CHAPTER-I

INTRODUCTION

Green infrastructure (G.I) is broadly referred as an interconnected network of natural areas and other open spaces that helps in conservation of natural ecosystem principles and its functions endure clean air and water and provide a wide range of benefits to human population and their surroundings.[1] In this context, it is an ecological framework for protecting and restoring our natural life-support system that includes environmental, social, and economic aspects. It mainly emphasis on open and green spaces importance and differ from conventional approaches to open space planning because it focuses on conservation values and actions in concert with land development, growth management and built infrastructure planning. Green infrastructure helps communities recognize and prioritize conservation prospects and plan development in ways that enhance the use of land to meet the needs of people and nature.

As a concept, the planning and management of a green infrastructure network can monitor the creation of a system of open space hubs and links that support conservation and associated outdoor recreational spaces, connect both existing and future green space resources, and helps to *"fill in"* the gaps as shown in the ***Figure No:1***. In addition to this, it can be used to guide future growth and future land development and land conservation decisions to accommodate population growth, protect and preserve community assets and natural resources.[2]

Figure: 1 Green infrastructure helps communities plan for land conservation and land development in a way that optimizes land use to meet the needs of nature and people. (Michigan)

Green infrastructure methodology facilitates orderly and planned conservation activities, value to project, and provides predictability for both conservationists and developers. It uses planning, design, and implementation approaches similar to those used for roads, water management systems and other

[1] Mark A. Benedict, Edward T. McMahon, Mark A, *"Green infrastructure: Smart conservation for the 21st century".*

[2] Mark A. Benedict, Edward T. McMahon, Mark A(2006), The Conservation Fund, *"Green infrastructure-Linking landscapes and communities"*

community support facilities. The approach can be applied at multiple scales e.g., across landscapes, watersheds, regions, jurisdictions) and help move communities beyond jurisdictional boundaries.

Green infrastructure incorporates a wide variety of natural and restored built-in ecosystems that create up a system of "hubs" and "links." Green growth can be achieved by integrating sites (in the form of sensitive habitats, shopping centers or schools etc.) hubs (in the form of small towns, metro parks, city parks, state recreation parks etc.) and links (in the form of river corridor, rail-trail, trail along a landscaped roadway etc.) as shown in the ***Figure No: 2.***

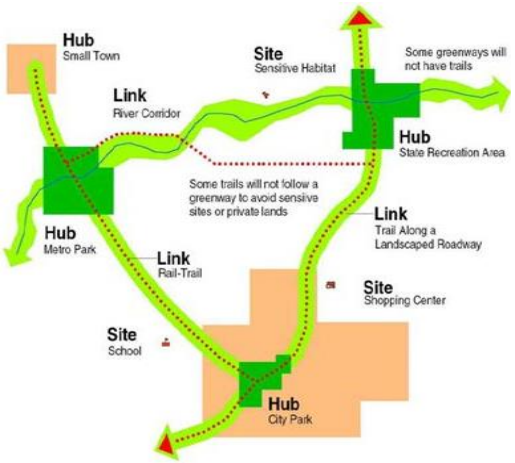

Figure No: 2 Integration of existing and future open space hubs and links.

HUBS provide an origin or destination for wildlife and ecological processes moving to or through it. It comes in all shapes and sizes, including reserves, managed native landscapes, working lands, regional parks and preserves, community parks and natural areas.

Whereas, ***LINKS*** tie the system together and enable green infrastructure to work. They differ in size,function and ownership,includinglanscape linkages,conservation corridors, greenways, greenbelts,ecobelts.[3]

1.1. Definition

1.1.1 Global context

Infrastructure can be defined as *'the substructure or underlying foundation, especially the basic installations and facilities on which the continuance and growth of a community depends'* and the term '*green*' is akin to conservation and is related to ecology and environment.

The first definition of GI was given by Mark Benedict, USA as '*an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife*.'

[3] Mark A. Benedict, Edward T. McMahon, Mark A, "Green infrastructure: Smart conservation for the 21st century".

As per ***Green Infrastructure Work Group, US***, 'GI is an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for communities and people.'

The ***Town and Country Planning Association, UK*** defines GI as 'the sub regional network of protected sites, nature reserves, green spaces, and greenway linkages.' The linkages include river corridors and floodplains, migration routes and features of the landscape which are of importance as wildlife corridors.

As per the ***latest definition of Natural England***, GI is 'a strategically planned and delivered network comprising the broadest range of high quality green spaces and other environmental features. It should be designed and managed as a multifunctional resource capable of delivering ecological services and quality of life benefits required by the communities it serves and needed to underpin sustainability.[4]

Green infrastructure is more often related to environmental or sustainability goals that cities are trying to achieve through a mix of natural approaches. Examples of "green" infrastructure and technological practices include green, blue, and white roofs; hard and soft permeable surfaces; green alleys and streets; urban forestry; green open spaces such as parks and wetlands; and adapting buildings to better cope with floods and coastal storms.

Green Infrastructure is a term that is appearing more and more frequently in land conservation and development discussions across the country and around the world.

Green Infrastructure is the network of natural and semi-natural areas, features and green spaces in rural and urban, and terrestrial, freshwater, coastal and marine areas, which together enhance ecosystem health and resilience, contribute to biodiversity conservation and benefit human populations through the maintenance and enhancement of ecosystem services. Green Infrastructure can be strengthened through strategic and co-ordinated initiatives that focus on

[4] Suresh Kumar Rohilla, Shivali Jainer and Mahreen Matto 2017, "Green Infrastructure: A Practitioner's Guide", Centre for Science and Environment, New Delhi

maintaining, restoring, improving and connecting existing areas and features, as well as creating new areas and features.[5]

However, green infrastructure can also mean "low-carbon infrastructure" such as renewable energy infrastructure and public transportation systems.

Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. While single-purpose gray storm water infrastructure-conventional piped drainage and water treatment systems is designed to move urban storm water away from the built environment, green infrastructure reduces and treats storm water at its source while delivering environmental, social, and economic benefits.[6]

Green infrastructure refers to the network of green and blue spaces (as well as features such as street trees and green roofs) that is planned, designed and managed to promote healthier living and lessen the impacts of climate change, improve air and water quality, biodiversity and ecological resilience and encourage walking and cycling.[7]

Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or country, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to storm water management systems designed to mimic nature by soaking up and storing water.[8]

1.1.2. Indian context

In Indian cities, urban greens refer to any area within the city limit which has been created and preserved for the purpose of growing plants. However, urban landscapes have evolved under extremely complex influences of changing land uses and management practices, sustaining some habitats and fundamentally altering others.

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[5] Green Infrastructure Evidence Base retrieved from http://gievidencebase.botanicgardens.sa.gov.au/contents/green-infrastructure-concepts-and-definitions#Green-Infrastructure, Botanic Gardens of South Australia

[6] Green Infrastructure retrieved from https://www.epa.gov/green-infrastructure/what-green-infrastructure, United States Environmental Protection Agency

[7] Chapter Green Infrastructure, retrieved from https://www.london.gov.uk/sites/default/files/green_infrastructure .pdf, London Environment Strategy

[8] Introduction to Green Infrastructure, retrieved from https://dnr.mo.gov/env/wpp/stormwater/docs/gi-chapt1.pdf

According to the ***Centre of Science and Environment, New Delhi***, Green infrastructure refers to natural or semi-natural ecosystems that provide water resource management by introducing the natural water cycle into urban environments. It provides effective measures to manage urban flooding, water supply and quantity regulation, at the same time generating multiple environmental benefits.[9]

1.1.3. Derived definition

Green infrastructure refers to the inter-linkage between the natural and manmade elements in order to provide sustainable and cordial living environment to the humans. Green infrastructure (GI) is globally recognized as an essential component of livable and sustainable places.

GI is an approach to water resource management that incorporates vegetation, soils, and natural processes into the built environment to manage storm water, mitigate the impacts of climate change, and maintain healthy and sustainable communities.

It is widely acknowledged that GI is the primary mechanism for delivering ecosystem services in towns and cities, and there is a substantial body of research demonstrating the multiple benefits of GI to urban populations. Despite this evidence base, there is still considerable uncertainty about the best way to design, deliver and maintain GI. Therefore, this study helps to provide an outline of approaches to enhance the use of green infrastructure for sustainable development.

1.2. Green Infrastructure: It's Evolution in India

The evolution of GI in the Indian sub-continent started in the pre-historic era in the floodplains of Indus Valley Civilization (around 3,000 B.C.). The city of Mohenjo-Daro can be considered as the first example of a designed water management system, exhibiting Green Infrastructure solutions at the city scale. In the ***Figure No: 3*** given below evolution of green infrastructure in India from 3000 B.C to 2017 have been mentioned.

