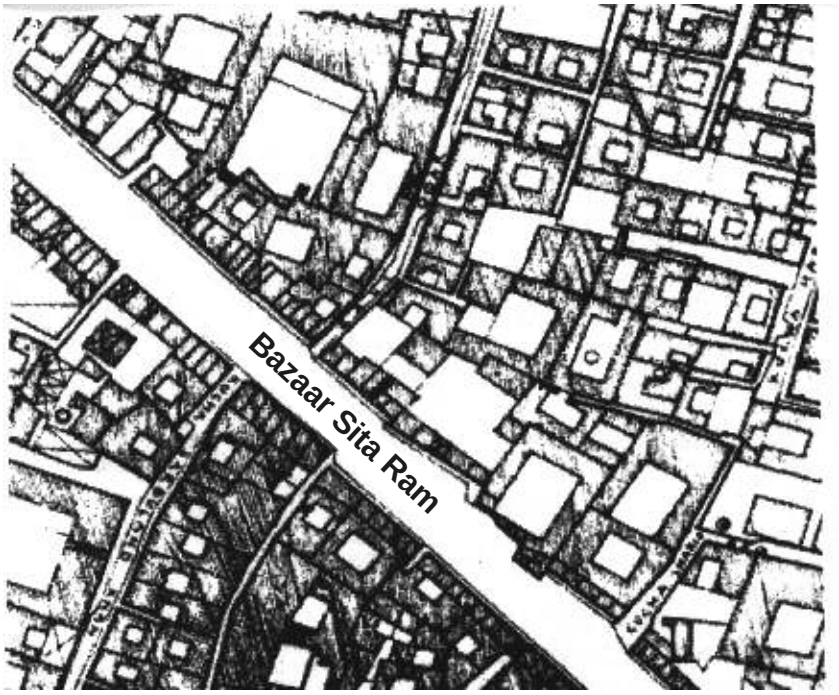

Fig.1.18: Spatial Structure of Shahjahanabad–Compact, Introvert and High Density

Source: Fonesca, Rory, The Walled City of Old Delhi in Shelter and Society 1976.

The breakthrough in technology has multiplied the space, energy and time. It is now realized that — "less is more" with the practical applications of microchips, micro-computers, microwaves, nano–technology, etc. The buildings and services are yet to capture this breakthrough. It is time that new forms of energy, services and construction are evolved. Renewal energy and recycling must be the key concepts in services and buildings. A new pattem is emerging, shrinking space and time. The network of society, cyber–space, e–topia is changing the familiar borders like inside–outside, private–public, here–there, city–country and yesterday–tomorrow. The world of space and place is characterized by online exchange of information, interactions, dynamic networks and floating nodes. Recycling of waste water, rain water harvesting, coupled with waterless toilet will save the environment and avoid impending water crisis. Geothermal heating and cooling system by circulating water through a grid of underground tunnels and

Table 1.11. How city systems can be made smarter with instrumentation, interconnection and intelligence

System	*Elements*	*Instruments*	*Interconnection*	*Intelligence*
City service	• Public service management • Local government administration	Creation of local authority Management information system	Interconnected service	Immediate and joint-up service provision
Citizens	Health and education	Patient diagnostic and screening devices	Interconnectex records for doctors, hospitals and other health providers	Patient-driven pre-emptive care
Business	• Business environment • Administrative burdens	Data gathering about use	Interconnected stake-holders across city's business system	Customized service delivery for business
Transport	• Cars, roads • Public transport • Airports, seaports	Measuring traffic flows and toll use	Integrated traffic, weather and traveller information services	Road pricing
Communication	• Broadband, wireless • Phones, computers	Data gathering via mobile phones	Interconnected mobile phones, fixed line, broadband	Information for consumer on city services, on their own time
Water	• Sanitation • Freshwater supplies	Gather data for water quality monitoring	Interconnected nodes, ports, energy, water	Quality, flood and drought prevention.
Energy	• Oil, gas • Renewables	Fit sensors to gather data on usage across the energy system	Interconnected appliances and devices between energy consumers and providers.	Optimize use of the system and balance use across time

Source : IBM Institute of Business Value Analysis

wells, where the earth's temperature is 15°C to 20°C, can provide environment friendly solutions to micro-climate and energy needs. The living pattern and city services should manifest a circular metabolism, replacing the existing linear system of input-output. The city and buildings have not only to be comfortable, green and efficient but also intelligent and integrated. How this can be done is demonstrated by the following study of Curitiba.