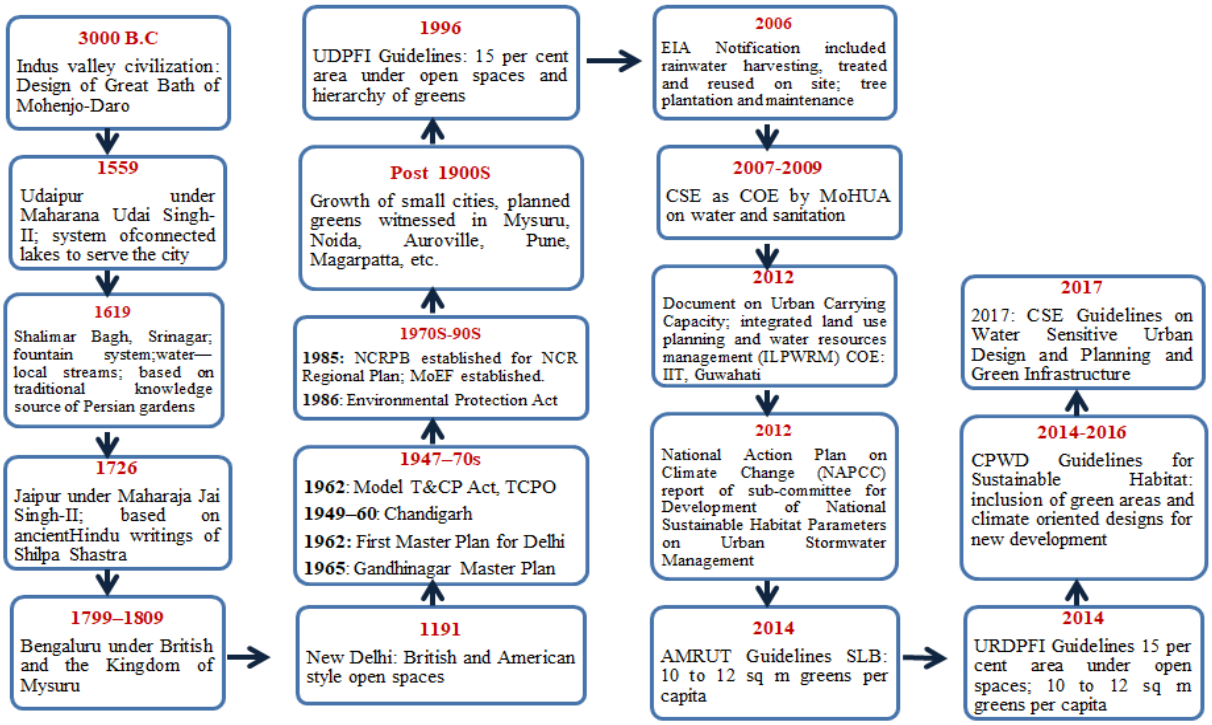


Figure No: 3 Green Infrastructure: It's evolution in India

1.2.1. Present Scenario in India

In an Indian context, it is still in a bare situation although a growing number of infrastructure companies have acknowledged issues affecting environmental degradation by adopting energy-efficient technologies. In fact many projects related to infrastructures are being completed taking under consideration of environment-friendly raw materials, and there is a growth in the number of infrastructure companies that are consulting environmentalists. They have started to work on research and development of green infrastructure including water and energy-related services in their designs. For example, one such company is Paharpur Business Centre & Software Technology Incubator Park (PBC) in Delhi that proves building sector – which takes up 40% of world's energy and 40% of world's natural resources at construction stage – can also go green. A 25-year old building built to government design, PBC is the first USGBC LEED Platinum certified retrofit green building in India, and also a certified Bureau of Energy Efficiency five-star building. PBC is retrofitted with various energy and water efficient technologies which have not only helped reduce its environmental footprint but also make energy and water savings thereby reducing operational costs considerably.

However, at large scale people in India are not aware of the benefits of green infrastructure at an economic and ecological level still they feel that implementing green infrastructure elements is costlier in comparison to a non-green or conventional building - which is not factual.

Considering another example is Green Spaces that supports the feasibility and commercial sustainability of green buildings. Projected to be world's greenest and most energy-efficient commercial building, Green Spaces will be an innovation-based project with concepts such as 100% waste and water reclamation, instrumentation and interconnection of all systems, recharging ports for electric cars, ventilated chairs, etc.

According to a comprehensive study conducted by The Energy and Resources Institute (TERI), Green Spaces' proposed design has already achieved 74.4% reduction in the Energy Performance Index (EPI) i.e. energy use per unit area for a green building. 41 million kWh of energy will be saved per year, approximately 36,000 tons of carbon dioxide emissions shall be avoided on the demand side, and even more from the generation of 1 MW from Photo Voltaic (PV) and electricity produced from waste.

It is because of all these aspects intertwined together, economists and social scientists feel sustainable infrastructure is smart conservation for the twenty-first century and therefore, also call it, smart / intelligent infrastructure.

1.2.2. Norms Followed currently in India

While considering the future impact of effecting eco-friendly infrastructural facilities, it becomes necessary to understand the existing practices. Presently, infrastructure projects (such as in Energy sector, Manufacturing and Processing, Mining and Mineral Processing, Transport, Water Management, Dams, Irrigation and Flood Protection, Waste Disposal, Environmentally Sensitive Areas etc.) in India are followed an Environmental Impact Assessment (EIA) report to obtain an approval from the Government of India (GoI). Likewise, the developmental projects have to acquire the Ministry of Environment and Forests' consent to initiate work.

Over the years, the EIA norms have been modified to help accelerate the approval process. However, authorities have failed to address the environmental concerns linked with

infrastructure development. Therefore, no notable steps have been undertaken to facilitate environmental support.

The Central government has been quick in dealing with the difficulties faced by most infrastructure companies while seeking approval for their projects. However, the environmental factors have been not taken under consideration while modifying the existing norms.

For urban green spaces, the planned recreational areas are provided on the basis of planning norms. These norms are as per the Master Plan for Delhi, 2021 and are accepted as a reference point in the URDPFI Guidelines. As per URDPFI Guidelines, 2014, open spaces can include the following three categories:

- Recreational space
- Organized green
- Other common open spaces (such as vacant lands or open spaces including floodplains, forest cover etc.) in plain areas.

Considering overall open spaces in an urban area, the Guidelines suggest the norm of 10-12 sq. m of open space per person. However, in hilly areas, the protected zones and ecological conservation areas shall be considered to be over and above this open space requirement. The hierarchy for organized greens such as parks plays fields and other open spaces are also included. In case of Haryana standard of 2.5 sqm/ per person of green spaces are provided.

CHAPTER- II

IMPORTANCE OF GREEN INFRASTRUCTURE

2.1. Green Infrastructure: Conceptual Framework

Green infrastructure refers to the inter linkage between manmade and natural elements in order to achieve healthy and sustainable living environment both for humans and surrounding ecosystem. It is important to give clear distinction to a green city from the following existing concepts, although partly overlapping:

1. ***Sustainable City:*** This concept is broader in scope and includes objectives of economic growth and social equity and justice as primary parameters alongside environmental performance. It is also more ambitious and applying a concrete methodology may be more challenging. The major components that make a city sustainable as shown in the ***Figure No: 4*** are: Public Transportation, Green Spaces, Green Buildings and Smart Cities.

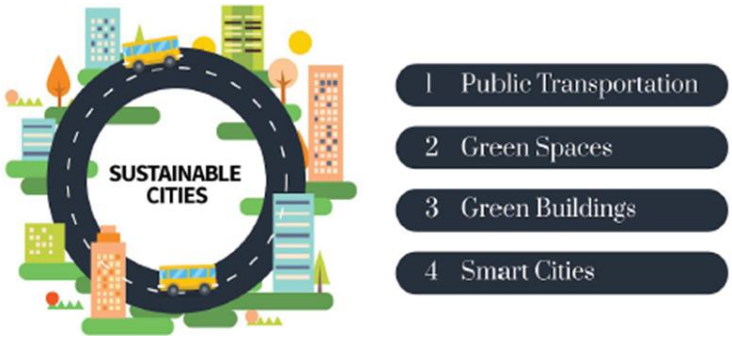


Figure No: 4 Core Components of the Sustainable Cities

2. ***Smart city*** (also known as or similar to other concepts such as "digital city", "intelligent city" or "knowledge-based city") this concept has often been used in different and inconsistent ways, resulting in some confusion about its added value. Major components of smart or intelligent city are shown in the ***Figure No: 5***. A common understanding, as articulated in recent studies of the OECD Green Cities Programme (Green Growth in Bandung, Indonesia, forthcoming), is that smart cities use Information and Communication Technologies (ICT),

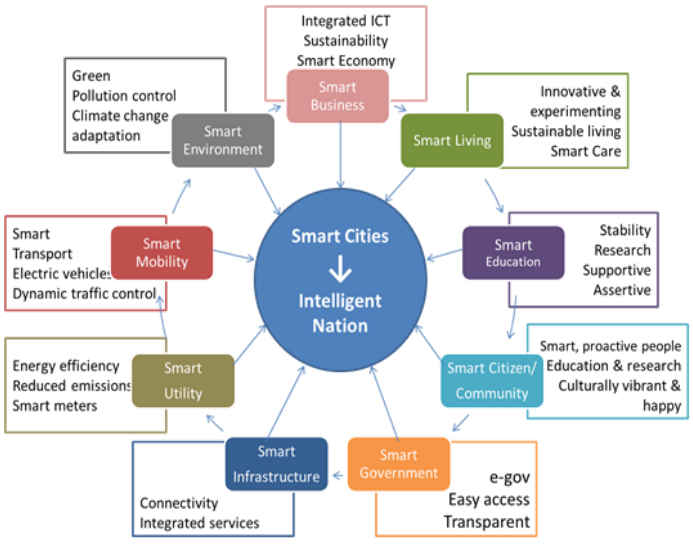


Figure No: 5 Core Components of the Smart Cities

or digital technologies, to make the critical infrastructure components and services of a city more interconnected and efficient. There are many applications and potential objectives of using such digital technologies, and not only to improve cities' environmental performance.

In other words, smart city tools can be a means to support green cities. Smart cities are required in order to manage the problems like global environment and urbanization, global warming and climate change, population increase and resource depletion and adverse effects of increasing urbanization (Hitachi, 2012). Further, the smart cities are aimed at addressing the need for a long-term approach to developing sustainable cities, managing the lifecycles of cities, improving economic performance over the entire lifecycle e.g. pollution, that are very expensive to clean up later and enhancing city competitiveness. [10]

3. ***Resilient city:*** The basic idea behind the concept is that resilient cities are prepared for and able to withstand shocks of different natures (environmental, economic, political, social etc.). Core components of the resilient city are green public spaces, urban agriculture, socially mixed housing, strategic leadership etc. as shown in the ***Figure No: 6.*** One of the most concrete aspects of this approach is resilience to natural disaster risks, which is a sub-set of the green city.

Figure No: 6 Core Components of the Resilient Cities

4. ***Green City:*** The basic idea behind the green city conceptual framework as shown in the ***Figure No:7*** is that it covers the entry points or distinctive aspects which are run by facilitators or enablers (such as Government authorities, NGO's, Public/private stakeholders etc.) to work on the thematic areas of the city in each domain such as:

[10] Dwivedi Manish (2015), "New Horizons in Planning Smart Cities using LiDAR Technology" al.https://www.researchgate.net/publication/283291632_New_Horizons_in_Planning_Smart_Cities_using_LiDAR_Technology

a. ***Green Transport:*** Green transport encompasses Sustainable transit, Sustainable streets, sustainable vehicles, Transit Oriented Development Principles, Multimodal integration etc. which has been discussed in the recommendation section further in the report.

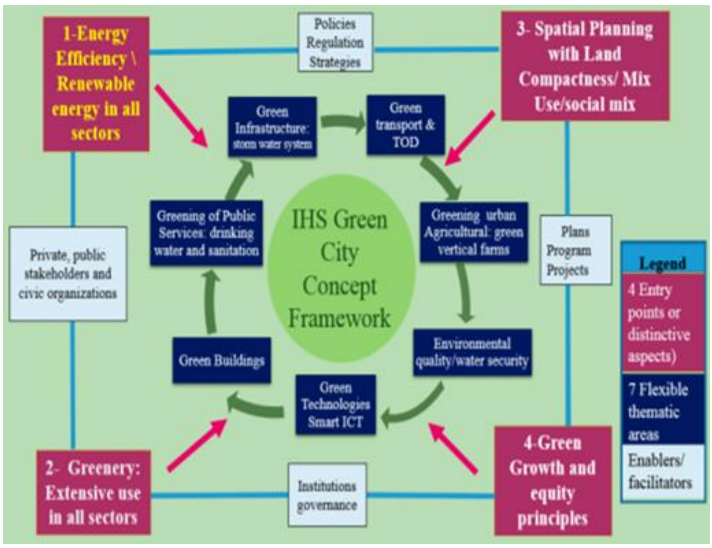


Figure No: 7 Green City Conceptual Framework

b. ***Green Ecosystem:*** It can be achieved through various growth measures to be taken at local, state and regional level and implementing it through biodiversity actions plans as discussed further.

c. ***Environmental Water Security:*** Includes the provision and operation of facilities to ensure that proper quantity and quality of water to be delivered to cities through following approaches of integrated water resource management system and promoting strategies of water conservation techniques are recommended further.

d. ***Green Buildings***: Recommended an intelligent approach to conserve energy and safeguarding water resources at household or building level may be taken as techniques to keep our environment green. Also at national and state level, specific green building codes may also be developed.

e. ***Green Growth in Public Services:*** Strategies are recommended in this report further that includes the provision of water supply, collection and treatment of waste water and faecal sludge. Looking at greener options for waste management in urban areas may reduce local impact and provide city a health environment.

2.1.1 Green Infrastructure Planning: Aim

- **Identify** the significant needs and opportunities (of a social, economic or environmental nature) in an area of search

- **Assess** if green infrastructure components (individually and collectively) meet these needs, now and into the future
- **Conserve** those components which are essential parts of the green infrastructure
- **Create** brand new components where they can best meet local needs or fill gaps in the existing green infrastructure network
- **Uplift** poorly-functioning green infrastructure to meet local needs or fill gaps
- **Target** policies, resources and interventions to conserve, connect and re-build a healthy green infrastructure[11].

2.1.2 Need for Green infrastructure

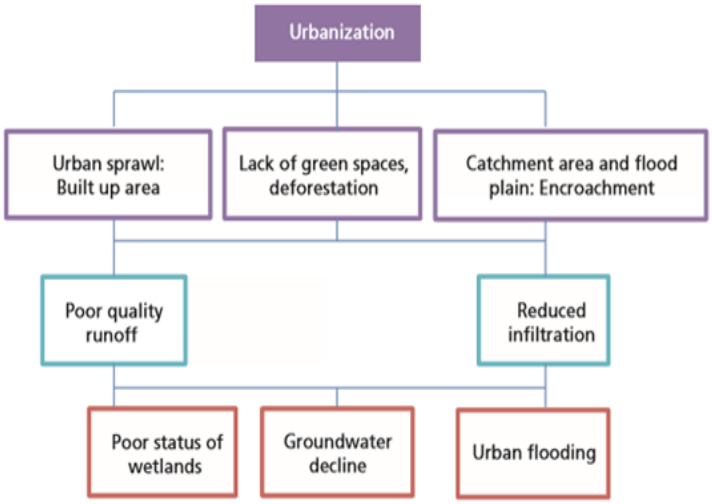


Figure No: 8 Need for Green Infrastructure

Over the past decades, growth has sprung beyond cities and older suburbs into many areas that were once rural. Increasing development and urbanization has converted farms and forests to other uses thus resulting in Urban sprawl, Deforestation, Encroached catchment area leading to poor quality runoff, poor status of wetland, decline in groundwater and urban flooding as shown in the ***Figure No: 8.*** Land consumption is accelerated at a faster rate ever than before leading to fragmentation of open land which is the primary challenge that our nation is facing. In various metropolitan areas, green spaces are disappearing rapidly. Rural communities are also affected by development, not only this but human modification of land has created fragmented development patterns that endanger native plant and wildlife communities and associated ecological functions and processes. Studies show that farming generates substantially higher revenue than the number of public services they require. Residential development has the opposite effect. Urban sprawl and the inefficient use of land and resources require communities to deliver services across a larger geographic area. Because developments and buildings are spread further apart, sprawl stretches municipal services, resulting in both ecological imbalance and higher taxes.

[11] (2008),"*North West Green Infrastructure Guide*", prepared by the North West green infrastructure think tank.

Green infrastructure is a provider of a number of ecological, economic and social benefits by considering spatial and planning policy through a systematic approach that supports the historical context of a space.[12] They propose spaces that have multi-functional benefits for a wide range of demographic groups and can be located in all areas of the urban–rural environment.

However, there are a number of fundamental principles that underpin a green infrastructure planning approach. Authors including *Benedict and McMahon* have promoted the ecological function of green infrastructure as a tool supporting conservation goals and highlight its role as a connective ecological element.

2.1.3 Green Infrastructure: Benchmarks

A Green City is a city which shows high environmental performance relative to established benchmarks in terms of:

- ***Quality of environmental assets*** (air, water, land/soil and biodiversity),
- ***Efficient use of resources*** (water, energy, land and materials) and
- ***Mitigating, and adapting to, risks deriving from climate change***, while maximizing the economic and social co-benefits and considering its context (population size, socio-economic structure and geographical and climate characteristics).

[12] Thwaites K., Porta S., Romice O. And Greaves M (2007),"Urban Sustainability through Environmental Design: Approaches to Time–People–Place Responsive Urban Spaces". Routledge, London.

CHAPTER-III

POTENTIAL OF GREEN INFRASTRUCTURE IN INDIAN CITIES

GI can be categorized into several systems with a set of functions under each of them. These systems operate at various hierarchies, from national-or regional-level to the household-level. However, they are broadly classified in two categories:

- Regional-scale
- City-scale

a) State and Regional Scale: Encompassing statewide and national conservation and open space planning. At regional level green infrastructure protects diverse ecological and social functions of high quality core landscapes and connect these areas to community scale open spaces as shown in the ***Figure No: 9.*** As per India's 2013 National Land Utilization Policy, the following 'land use management areas' are to be identified within existing 'land utilization zones' for proper management:

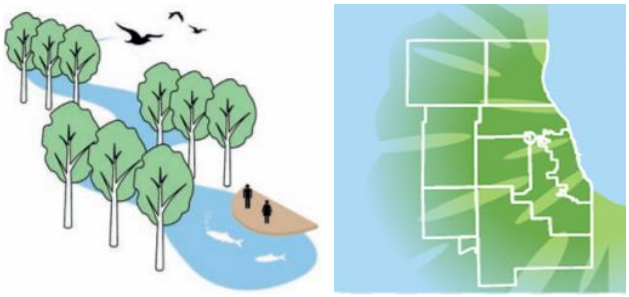


Figure No: 9 Regional and National Scale City-Region

i. **Protected Areas** *protected from all human activity except those clearly specified under law*. *Such areas include environmentally sensitive and fragile ecosystems* like national parks, forests, biosphere reserves; socially important areas like protected tribal settlements; and culturally important areas like historic sites and monuments. Any change in their status has to be mandated by an appropriate law or ruling.

ii. **Regulated Areas** *In regulated areas all human activities except those specifically prohibited under law can be carried out.* Such areas may include prime agricultural lands, rural settlements, sensitive ecosystems, regions rich in natural resources (other than those covered under protected areas), regions demarcated for landscape conservation and tourism, cultural and heritage sites, and hazard prone zones. Land use of these areas should preferably not be altered. In case any alteration is necessitated, such changes should be governed by a set of rules, regulations and procedures. For example,

construction activities should not be carried out in prime agriculture lands, unless backed by a new law or ruling.

iii. **Reserved Areas** *Human activity is permitted in the reserved areas, but should be carried out with caution and only when no other option is available.* These are areas which should ideally be protected but are under pressure from the needs of development. Such areas may include regions close to human settlement like green belts and recreational areas.

b) ***City and Community-Scale:*** Supporting local conservation and restoration efforts including parks, recreation and other open space projects. At city and community scale green infrastructure will provide multiple health benefits to the people as shown in the ***Figure No: 10.***

i. ***City Park and District Park:*** It is a designated term as per the hierarchy of green spaces in a city. A district park is a prominent recreation space and is developed to provide vital lungs for the city air shed.

ii. ***Community Park:*** It is developed at the community level and acts as a link between the neighborhood and city-level green areas. It is generally centrally located in settlements and has direct links with other natural systems.

iii. ***Multi-Purpose Ground:*** It is provided at the city, district and community level. It is generally meant for active and passive recreation and other community activities.

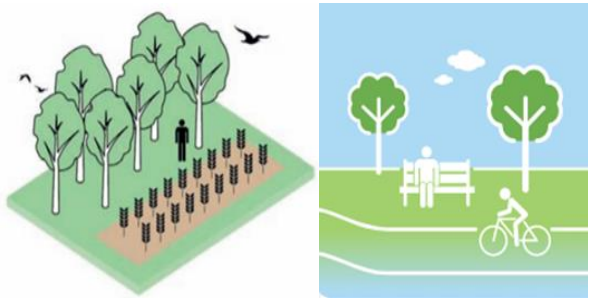


Figure No:10 Town, City and Zone Scale

iv. ***Neighborhood and Housing Area Park:*** It is developed at the neighborhood level for a population of 10,000. The park is conveniently located within the developed residential areas at walking distance from all the households.

v. ***Playground:*** It is normally provided in educational institutions and neighborhoods. It is specifically meant for active recreational activities.

vi. ***Tot lot:*** The lowest level in the hierarchy of green areas, it is located in residential premises and is specifically meant for recreational activities of children.

vii. Green Belt (buffer): Includes spaces like a green girdle, park belt, rural belt, rural zone, agriculture belt, country belt, and agriculture green belt. A green belt is defined as an area of land predominantly agricultural in character and located around the proposed urbanisable limits of the urban center.

viii. Green Strip: It is developed on vacant land, for example, land under high tension power supply lines. It is also developed along the arterial roads separating residential areas from other areas.

3.1. Guiding Principles of Green Infrastructure

Taken together, following six guiding principles provide a strategic approach and framework for conservation that can advance the sustainable use of land while providing an interconnected system of green spaces that benefit people, wildlife and the economy. They are intended to help in designing, planning, acquisition and other decision-making guidance for community-based sustainable development. It is our hope that planners, developers, landowners, state and local officials, and others will use these principles as benchmarks or standards for integrating a green infrastructure approach into existing and future plans and policies in land conservation and land development projects.

PRINCIPLE 1: Green infrastructure should be the framework for conservation and development.

Over the years our national conservation policies for land have focused on the protection of individual parks, preserves, or other isolated areas that have natural or cultural importance. Green infrastructure framework for conservation helps communities to plan interconnected green space systems. Also, it restores already existed isolated islands of nature and supports them identify opportunities to protect the vital ecological connections that are necessary for the survival of those protected areas.