Integrated Planning and Environmental Improvements In Curitiba, Brazil

By the late 1960s, Curitiba, with a metropolitan population of 800,000 people (now over 22 million), was becoming another automobile-dominated city plagued by traffic congestion, urban sprawl, and inadequate public transportation. The municipal government initiated a series of integrated measures to encourage higher densities around major public transportation routes, reduce dependency on the private automobile, and make the city more accessible to pedestrians and cyclists. These measures have been sustained and have produced impressive results:

Measures

- **Integration of transport and land use policies:** Land use legislation enforces higher densities around major transport corridors and roads are geared to land use in each area.
- **Public transport:** Main roads have an express bus lane; different lines are integrated for rapid transfers; the system is faster and cheaper than those in other Brazilian cities.
- **Provisions for pedestrians and cyclists:** A network of bike paths links city neighborhoods and parks; pedestrians have priority in downtown areas with streets closed off to form pedestrian malls.
- **Preservation policies:** New development is concentrated in existing urban space; old structures are renovated for new uses.
- **Traffic control:** Some streets are closed to autos; in others, speed limits and trees slow car traffic.

Effects

- Curitiba has one of the lowest rate of ambient air pollution in Brazil; fuel consumption has been reduced by 25 percent, with gasoline use per vehicle 30 percent less than in other Brazilian cities.
- The bus system serves 1.3 million passengers daily or 75 percent of all commuters; people spend about 10 percent of their income on transport, which is one of the lowest rates in Brazil.
- Once-declining, shopping districts are now lively and profitable; there is little traffic congestion although Curitiba has over 500,000 cars (second highest amount per capita in Brazil).
- Historic buildings are preserved and degraded land is reclaimed for such uses as an operas and a botanical garden; green space per capita has expanded from 0.5 to 50 m^3.
- Curitiba's rate of accidents per vehicle is the lowest in Brazil.

Source: Rabinovitch W. Leitmann (1993); Lowe (1992)

Urban Transport

According to *Traffic and Transport Policies and Strategies in Urban Areas in India* (Wilbur Smith Associates, MoUD Report, 2008), the urban transport scenario is quite depressing. Vehicle population in India increased 80 folds in the last 40 years, but road area increased by only 5 per cent. Only 17 of the largest cities have organized bus services, and only three cities - Mumbai, Kolkata and Chennai- have an intra-urban rail system. In metropolitan cities, 40 to 50 percent people walk and use non-motorised transport, while 30% people use public transport Private vehicles are growing three to four times the population growth in urban areas and peak traffic density is around 170 vehicles per lane km. It is estimated that to meet with the deficiencies of urban transport infrastructure, 2.5 billion square meter roads and 7,400 km of metro rail network and subways are needed. In Indian cities about one-third to two-thirds of trips are solely by walk and a number of city roads do not have appropriate footpaths. Although highways and major roads have signage, signboards, road markings, etc., there is need for further improvement. Funds and resource availability need to be augmented. Encroachment is also a menace which creates hindrance to smooth flow of traffic.

Carbon neutral cities have to reduce their ecological footprint due to transport, which is responsible for 18% of carbon emissions due to use of fossil fuels. The need to travel can be reduced by mixed land use and better synergy among public transport, walking, NMTs, urban structure (form, density and floor area ratio) and by transit oriented development. An important element of policy should aim to shift private vehicle users to public transport. Apart from aspects like frequency, inter-modal integration, a possible single ticketing systems, the quality of public transport, particularly buses, would need to be significantly upgraded, inter-alia, keeping in view the element of clean and green fuel and traffic calming. Organisation of land use, circulation pattern and decisions regarding density, Floor Area Ratio and other controls should be around the Public Transport System, which reduce the need of personal vehicles and transport. The spatial model should be based upon the principle of "less travel, more energy savings." As such, a compact development can significantly help in saving fossil fuel consumption, climate change and environment. Critical instruments for more accessible urban pattern include synergy with public transport, infrastructure development, mixed land use and e-governance, which reduce the need to travel. A least-cost life cycle analysis of urban mobility options and transportation systems across a range of carriageways and modes should establish an optimum long term mix A mix of pedestrians, bicycles, people movers, trams, buses, metro and ferries provides safer, faster and cheaper mobility than the personal car. This calls for replanning of urban form which promotes walkability and NMTs and curtail the need to travel. Transport policy and plans linked to pollution control, including noise, should be the basis of a City Plan. Providing a barrier free environment is a mandatory requirement for outdoor and indoor mobility.

The systems of urban transportation need to undergo a radical change. The basic purpose of sustainable development is to achieve efficiency, equity, ecology and economy. Compact cities contribute significantly in conserving fossil fuels, climate change and environment. "Smart growth" practices create more accessible land use patterns which reduce the travel need. As we find in the traditional cities like Jaipur and Shahjahanabad a walkable community provides the fundamental building block in creating a sustainable urban form. The concept of modular and polycentric urban structure comprises a network of linear local centres, defined by the walking catchment (about 500 m).