Green infrastructure strategies also help planners and developers to minimize the harmful impacts on ecosystem functions and services due to rapid growth. For example, the loss of wildlife habitat and migration corridors and the loss of riparian and other natural areas that absorb nutrients, recharge ground and surface water supplies, slow and absorb storm water runoff, and replenish soils. Green infrastructure ensures existing open space and working lands

that are seen as part of the community's essentials assets and not left at risk to development pressures that would leave green infrastructure fragmented.

PRINCIPLE 2: Design and plan green infrastructure before development- It is essential to identify and protect critical ecological sites and linkages before the planning and construction of roads, buildings, and other developments. Therefore, green infrastructure provides the ecological framework for the sustainable use of land.

PRINCIPLE 3: Linkage is the key- The main function of all green infrastructure initiatives is the creation of a green space network that works as an ecological whole, not as unrelated parts. The planned connection between different system components — parks, preserves, riparian areas, wetlands, and other green spaces — is critical to maintaining vital ecological processes and services (e.g., carrying and filtering storm water runoff, storing and cleaning fresh water, cleaning urban air) and to maintain the health and biodiversity of wildlife populations. Also, it requires linkages to be made among different agencies, on-government organizations, and other private agencies. Linking or integrating green infrastructure with programs that focus on growth and development will support state and community efforts to protect the land.

PRINCIPLE 4: Green infrastructure functions across multiple jurisdictions and at different scales- Green infrastructure needs to be design strategically to connect across urban, suburban, rural and landscapes, incorporate green space elements and functions at state, regional, community scale. For example, Toronto's "Greening the Portlands" project in Ontario, Canada focuses on major parks, minor parks, wide corridors, narrow corridors, and development parcel landscapes.

PRINCIPLE 5: Green infrastructure is grounded in sound science and land use planning theories and practices- Various theories and practices of land planning related professions-including conservation biology, landscape ecology, urban and regional planning, landscape architecture, geography, and civil engineering — all contribute to the successful design and planning of green infrastructure systems. Scientists, land use planners and engineers have come to recognize that networks of linked natural areas and habitats managed for biodiversity purposes also can protect urban and rural areas from natural disasters, can improve the health of the human community and can provide recreation options and other public amenities.

PRINCIPLE 6: Green infrastructure is a critical public investment-

Green infrastructure creates interconnected green space systems benefits communities by providing land for resource protection and restoration, recreation and other public values. It reduces a community's vulnerability to risk of floods, fires, and other natural disasters. Identifying the public benefits of green infrastructure is an important first step in providing sufficient funding. For all of these reasons, green infrastructure is an appropriate and necessary use of public funds.

3.2. Green Infrastructure: Examples

1. Rain Gardens

Rain gardens share a common purpose. They absorb rainwater and allow it to percolate rather than putting stress on our storm water systems and also filter contaminants. They remove sedimentation and debris from Storm water run-off to improve water quality reduces or eliminates flooding, improve the efficiency of storm water systems and create natural habitats as shown in ***Figure No: 11.*** It is a natural, sustainable solution for dealing with boggy areas, flooding and landscape damage.

Figure No: 11 Rain Gardens

2. Green Roofs

Vegetative rooftops, commonly called green roofs, can reduce energy consumption and reduce storm water runoff. Green roofs as shown in ***Figure No: 12*** can extend a roof's lifespan by two to three times. Also, green roofs reduce pollution and offset the urban heat effect.

Figure No: 12 Green Roofs

3. Permeable Paver Parking Lots

Asphalt and pavement parking lots are hotbeds impact the surrounding environment. Permeable paver parking as shown in ***Figure No: 13*** lots are an alternative to asphalt and pavement as these permeable surfaces absorb water run-off, reduce

Figure No: 13 Permeable Paver Parking Lots

the stress on storm water systems and decrease or eliminate flooding. It stay surface cooler and affect the natural surroundings.

4. Urban Tree Canopies

Urban tree canopies as shown in ***Figure No: 14*** helps in improving the environment of the city. Cities like Louisville and Lexington, Kentucky are some examples of increasing use of urban tree canopy.[13]

Figure No: 14 Urban Tree Canopies

5. Storm water Green streets

Storm water Green streets as shown in ***Figure No: 15*** are designed to collect and manage storm water that overflows the streets and sidewalks. However, Storm water Green streets are typically constructed on the roadway, are usually larger, and have varying lengths, widths and soil depths based on the characteristics of the existing roadway.

Figure No: 15 Storm water Green Street

6. Blue Roofs

Blue roofs as shown in ***Figure No: 16*** are designed without vegetation for the primary purpose of detaining storm water. Weirs at the roof drain inlets create temporary ponding and gradual release of storm water.

Figure No: 16 Blue Roof

7. Subsurface Detention Systems

For temporary storage of storm water runoff provision of underground Subsurface Detention Systems with infiltration capability. It has an open-bottom and can incorporate perforated pipe and storm water chambers for additional detention volume. It is primarily designed with a gravel bed that stores water until it can infiltrate into the ground.

Figure No: 17 Subsurface Detention Systems

[13] Roscoe Klausing (2016),"What Is Green Infrastructure? A Definition and Examples of How It Can Work on Your Commercial Kentucky Property" retrieved from https://www.klausinggroup.com/blog/what-is-green-infrastructure.

8. Cisterns and Rain Barrels

Cisterns and rain barrels as shown in ***Figure No: 18*** are watertight receptacles designed to catch and store storm water off of roofs or other impervious surfaces and are located underground, at ground level, or on an elevated stand. Rain barrels are connected to the existing downspout of a roof and reuse the storm water for watering plants and other landscaping uses.

Figure No: 18 Cisterns and Rain Barrels

CHAPTER-IV

THE ROLE OF THE GOVERNMENT

Government plays an important role in the execution of every type of project, possibly at different levels, in managing the project. It will also have a role in monitoring and implementation:

i. ***Role of Central Government***

Central government plays an important role in the initiation and implementation of the project. Such as in order to achieve green growth has launched different schemes such as JNNURM Mission, AMRUT Mission etc. Some of the works undertaken at Central level are given below:

a) Definition of the Smart City Framework
b) Devise Smart City Tool Kit
c) Define funding structure in partnership with State and Local governments
d) Provide training to ULBs on the components of Smart City
e) Formulate a procurement process
f) Launch the Smart City Scheme
g) Establish a PMU at the Central Government level for enabling approval processes for enabling funding.

ii. ***Role of the State Government***

State government plays a vital role, such as in case of Haryana Town & Country Planning Department prepares the development plans for the controlled areas declared around the municipal towns and in areas having potential for urban development. The regional and development plans mainly prepared according to the URDPFI guidelines wherein standards for green spaces are prescribed. Development plans prescribes landuses including those of regional, recreational Centres, town parks, city forests, urban gardens etc. In the layout plans provision of Green Spaces is 2.5 sqm/per person. Some of the works undertaken at State level are given below:

a) Adaptation of the definition of the Smart City Framework to State and specific Cities at State level
b) Adapt Smart City Tool Kit to the Town & Country Planning Acts

c) Define funding structure in partnership with Central and Local governments
d) Provide training along with Central Government to ULBs on the components of Smart City
e) Adapt the procurement process within land laws at State Level: at three stages of the project: Planning, Implementation and Management
f) Launch the Smart City Scheme for select cities
g) Establish a State Level Nodal Agency for enabling approval processes for enabling funding.

iii. ***Role of the Local Government***

Local government also plays a vital role for example, Haryana Shahari Vikas Pradhikaran, HSIIDC, Haryana State Agricultural Marketing Board, Private Developers etc. undertakes the development of the local areas, residential areas, industrial areas and commercial areas as provided in the development plans. Some of the works undertaken at Local level are given below:

a) Adaptation of the definition of the Smart City Framework to specific/ selected Cities
b) Define funding structure in partnership with Central and State governments
c) Adapt Smart City Tool Kit to select administrative/ electoral wards in the ULB planning area.
d) Deploy staff for training from selected ULBs on the components of Smart City.
e) Launch the Smart City Scheme for select cities.
f) Refine the RFP and launch the procurement process within land laws at State Level
g) Establish a consultative process with multiple stakeholders.
h) Establish the process with the SLNA and PMU at the Central Government level for enabling approval processes for enabling funding.[14]

iv. ***Role of Multi stakeholders***

Multi-stakeholders play an important role in designing and implementing the project, as it is required for a more efficient interaction and better accepted projects. Some of the involvements of multi-stakeholders in designing and implementing the projects are shown in the ***Figure No: 19.***

a) Conduct information and background surveys to identify project need.

[14] July (2014)"Shaping Sustainable Smart Cities in India", Aligning Planning to Outcomes, EGIS.

b) The major components of the project are collection of data and other relevant norms and standards, proposals and preparation of the detailed project report, implementation of funding and operation and maintenance can only be efficiently carried out in line with different government departments.

c) Communication campaigns and advocacy.

d) Evaluation of project and monitoring activities.

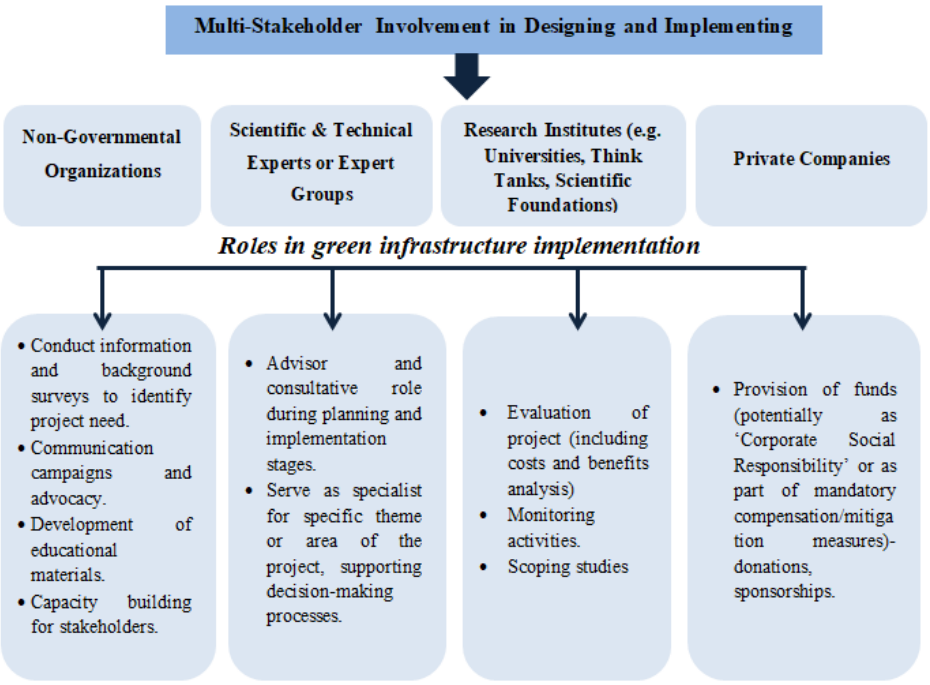


Figure No: 19 Role of Government in G.I Implementation

CHAPTER-V

GREEN INFRASTRUCTURE: FUNCTIONS AND BENEFITS

Green infrastructure systems help in protecting and restoring naturally functioning ecosystems and provide an outline for future development. It benefits by providing a uniformity of ecological, social and economic functions altogether through:-

- Increased recreational opportunities
- Improved health
- Enhanced connection to nature and feel
- Increase property values and decrease the costs of public infrastructure and public services, including the costs for storm water management and water treatment systems[15].

i. Environmental benefits

a) Provision of clean water.
b) Removal of pollutants from air and water.
c) Pollination enhancement.
d) Protection against soil erosion retention of the rainwater.
e) Improvement of land quality by increased pest control.
f) Mitigation of land take and soil sealing

ii. Economic benefits

a) Can reduce hard infrastructure construction costs.
b) Maintain ageing infrastructure.
c) Create jobs, business opportunities.
d) Increase property values.
e) Encourage economic development.
f) Reduce energy consumption and costs.

iii. Social benefits

a) Better health and human well-being.
b) Diversification of the local economy by the creation of jobs.
c) More attractive, greener cities.