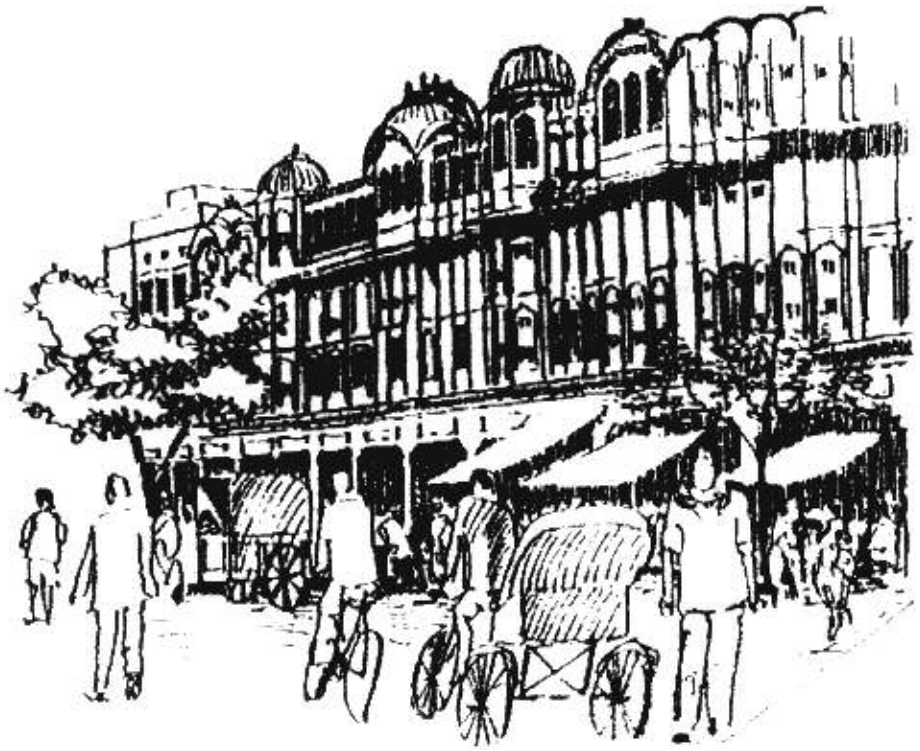

Fig.1.19: Jaipur is a climax of indigenous city planning with its characteristic inclusive and compact form and integrating climate conscious design, mixed land use, walkability and chopads (squares).

Smart and Sustainable Energy

The power demands in cities are growing exponentially, generation of which emits about one-fourth of carbon footprint. This needs action to reduce the power demand and resorting to energy efficiency. Load management techniques should be adopted and schemes to minimise power losses should be enforced. Renewable energy sources like solar/wind energy needs mandatory incentives and instruments.

Cooling, heating and lighting often account for bulk of the electrical consumption, which can be reduced by adopting energy efficiency practices, such as:

- Incorporating daylight design in all the buildings on a mandatory basis
- Adoption of energy efficient practices by regulation and energy labeling of lighting air-conditioning, air-cooling products, building glass, and imposition of minimum efficiency of lighting and electrical installations.
- Utilisation of heat reflective insulation on the roofs/green roof.
- Use of renewable sources of energy
- Use of technology which would consume minimum energy to maintain desired human comfort conditions. For example, replacement of bulbs by fluorescent lamps/CFLs and passive building design conforming to micro-climate may bring in substantial savings in electrical consumption.

Adoption of alternative cooling and air–conditioning systems, such as passive evaporative cooling micronisers (PECM), passive downdraft evaporative cooling (PDEC), tunnel cooling, shafts and courtyards for natural cooling and ventilation, can sustainability reduce electrical loads.

India is endowed with abundance of sun. However, its potential in producing energy is still to be explored. In a cloudless region, a roof area of 100 sq.m. receives about 500 KW per day from eight hours of sunshine. In the hot–arid regions (the greatest solar radiation intensity occurs between latitudes 15 and 35 degree north or south), more than 3,000 hours of solar radiation could be obtained and even in the warm–humid region here are about 2300 hours of solar radiation. Adoption of solar energy devices can help in the conservation of natural resources and fossile fuels such as coal, oil, or gas. Solar water heating for domestic hot water or as part of a home heating scheme has become more widely used in some countries as a response to the energy and environment crisis. As solar energy is initially captured in the form of heat, it is therefore best use of a variety of heating purposes. Solar water heaters (e.g. for canteens, schools, homes and hotels) solar steam cookers and water distillation units provide examples of practical applications of solar energy. It is time that solar energy is made mandatory for cooking in the establishment (hotels, restaurants, railway stations, langars, religious centers, etc.) wherever more than 1500 meals are cooked per day. This has already been successfully adopted in the Brahmkumaris headquarters at Mount Abu in Rajasthan, besides Tirupati, Auroville, Akshardham (New Delhi), etc.