[15] Mark A. Benedict, Edward T. McMahon, Mark A, *"Green infrastructure: Smart conservation for the 21st century".*

d) Higher property values and local distinctiveness.

e) More integrated transport and energy solutions.

f) Enhanced tourism and recreation opportunities

iv. Climate change adaptation and mitigation benefits

a) Flood alleviation.

b) Strengthening ecosystems resilience.

c) Carbon storage and sequestration.

d) Mitigation of urban heat island effects.

e) Disaster prevention (e.g. storms, forest fires, landslides)

v. Biodiversity benefits

a) Improved habitats for wildlife.

b) Ecological corridors.

c) Landscape permeability[16]

[16] Building a Green for Europe retrieved from http://ec.europa.eu/environment/nature/ecosystems/docs /green _infrastructurebroc.pdf, European Union (2013)

CHAPTER-VI
CASE STUDIES

6.1 International Context

In practice, green infrastructures are being used in the UK, Europe and North America to fulfill a number of urban and ecological policies (e.g. smart growth or sustainable communities). In contrast, research from the USA shows that green infrastructure is being developed to conserve and protect landscapes from over development and further landscape degradation.[17] In Maryland, county-level programmes have been developed to promote a number of exemplar conservation and landscape assessments projects highlighting the sustainable benefits of green infrastructure.[18]

a. **Kinston/Lenoir County, North Carolina** *(Green Infrastructure Plan Linking Hazard Mitigation to Community Conservation and Recreation Objectives)*

Developed by graduate students at the University of North Carolina, the Kinston/ Lenoir County Green Infrastructure Plan for the Neuse River Floodplain seeks to identify opportunities to maintain, restore, and provide new green infrastructure along the Neuse River floodplain and adjacent areas in Lenoir County and the city of Kinston. The area suffered considerable damage from flooding caused by Hurricanes Fran and Floyd. The local governments have used Federal Emergency Management Agency (FEMA) disaster relief funds to purchase many damaged properties lying in the floodplain. The plan uses green infrastructure planning principles and complements existing community projects and goals such as the Kinston-Lenoir County Parks and Recreation Master Plan and the Greater Kinston Urban Area Growth Plan. The components of the Green Infrastructure Plan present ideas for how the Neuse River and its floodplain can provide Lenoir County and Kinston with additional

Figure No: 20 Location map of Lenoir in North Carolina

[17] Heritage Conservancy, Growing with Green Infrastructure, HC, Doylestown, PA (2003), See www.heritageconservancy.org for further details. Accessed 15/11/2018.

[18] Weber T., Sloan A. And Wolf J, (2006) *"Maryland's green infrastructure assessment: development of a comprehensive approach to land conservation",* Landscape and Urban Planning.

recreational and environmental amenities. The governments can use the plan as a way to continue their flood mitigation work by turning vacant buyout areas into a network of parks, trails and habitats along the Neuse River and the Adkin Branch stream that connects downtown Kinston and others areas in the community.[19]

b. **Portland, Oregon** *(Metropolitan Green spaces Program Natural Resource Conservation in Urban Environments)*

In the late 1980's, a group of representatives from the metropolitan regional government (Metro), non-profit organizations, local governments and citizens formed to collaborate on green space protection in the region around Portland, Oregon and Vancouver, Washington. As a result of their efforts, Federal funding was allocated to establish a formal partnership between the U.S. Fish and Wildlife Service and Metro to initiate the Metropolitan Green spaces Program. The program focuses on environmental education, habitat restoration, public outreach and regional planning throughout the bi-state, four county metropolitan areas. This partnership serves as one of only two national demonstration programs involving the Fish and Wildlife Service as a partner in local natural resource conservation efforts in urban environments. Initially, the Metropolitan Green spaces Program supported natural area inventories and mapping to develop a strategic conservation plan for the Metropolitan region. In 1995, voters approved a $135.6 million bond measure to implement the plan by publicly acquiring an extensive network of trails and green spaces. Continued program funding of $300,000 annually has supported three grant programs and enabled the Fish and Wildlife Service to participate in regional planning and policy development efforts. Under the auspices of the program, a variety of integrated regulatory and non-regulatory tools are being used to protect green spaces, water quality, floodplains, and fish and wildlife habitat.[20]

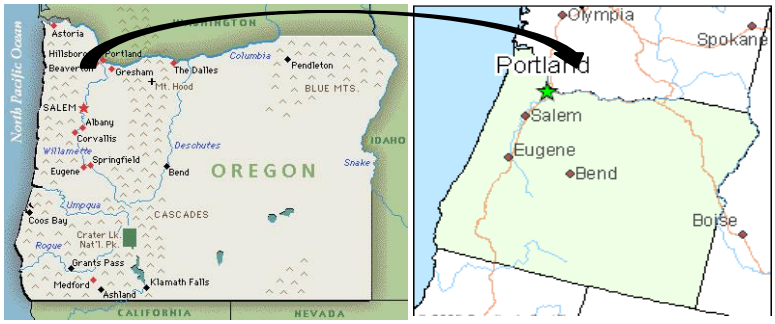


Figure No: 21 Location map of Portland in Oregon

[19]Retrieved from www.greeninfrastructure.net/kinston-lenoir.htm
[20] Retrieved from http://oregonfwo.fws.gov/greenspaces/gs-program.htm

c) Tallinn, Finland

Tallinn as shown in ***Figure No: 22*** is located in Estonia in Europe, Tallinn is the capital and most populous city of Estonia. Located in the northern part of the country, on the shore of the Gulf of Finland of the Baltic Sea, it has a population of 434,562. Tallinn is a major financial, industrial, cultural, educational and research Centre of Estonia. In Tallin different Strategies has been opted in order to achieve green growth in the city as given below in the ***Table No: 1.***

Figure No: 22 Location map of Tallinn in Europe

Table No:1 Strategies and outputs to Achieve a Green Growth

S. No	Aspect		Strategies
1.	Local Transport	Free Public Transport	• The number of ***passengers increased by 6% in 2013***, as compared to in 2012. • ***Quality of the service in the city has been improved*** due to the increase in the number of residents and the income tax received in the city budget. • The number of train rides in the city increased 2.3 times in 2014, in comparison to 2012. • Tallinn seeks to make public transport more convenient, as high connection speed makes public transport a reliable and punctual way to get around the city.
2.	Nature and Biodiversity	Mapping For Species And Habitats	• Tallinn has a particularly strong planning process for biodiversity, starting with good mapping based on survey work for species and habitats, and backed by bio-data inventories and research. • A set of policies, linked through these different scales of planning, leads to a good variety of implementation measures and projects.
3.	Waste Production and Management	Waste Management Centre	• Firstly, it makes it possible to ***provide a single waste collection service throughout the city*** – there are no big differences in prices or the quality of customer service across regions. • Secondly, it creates the possibility to ***cross-subsidies the price of the waste collect***ion service by type of waste, e***.g. establishing higher charges for emptying***

			mixed municipal waste bins and lower charges for separately collected waste, or emptying bins of recovery waste free of charge. • Thirdly, ***overseeing the process is easier for the City*** – it has current and immediate information about waste collection. The number of contracts increased by a remarkable 11.5% in the first 10 months. • Fourthly, it is possible for the ***City to provide several additional services*** (e.g. flexible transport of bulky waste, including leaves and Christmas trees, bin washing), which has directly helped to improve the waste management service and thereby boosted the willingness of people to collect waste separately. • In addition to the increase in the number of people that have joined the organized waste collection system, its implementation has also helped to create better opportunities for the separate collection of waste, and the volume of separately collected waste has increased.
4.	Water Management	Promotion of Tap Water	• The main emphasis, 10 years ago, was on water saving. After the success of dedicated campaigns, the emphasis has now shifted to promoting the drinking of tap water. • As a result of poor quality tap water in the 1990s, bottled water has become increasingly popular. • The quality of tap water in Tallinn has been very high for years, yet bottled-water drinking continues to be popular. • The ***website www.jookraanivett.eu was created*** to promote tap water drinking; site provides ***information*** about the ***benefits of drinking tap water, saving tap water and the campaigns*** that will be organized. • ***Many restaurants*** in Tallinn have joined the initiative Tap Water Is Drinking Water and are happy to offer free tap water to customers.
5.	Energy Performance	Fix The Facade	• Since 2010, Tallinn has been ***implementing the Fix the Facades project***, with a view to make their buildings more energy efficient (***insulation of facades and roofs, replacement of doors and windows, replacement or reconstruction of heating and ventilation systems).***

d) Umea, Sweden (Green Parking Payoff)

Umea is the thirteenth biggest in Sweden as shown in ***Figure No: 23***, with 84,761 inhabitants in 2016. In the Green Parking Payoff project, there is provision of sustainable mobility services in exchange for lower parking requirements. There is provision of services such as Provision of bicycle facilities including service stations and dressing rooms, facilitation for carpooling and allocation of resources to a mobility management fund. Some of the techniques and sustainable strategies have been given below in the ***Table No: 2.***