Photovoltaic power generating systems can be used in remote electric supplies for water pumps, electric fences, communications and navigation equipment stand-alone power systems for consumer products like computers, radios, walkway, lighting and auto-battery chargers. These are already in practical use, which need to be taken further.

Wind power, which is inexhaustible, and nonpolluting, is a promising way out of the energy crisis. The grouping of large windmills is capable of generating 10,000 or more kilowatts of electric power. Already new type of vertical-axis wind turbines have been designed and installed in various parts of the country, which are producing electrical energy for grinding and pump water. They are cheaper and far more efficient than the traditional horizontal-axis wind mills.

Shifts in energy policy, technology, and consumer focus are driving transformation throughout the industry, though many organizations are still in the early stages. For most energy and utility companies, success will be achieved through transforming the utility network, improving generation performance, and transforming customer operations. They are making investments to upgrade the capabilities of the grid and to enable consumers to take a more active role in managing their energy use via smart meters, connected appliances, and Web portals. Utilities are installing technologies that improve the efficiency of the grid, and developing new capabilities for integrating renewable energy into the grid with equipment for storing energy.

The resulting smarter energy systems will help save huge operating costs and reduce the need to build more capacity; anticipate, detect, and respond to problems quickly; empower consumers; and help integrate electric vehicles and energy from renewable sources. The term “smarter energy”, denotes integrated, scalable system that extends from businesses and homes, through the distribution and transmission systems, back to the sources of energy. A smarter energy system is instrumented with sensors and controls embedded into the fabric of its operations; it is interconnected enabling the two-way flow of information, including pricing. It

is intelligent, using analytics and automation to turn data into insights and to manage resources more efficiently.

Smarter grids also stand to be more resistant to attack and natural disasters. A next-generation grid that anticipates, detects, and responds to problems quickly has the potential to reduce wide-area outages to near zero, and at a lower cost. Consumers empowered with better information can make smarter choices about how they use energy. By integrating energy from renewable sources like solar and wind onto the grid, overall impact on the environment can be curtailed, and regions can be more self-sufficient in energy.

Design With Nature

Sustainable development is basically a process of 'design with nature'. It involves minimum interventions in natural system to the extent of carrying capacity of an area. The carrying capacity of an area is the population or level of activity that can be sustained for a given length of time without depletion of the resources or breakdown of the biological natural systems. In order to address the needs of the majority of the people, that is poor, a major focus area has to be the promotion of the local economy and poverty reduction. A large number of the unemployed are forced to take on informal, illegal or uncertain jobs, and the economic development stagnates. As such, there is an urgent need to focus on the promotion of small and medium-sized enterprises that are labor intensive and create jobs. This would help in integrating the social, economic and ecological aspects of sustainable development.

For sustainable human settlements, the following ten key elements have been identified by the Building and Social Housing Foundation:

- Resource budgeting;
- Energy conservation and efficiency;
- Renewable energy technology;
- Long lasting built structures;
- Proximity between home and work;
- Efficient public transport systems;
- Waste reduction and recycling;
- Organic waste composting;
- A circular urban metabolism;
- Supply of staple foods from local sources.

Design with nature is a subject which cuts across various disciplines. It is an all embracing and complex process. Various thinkers, architects and planners have interpreted, evolved and translated their own principles of design with nature. For example, Le Corbusier, the pioneer of modern movement, as early as in 1947, developed a metaphoric style of design with nature, which he used in the planning of Chandigarh and various other projects.