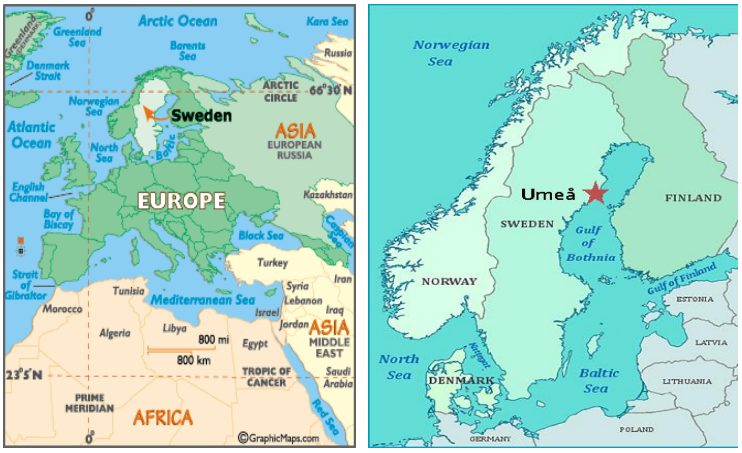


Figure No: 23 Location map of Umea in Europe

Table No:2 Sustainable Strategies and Techniques

Aspect	Issues	Sustainable strategies	Techniques
Local Transport	• Traffic congestion in the urban areas. • Negative impact on citizen's health.	Developing cleaner / greener towns and cities	• Developing and implementing new and clean technologies (energy efficiency, alternative fuels) • Redefining green zones (developing a pedestrian zone within towns and cities, restricting access zones)
		Smarter Urban Transport	• Smart charging systems • Better traveller information • ITS application in towns and cities.
		Accessible Urban Transport	• Seamless and accessible collective transport and safe infrastructure for walking, cycling and private vehicle use.
		Safe and Secure Urban Transport	• Possible solutions must cover behavioral, vehicle and infrastructure aspects. • Strict enforcement of traffic rules. • Sustainable urban mobility is primarily about people, with a significant emphasis on citizen and

	stakeholder engagement, as well as fostering changes in mobility behaviour

6.2 Indian Context

It is widely acknowledged that Green Infrastructure is the primary mechanism for delivering ecosystem services in the Indian towns and cities. Despite this evidence base, there is still considerable uncertainty about the best way to design, deliver and maintain Green Infrastructure. So, in order to have strategies for Green Growth in an Indian context, case study of Agartala, Tripura have been discussed below.

a) Agartala City, West Tripura

Agartala, as shown in ***Figure No: 24*** is the capital and the most populous city of Tripura, is one of the most important and progressive city not only in Tripura but also in the entire North East. The city is home to almost 4 Lakh people within the city limits. The city represents administrative cities as well as very fast growing urban agglomerations. The decadal population growth of Agartala city in 2011 was more than 110%, which is well above the national average of 17.64%.

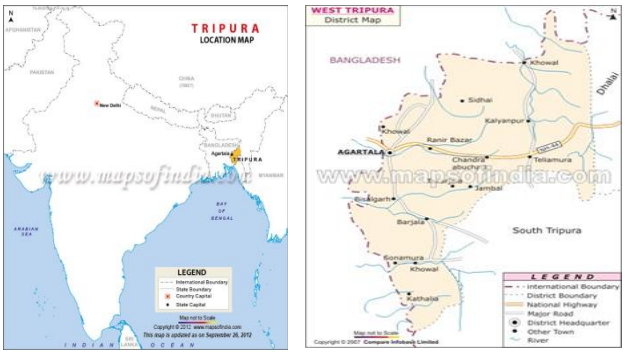


Figure No: 24 Location Map of Tripura in India

Table No:3 Main Features Of The City

City	Agartala
District	West Tripura
Area of city	62 sq.km
Population	3.99 lakhs (2011 census)
Literacy	93.88% (2011 Census)
Climate	Tropical monsoon
Economy	• State Capital • Trade city • Administrative city • Tourism sector

The population growth in 2001 and 1991 was around 20% and 19% respectively. In the last decade the city experienced a high decadal population growth rate mainly due to its trade growth and accompanying opportunities. Recommended Strategies to achieve a Green Growth v ision in the Agartala city has been given below in the ***Table No: 4.***

Table No: 4 Recommended Strategies to Achieve a Green Growth Vision

Aspects	Issues/problems	Strategies
Growth pattern and land management	• Severe congestion in the core area specially the old municipality area with high density of population. • Unplanned growth of the city without any land use controls. • Lack of development controls especially in the flood prone and low lying areas.	• Introduction of appropriate land Management Practices. • Zoning that allows mixed use development so as to reduce home-work distance • GIS-based mapping of land use and develops a Master Plan based on the surrounding ecosystem
Transportation	• High Congestion • Inadequate Public Transport • Absence of NMT • Inadequate parking • Encroachments by vehicles • Lack of pedestrian facilities • Improper traffic management	• Master Plan should lay special focus on TOD development with integration of land use and transport and optimal land utilization based on the principles of compact development • introduction of a public transport system integrated with the IPT, Smart Multi-Level Car Parking • Promoting Safe Pedestrian Movement. • Road & Junction improvements • Identification of designated parking areas • Develop traffic management system.
Water supply	• Non utilization of optimum capacity of the water treatment plant; • Underproduction from ground water; • High iron content in ground water. • High operation and maintenance cost. • High amount of unaccounted for water (UFW), presently about 35% of production • Severely deteriorated distribution system, particularly in the older parts of the city.	• An integrated water resource management approach like runoff through rainwater harvesting and reuse and recycling of wastewater. • Efficiency in Operation and Maintenance- Replacement of old machinery and network systems • Capacity building of staff.
Sewerage and Sanitation System	• Absence of sewerage system, • Direct disposal of sewage	• DEWATS can thus be encouraged especially in the peri-urban areas of the city.

	and effluent into drains and open spaces, • Open defecation widespread. • Lack of enclosed bathing spaces in the slums and low income areas.	• Provision of underground sewerage system • Provision of household sewer connection • Provision of public toilets to prevent open defecation.
Energy Efficiency	• City level data for energy consumption in various sectors is not available. • The existing central energy monitoring system of Agartala does not cover all of its facilities and buildings.	• Application of intelligent lighting concepts and introduction of solar master plan targeting 10% reduction in conventional energy through the implementation of a combination of renewable energy and energy efficiency measures.
Solid Waste Management	• Waste collection limited to selected area. • Inefficient waste collection and transportation. • No segregation of waste at source. • Lack of awareness on hygiene practices.	• Initiate house to house waste collection with source segregation; • Provide mechanized storage bins; • Regular maintenance of the container bins; • SWM coverage areas to be increased • Adopt segregation of biomedical waste with MSW. • Refuse vehicles shall be covered to reduce waste spillage during transportation. • Provide bio-gas compost plant
Drainage	• Absence of proper drainage system. • Most of the drains unlined and choked with silt and solid waste. • Water logging and flooding common during rainy season.	• Construction of lined drains along roads. • Construction of embankments along the rivers.
Natural Ecosystem and Biodiversity	• Increase in population causes need for more open spaces, parks, trees and water bodies in the city.	• Restoration of water bodies. • Rare/endangered tree/plant species have to be identified that need to be taken up for conservation or special protection.

b) Haryana, India

Haryana as shown in ***Figure No: 25*** with a population of 25 million (Census 2011), living in 23 districts is spread over a geographical area of approx. 44,000 $km^{2.}$ It is one of the fastest growing

economic sub-regions in India. Haryana has traditionally been the agriculture dominated small state with its location advantage.

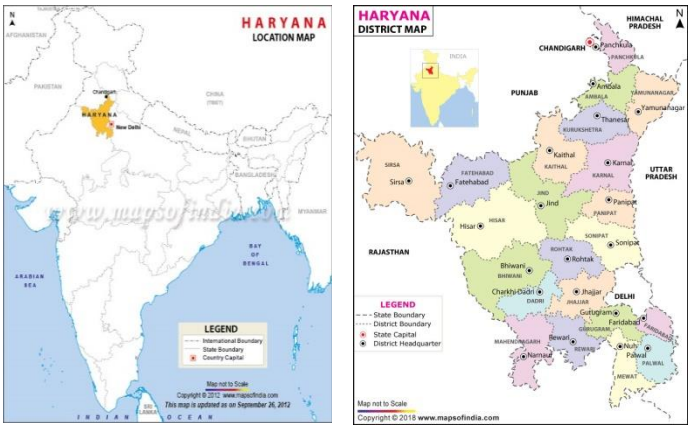


Figure No: 25 Location map of Haryana in India

Table No:5 Main Features of Haryana	
Population	25 million
Urban population	8,842,103
Rural Population	25,351,462
Number of Towns with Development/Draft Development Plans	73
Population Growth	19.90%
Area km^2	44,212
Density	573

Development plans provides for about 10-15% of urbanisable area in the form of parks, open spaces and green belts. Major town has a town park of around 20 acres. Development plans of the cities such as Faridabad-Balabgarh complex, Gurugram, Sonipat, Panipat, Kurukshetra, Ambala, and Panchkula provides for town parks, golf grounds and regional/recreational centers etc. in the form of green infrastructure in the Haryana.

Also there are Eco-Sensitive Zones in Haryana which encompasses around 2 National Parks (Sultanpur and Kalesar National Park) and 8 Wildlife Sanctuaries (Kalesar, Khol Hi Raitan, Bir Shikargarh, Nahar, Chhilchhila, Abubshaher, Bhindawas and Khaparwas Wildlife Sanctuary). The eco-sensitive zones extend Upto 1km to 5km from the boundary specified Protected Areas in ESZ notifications.[21]

Gurugram with 2.5 million populations, the Township has seen India's third largest jump in per capita incomes, and contributes to 48 per cent of Haryana's revenues. According to the National Capital Region Plan 2021, it is mandated for the NCR towns to reserve 2-5 per cent of land area for water bodies – natural or constructed. The key water bodies in Gurugram including Basai, Sukhrali, Faizalpur Jharsa, and Samasthpur and johads such as the Sikanderpur pond, Badshahpur johad etc. need conservation, rejuvenation and augmentation.

[21] http://haryanaforest.gov.in/Portals/0/overview_1.PDF

For Example: Ghata Jheel has been converted into township and some other natural drains in Gurugram have been closed and diverted leading to flooding of the area. So, State government should avoid urbanizing the water bodies in order to mitigate the natural disasters such as flooding and should also impart awareness among people for conserving the water.