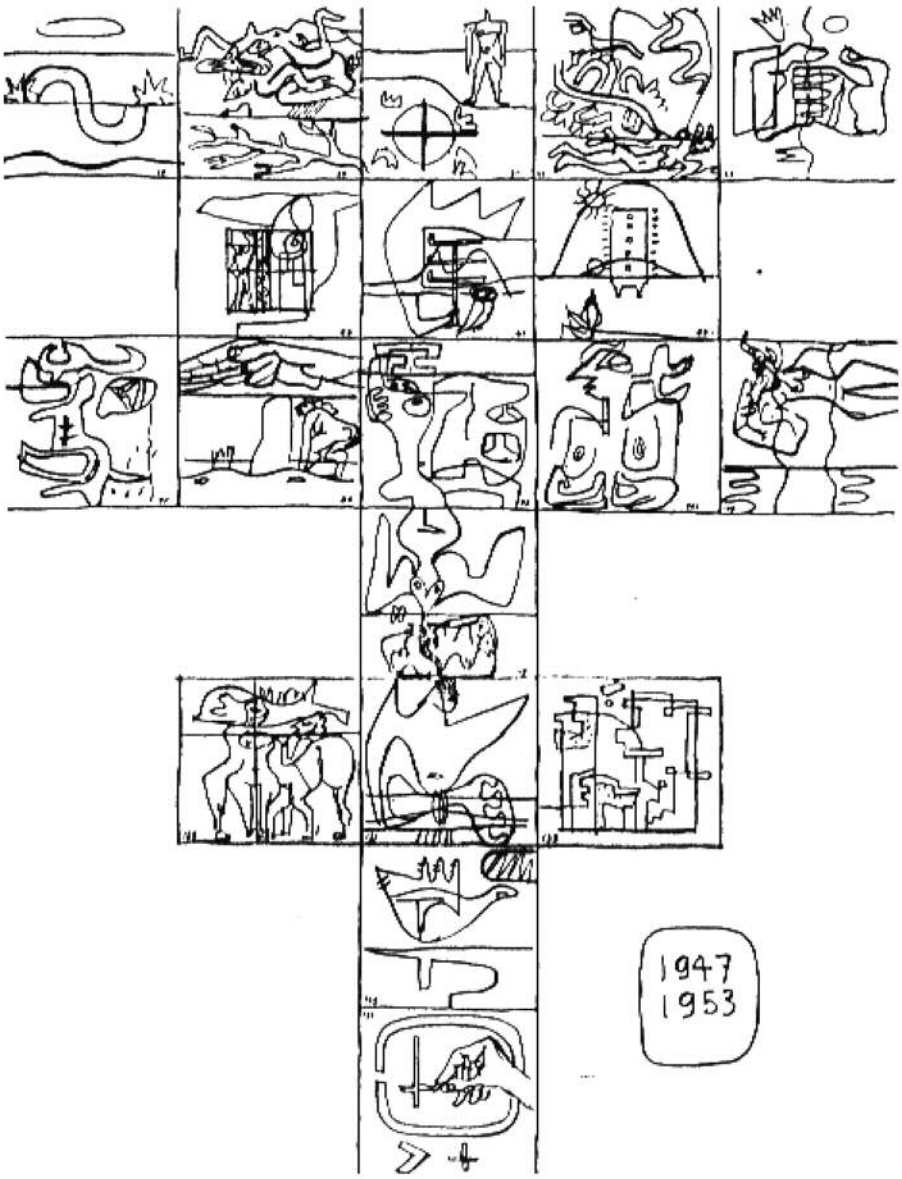

Fig.1.20: Le Corbusier in his inimitable, metaphoric style classified the human environment in seven categories: the right angle, the hand, the character, the fusion, the human body, the spirit and the environment. The composition progresses hierarchically (from bottom top), from the intuitive nature of man to a comprehensive and global world.

Source : The Iconographic Structure of the Poeme de L'angle droit, a collection of Le Corbusier's drawings executed between 1947 and 1953, published in 1955.

Fig.1.21: Le Corbusier's Chandigarh, the Secretariat and Legislative Assembly, constructed from 1956 to 1970, became the testing ground for many of the architect's ideas on how to design for the combination of extreme summer heat and cool winters. Huge brise-soleils dominate the assembly building. The device for creating shade had come of age. Chandigarh as the administrative capital comprised a series of buildings: the Secretariat, the Assembly, the Governor's Palace, and the High Court. In developing his design for the complex, Le Corbusier drew on the skills of traditional Mughal building, notably Fatehpur Sikri.

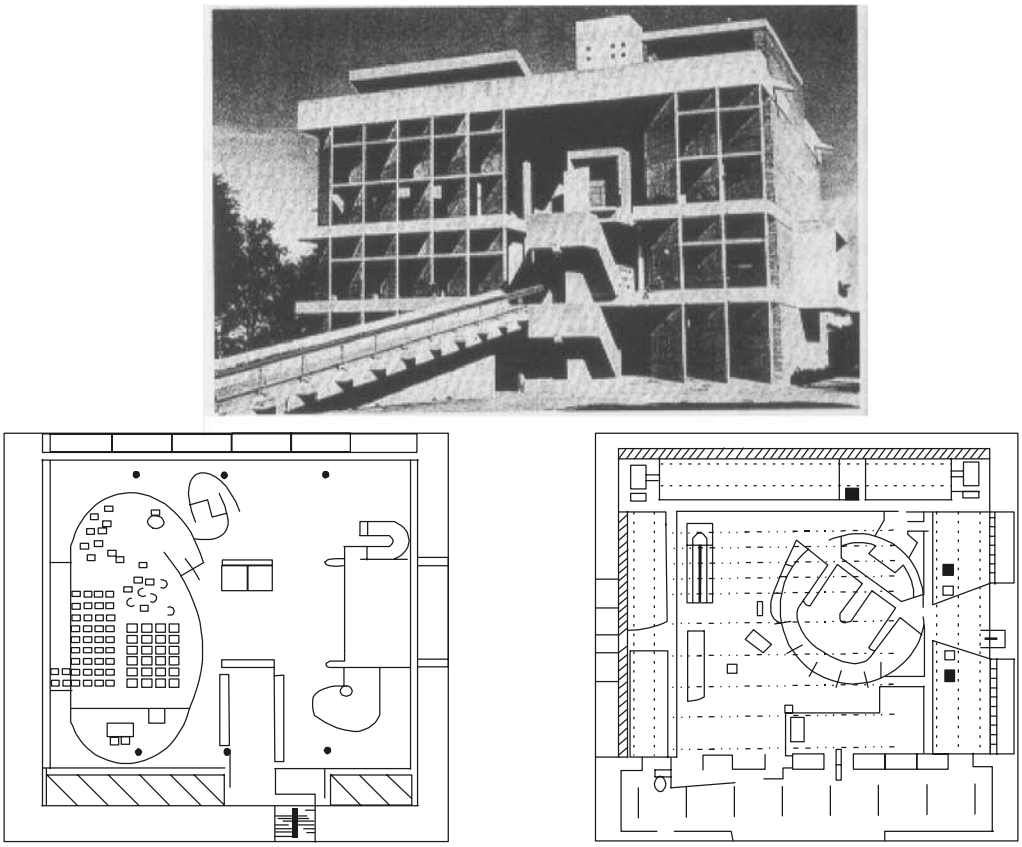

Fig.1.22: Le Corbusier's 1954 building for the Mill Owner's Association in Ahmedabad has walls of brise-soleils on the east and west facades. The hall is indirectly lit by reflections from the curved ceiling, which is kept cool by gardens and a water reservoir on the roof.

An Agenda for Sustainable Development

For an action oriented approach, there is a need to disaggregate the agenda and focus upon the key elements at policy level, local level, and building level. The policy agenda is derived from an inventory of ecological resources and cultural processess. It takes into account the demographic trends, urbanization, rural/urban ecologies, energy, water, sanitation, hygiene and public health infrastructure.

- Key principles, such as– intra and inter–generational equity, pollution prevention principles, biodiversity, etc, are defined taking an over view of sustainability, that is triple bottom line approach along with legal and governance issues.
- Performance and management are participatory and incentive based, such as development rights, green demonstration projects, pricing policies, subsidies, emission trading and carbon credits.
- Planning strategies and public participation are based on sustainability principles and a rigorous analysis of suitability criteria for various activities and land uses.
- Statutory planning instruments may cover a wide range of environmental aspects, documentation, monitoring and parameters, as given below :

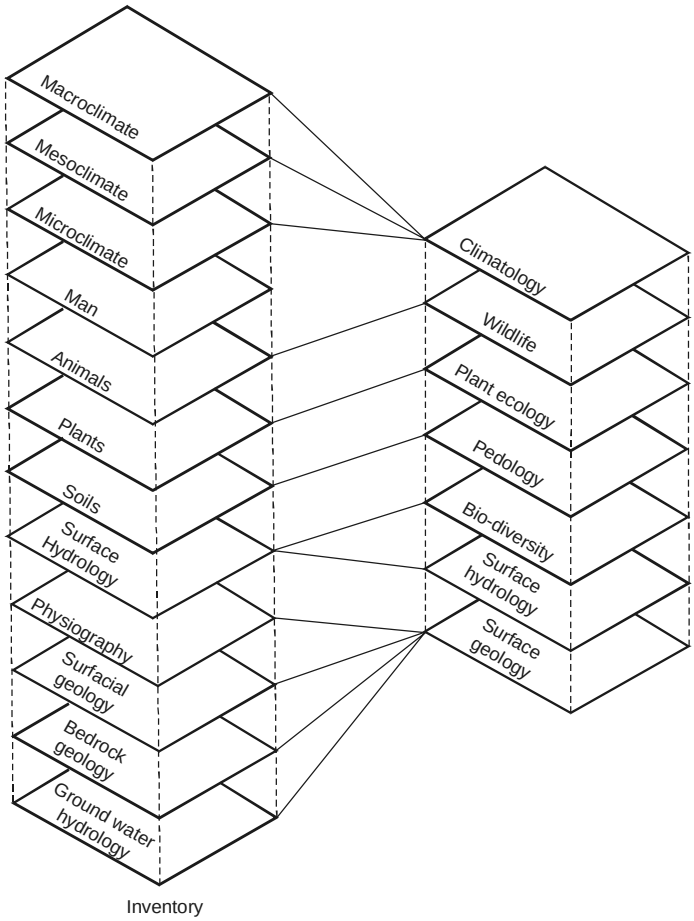

Fig. 1.23. Layer cake representation of the phenomena of landscape and cultural processes.