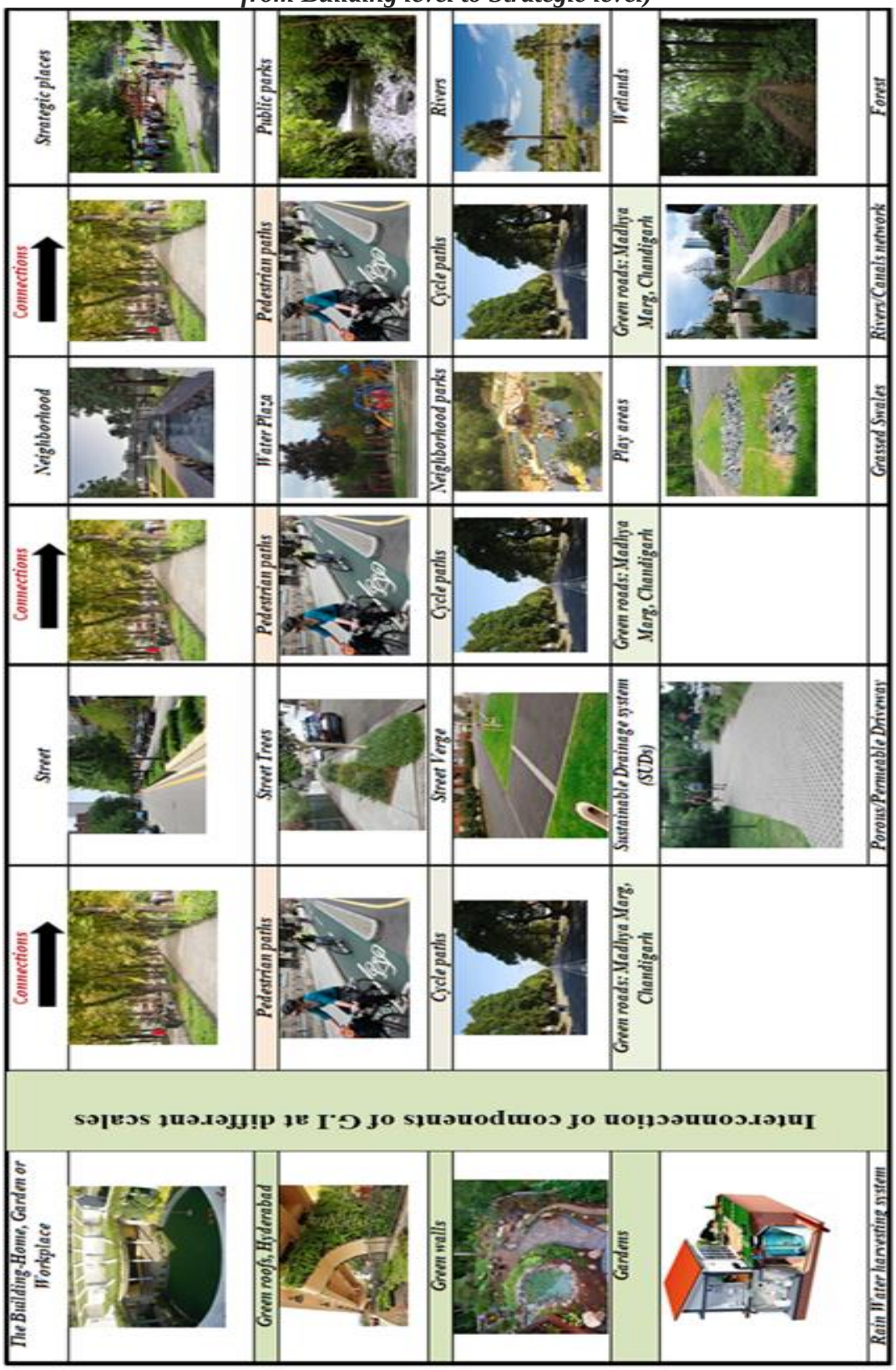
CHAPTER-VII
RECOMMENDATIONS

Green Infrastructure or **blue-green infrastructure** is a web providing the "ingredients" for solving urban and climatic challenges by building with nature. Green Infrastructure is not about green spaces or open spaces, but it includes blue infrastructure that is sustainable urban drainage, swales, wetlands, rivers and canals banks and other water courses. Green infrastructure refers to the integration of different elements in order to achieve the sustainable environment, quality of life and economic growth as shown in ***Figure No: 26***.

Figure No:26 Green Infrastructure Development

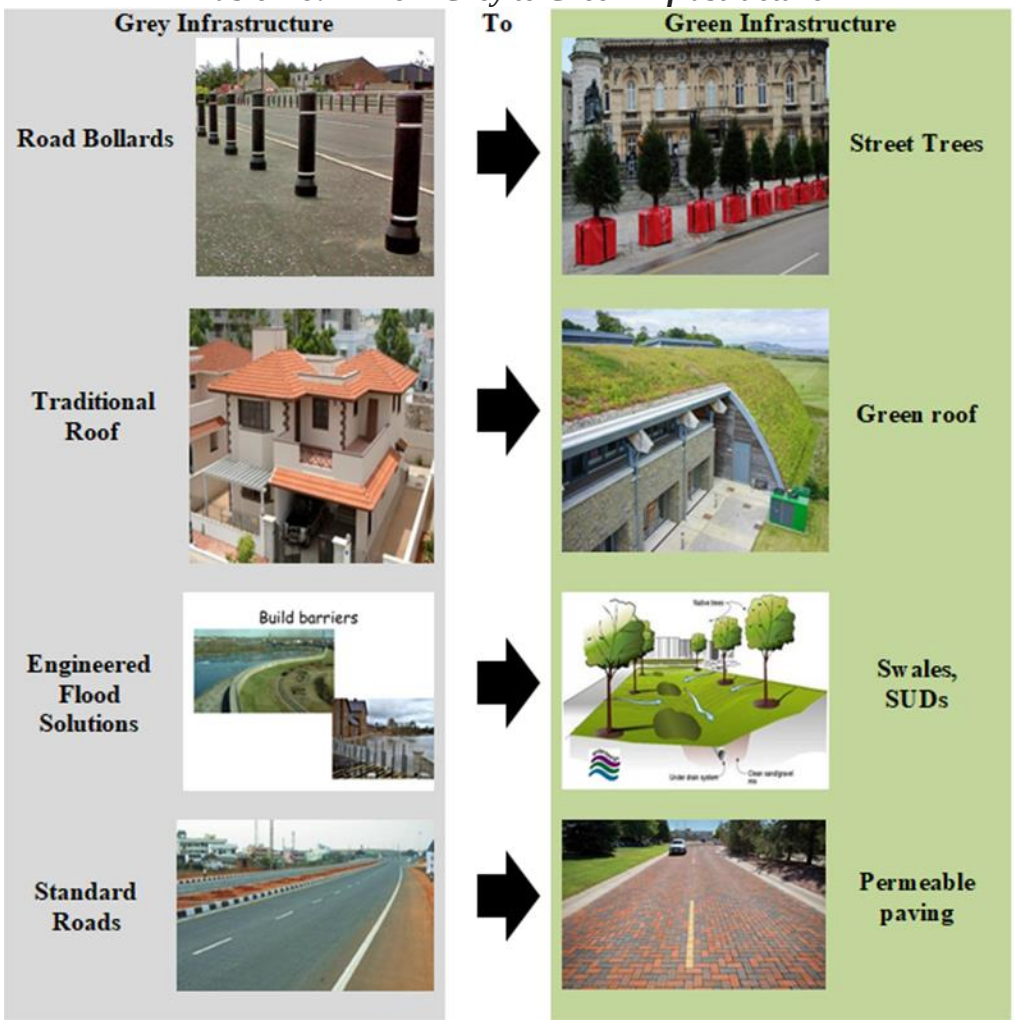
Elements of green infrastructure can serve a useful purpose, without being connected. But linking together of all the components in order to form green networks adds benefits at strategic level from neighborhoods and within streets connecting to individual house. ***Table No: 6*** show the integration of green infrastructure at each level for the easier connections or movements.

Table No: 6 Interconnection of components of G.I at different scales (i.e. from Building level to Strategic level)



Shifting from "grey" to "green" infrastructure should be incorporated in the zoning regulations of the development plans and master plans of the towns and for detailed provisions needs to be added in the building codes for the sustainable future development of a town or city. Few examples for shifting infrastructure from grey to green are shown in ***Table No: 7.***

Table No: 7 From Grey to Green Infrastructure



Further social auditing of Green Infrastructure projects should be incorporated after implementation of the following strategies. It can achieve transformational changes through following practical strategies as discussed below:-

The main components of this approach include:

1. Biodiversity
2. Sustainable energy production
3. Economy and Business

4. Housing and Buildings Sector
5. Better transport
6. Clean water and sanitation
7. Solid waste management.[22]

7.1. Strategies for Green Growth in Urban Areas

7.1.1. Ecosystem and Biodiversity

Biodiversity is the term used to describe the variety of life found on Earth and all of the natural processes. This includes ecosystems, genetic and cultural diversity, and the connections between these and all species. Urban ecosystems and biodiversity are important as a measure of quality of life in urban areas. Even though the urban ecosystem and biodiversity is an overarching sector, there has been little focus on this until now. However, emerging trends in Indian cities show the need to change this approach, as rising urban pollution is reaching levels that severely impact human population. Applying Green Growth measures to this sector will make Indian cities more livable.

Figure No: 27 Sketch showing Forest Woronoff

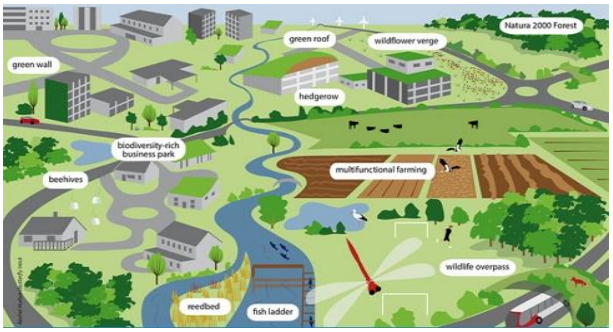


Figure No: 28 Green Infrastructure Components for Biodiversity Enhancement

- ***Document the existing status of environment and biodiversity in the city*** (through Involvement of schools, citizens and private parties in this exercise and carry out awareness activities).
- ***Declare a local policy and include in the Master Planning process*** (through a mandatory three year review of the status of environment and biodiversity. Introduce

[22] https://en.wikipedia.org/wiki/Green_infrastructure#Benefits

environmental resource budgeting tools such as Eco Budget, developed by ICLEI – Local governments for Sustainability).

- ***Develop a plan*** (for maintaining the quality of the environment and conserving local biodiversity in the city by including conservation, greening, and pollution reduction and treatment projects).
- ***Involve the community*** (to protect local biodiversity as a part of the city plan. Seek national government funding through the biodiversity action plans for community engagement related initiatives).
- ***Promote urban agriculture, green public spaces, urban forestry, river and lake conservation, plantation drives, and green roofs in the city*** (by involving private partners and providing incentives to citizens).[23]

7.1.2. Energy Sector and Green Growth

Cities account for only 2.35% of India's land area they account for about 80% of the country's electricity consumption. Energy in the form of electricity, oil and gas is an inescapable necessity to enable urban infrastructure development, be it water supply, sewerage network, transportation, construction, manufacturing, information and communication technology (ICT) or provision of social infrastructure to enhance quality of life.[24] For each city, a prioritization of these strategies can be found.