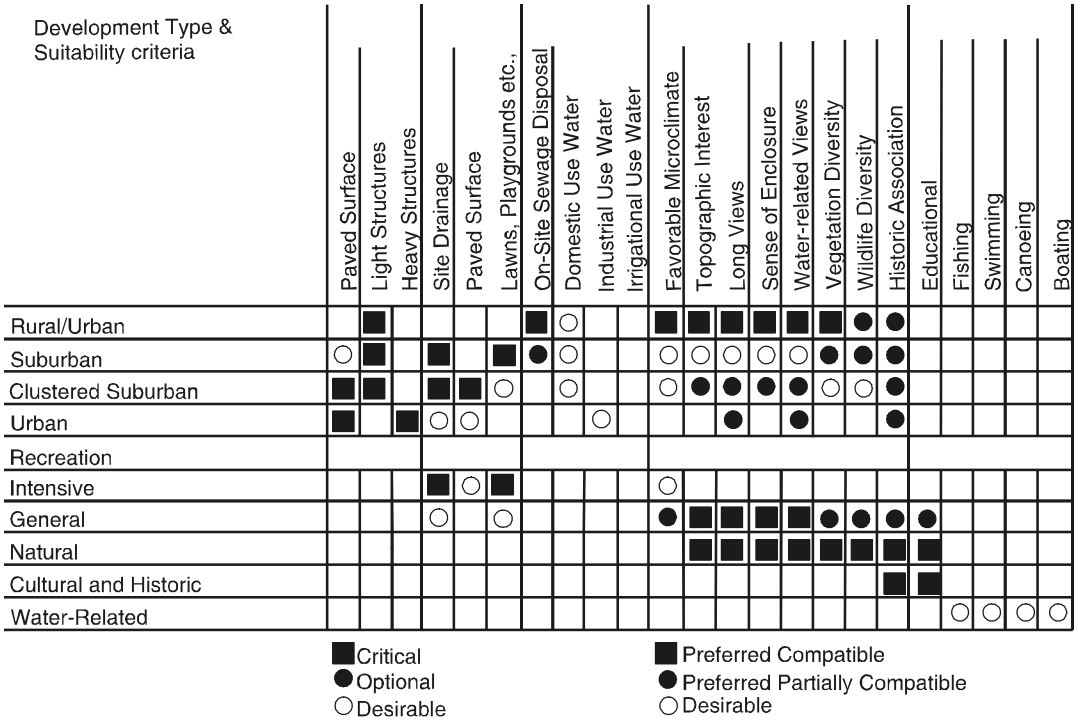

Fig. 1.24 : Suitability Criteria: Recreation and Urbanization

Source : Suitability criteria for recreation and urbanization in Medford Township, New Jersey, 1974.

Vision of Indian Green Buildings Congress (IGBC)

The following are goals set by IGBC to achieve the vision – 2025:

- 50% of India's built environment to be Green
- 1,00,000 registered Green Buildings
- 25 Billion sq.ft. Green Building footprint
- 1,00,000 Green Building professionals
- 1,000 Green Building products & equipments

The IGBC recommends the following actions to achieve its Vision–2025:

- Promote net zero energy and zero water discharge concepts in all buildings
- Adopt ECBC for new commercial buildings in all States
- Equip rural sector with knowledge on tapping natural lighting, ventilation and renewable energy in buildings
- Include Green products into the 'schedule of rates' of Public Works Department (PWD)
- Demonstrate few Indian cities as sustainable cities
- Encourage transit oriented development in all cities

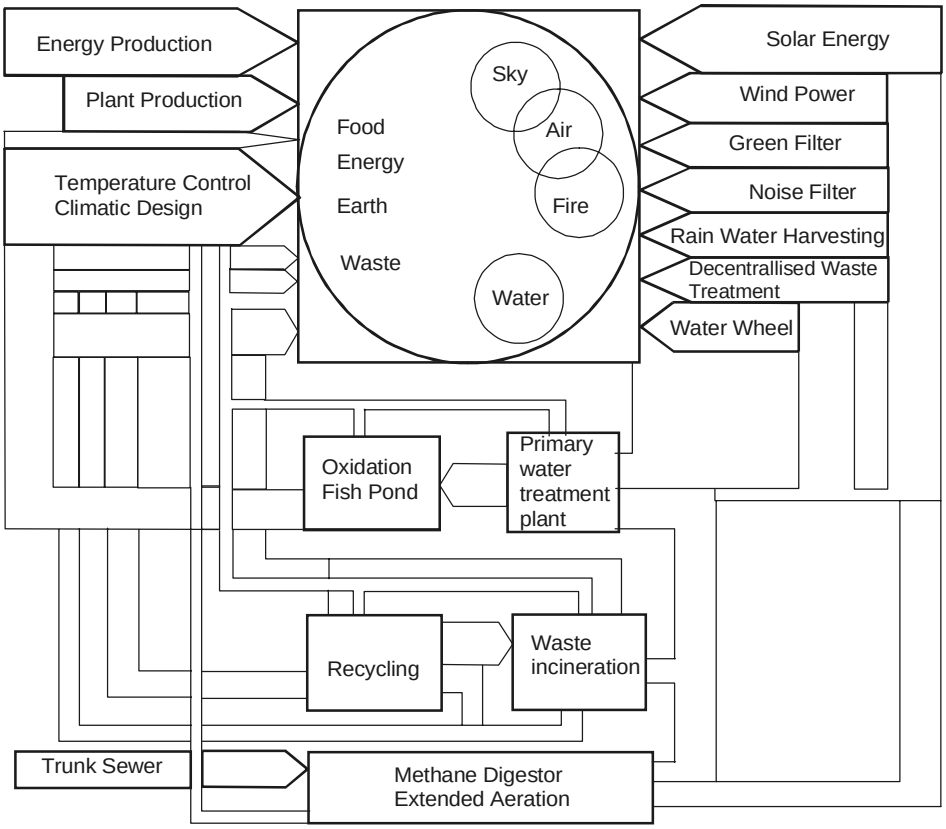

Fig.1.25: The waste management process should embody the principle of circular metabolism, which means recycling wastes to produce energy, adoption of eco-technology for zero polluting energy (wind, solar and water wheel), development of green filters, noise buffers and rainwater harvesting.

This require adoption of eco-efficiency benchmarks (energy, greenhouse gases, water, waste, air quality and particulate levels), together with a mandated performance. A key area of sustainable development is an integrated process of waste management that encompasses the conservation of five elements of nature, as well as meets the human needs. The city, infrastructure, mobility and buildings have a crucial role in this endeavour.

The starting point of organizing sustainable space is ecology and environment. Environmental guidelines, norms, standards and codes should form the backbone of planning and design. The organization and hierarchy of the following should determine the physical form and community module:

- Transportation (including parking, cycleways and pedestrian precincts);
- Open spaces, parks, playgrounds;
- Community facilities;
- Neighborhood module, housing;
- Decentralized and local infrastructure services.

Management and sustainable maintenance need to be given serious attention at the design stage. Not only the buildings, but the cities need to be intelligent and should be visualized to cater to the needs of the next generation.

For environmental and micro–climate focus, the concepts of site planning, building design, technology and materials have to be re-examined. It is at the design stage that the environmental efficiency and compatibility of a building are largely determined, which is popularly called 'green architecture'. The buildings should incorporate flexible systems which respond to the changing micro-climatic needs and varying conditions of natural ventilation and light. The design should obviate outdoor and indoor pollution. It should provide for rooftop rainwater harvesting and recycling of wastewater and exploitation of non-conventional sources of energy (such as photo–voltaic system). The city and buildings should connect the people and environment. Indian philosopher J. Krishnamurti makes the connection between "human nature" and "nature" in this passage from *All the Marvellous Earth:*

> "There is a tree by the river and we have been watching it day after day for several weeks when the sun is beginning to rise. As the sun rises slowly over the horizon, over the trees, this particular tree becomes all of a sudden golden. All the leaves are bright, with life, and as you watch then as the hours pass by, that tree whose name does not matter – what matters is that beautiful tree — an extraordinary quality seems to spread over the land, over the river... Towards evening when the western skies are lit up by the setting sun, the tree gradually becomes sombre, dark, closing in on itself. The sky has become red, yellow, green, but the tree remains quiet, hidden, and is resting for the night. If you establish a relationship with it, then you have a relationship with mankind. You are responsible then for that tree and for the trees of the world. But if you have no relationship with the living things on this earth, you may lose whatever relationship you have with humanity, with human beings."