- ***Promote energy audits and energy performance standards:*** A city should ensure optimal energy use by promoting periodic energy audits for key sectors/energy end users to help establish their baseline energy consumption and also to encourage uptake of RE and EE interventions in identified areas. The promotion can be achieved through mandatory regulations or by offering fiscal incentives.
- ***Promote EE appliances and technologies*****:** EE appliances should be promoted in commercial establishments, residential & commercial buildings, industries, Government/institutional buildings, municipal facilities, educational campuses, low

[23] Niroop Abbu and Jyoti Dash (2015), "*Urban Green Growth Strategies for Indian Cites",* VOLUME 1,Urban Green Growth Strategies for Indian Cities.
[24] *Kalra P and Shekhar R (2006),"Urban Energy Management", India Infrastructure Report, Oxford University Press.*

income housing schemes, slum settlement to reduce energy demand in the city. This could be achieved through incentive schemes, policy mandates integrated in building by-laws/building approval process, appliance retrofit programs undertaken by ESCOs and power supply companies, etc.

- ***Promote green energy systems:*** Incentive schemes and mandatory regulations can help promote small scale RE applications such as solar water heaters, solar cookers, solar PV systems, small wind turbines, solar lighting, solar hoardings across major building/land use types as applicable. Fiscal incentives/subsidies (capital cost and energy generation based) for decentralized RE systems of a larger size can support other policy/regulatory mechanisms to stimulate their use in industrial estates, commercial clusters, IT parks, group housing complexes.

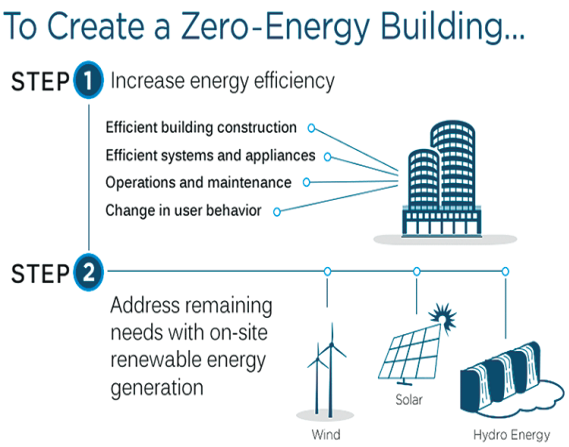


Figure No: 29 Zero-Energy Building Concept

- ***Promote clean green fuels:*** Use of clean fuels such as natural gas to meet thermal energy demand can be promoted through enabling fiscal benefits, improved infrastructure, fast track clearances etc. Improved cook stoves and biogas plants should be promoted in cities where significant biomass potential exists.
- ***Establish Energy Cell for the city:*** The city should set up a well-equipped Energy Cell having dedicated staff with strong expertise in areas such as strategic energy planning, conducting energy audits, developing feasible project proposals, RE/EE implementation, energy modeling & forecasting, and Programme implementation. The Energy Cell should be in charge of development and implementation of energy Master Plan, establishment of energy monitoring and recording systems/protocols, promotional/awareness generation activities, disbursement of subsidies/soft loans for RE/EE applications, and co-ordination between municipal departments, state nodal agencies, and Central Government agencies to develop and implement plans/programmes.

- ***Undertake awareness generation on RE/EE:*** The city should place a high priority on generating awareness through resource Centres, energy parks, demonstration Centres, exhibitions, publicity campaigns, print media, educational programmes, workshops; targeting specific stakeholder groups such as school children, youth, citizens, municipal staff, policy makers, businesses, industries etc.
- ***Promote local knowledge base and green energy industry:*** Creation of local industry base and expertise can help cater to increased market demand for RE/EE technologies and services (resulting from enabling strategies/programmes in the city) and create green jobs.
- ***Incorporate urban energy into city Master Planning process:*** The city should stress on incorporating urban energy into the overall urban development/Master Planning process and ensure its integration into infrastructure, services and physical form at the urban scale. [25]

Figure No: 30 Promoting use of Solar Energy System

Figure No: 31 Promoting Solar Led street lights

7.1.3 Economy

Urban economy is focused on promoting urban strategies and policies that strengthen the capacity of cities to realize their full potential as drivers of economic development, and of wealth and employment creation. However, the lack of economy-related data at the city level - normally centralized at the district and state level - represents one of the main challenges for Indian cities to develop appropriate interventions to scale up the sector.

- ***Technology innovation:*** Cities should invest in technology innovation and research to improve productivity. Environmental technologies for retrofitting the existing urban

[25] Niroop Abbu and Jyoti Dash (2015), "*Urban Green Growth Strategies for Indian Cites*", VOLUME 1, Urban Green Growth Strategies for Indian Cities.

form, reducing water leakages, foster smart transport systems etc., should be explored for creating more eco-efficient cities/smart cities and increasing business opportunities, thus leading to jobs creation.

- ***Streamlining the approval process:*** Cities should facilitate policy measures that streamline approval processes for business, ensuring time bound clearance for key economic sectors, promoting use of ICT to facilitate approvals, etc.
- ***Infrastructure upgrade:*** Cities should fast-track improvement in urban infrastructure investments to increase competitiveness of cities. The availability of adequate and cheap power, water and land is a basic requirement that attract business and investments.
- ***Integration of economy in development plan:*** Cities should integrate local environmental and economic policies in their development planning. Spatial development plans should promote densification and consider the development of business and economic activities.
- ***Promote local knowledge base in the cities***. Cities should encourage and promote local educational and training institutes, and research facilities, which can provide advanced knowledge and help local business to improve their competitiveness, as well as train the local workforce on the required skills.
- ***Eco-budgeting:*** Cities should complement traditional accounting systems with environmental ones in which physical environmental resources are measured instead of only finances.
- ***Innovative business models:*** Cities should promote and encourage innovative business models where businesses consider their entire environmental impact along with the impacts of their suppliers and clients.
- ***Redefining the urban economic structure:*** Cities should, within their possibilities, mainstream their involvement into local economic development and planning, pro-actively developing enabling policies and fiscal incentives for business. The roles and responsibilities between the local and the state level should be clearly defined.
- ***Promote sustainable procurement:*** Cities should promote and adopt sustainable procurement and innovation in procurement models to create green markets and increase demand for greener products and services.

7.1.4 Housing and Buildings

Available data suggests that buildings can be responsible for up to 40% of the energy, 30 % of raw materials, 20% of water and 20% of land used up by cities. Additionally, they account for 30% of solid waste generation, and 20% of liquid effluents discharged in our cities.[26]

- ***Collect accurate data*** on housing stocks at the national and state level collected through an institutional structure and make it readily available.
- ***Provide incentives*** for buildings which focus on energy and resource efficiency, waste reduction and pollution prevention, good indoor air quality and natural light to promote occupant health and productivity. This can be done by adopting city specific bye laws and Development control regulations. In progressive cities, specific green building codes could also be developed.
- ***Link families to housing credit*** through banks or community credit mechanisms, enabled poor people to access credit for housing upgrading i.e. building toilets in the houses. To prevent housing from being converted into a cash asset, the ULB may need to develop contracts between the owners, the local body and banks (if credit is provided) for apartment ownership, setting the terms of sale and transfer etc.
- ***Simplifying procedures*** for obtaining planning and construction approvals. Single window and channel procedures are needed to help bring in transparency in the local construction activities.
- ***Security of tenure*** should be recognized as an important and integral tool for relieving pressures on the housing market. This may be undertaken through regularization of settlements, community or cooperative ownership, security via lease, use rights, enabling in situ development to take place.
- ***Reviewing the processes of Master Planning*** and implement changes necessary to ensure a proper assessment of land requirements and allocation of such lands for different uses, including that of affordable housing.
- ***Re-densification and re-assignment of land*** through an upward revision in the FAR/FSI across cities of different sizes commensurate with investment in infrastructure that it will necessitate.

[26] Anon (2009),*"Green Buildings – an overview, Capacity Building Series (2008-2009)",* by TARA Nirman Kendra.

Taking an intelligent approach to conserve energy at household/building level

1. Minimizing energy use in all stages of a building's life-cycle, making new and renovated buildings more comfortable and less expensive to run, and helping building users learn to be efficient too.
2. Integrating renewable and low-carbon technologies to supply buildings' energy needs, once their design has maximized inbuilt and natural efficiencies.

i. Safeguarding water resources at household/building level

- Exploring ways to improve drinking and waste water efficiency and management, harvesting water for safe indoor use in innovative ways, and generally minimizing water use in buildings. Such as Reusing the RO water for the purpose of washing car, cleaning utensils, floor, washing cloths and watering plants/trees etc. as shown in ***Figure No: 32, 33 & 34.***

Figure No: 32 Washing Car

Figure No: 33 Watering Plants

Figure No: 34 Washing Cloths

ii. **Keeping our environment green at household/building level**

- Recognizing that our urban environment should preserve nature, and ensuring diverse wildlife and land quality are protected or enhanced, by, for example, remediating and building on polluted land or creating new green spaces.

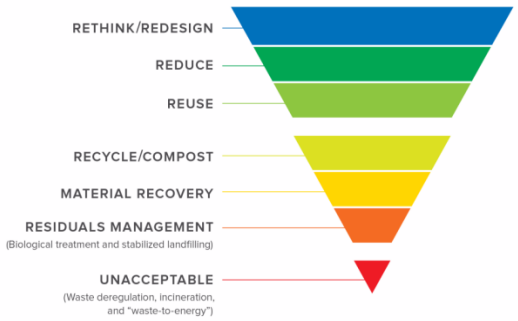


Figure No: 35 Zero Waste Hierarchy

iii. **Minimizing waste and maximizing reuse at household/building level**

- Using fewer, more durable materials and

generating less waste, as well as accounting for a building's end of life stage by designing for demolition waste recovery and reuse.

- Engaging building users in reuse and recycling.

iv. **Creating resilient and flexible structures**

- Adapting to our changing climate, ensuring resilience to events such as flooding, earthquakes or fires so that our buildings stand the test of time and keep people and their belongings safe.
- Designing flexible and dynamic spaces, anticipating changes in their use over time, and avoiding the need to demolish, rebuild or significantly renovate buildings to prevent them becoming obsolete.

7.1.5 Transport Sector

Transport is the result of the need to move people, goods and services from one location to another. This need for mobility is a result of improvement in land use, infrastructure and services but it often turns into increased vehicle population, traffic, pollution etc. Rapid growth needs to be supported by an efficient, reliable and safe transport system to be green in the long term. A key to achieve this is to leapfrog to a sustainable and accessible form of transport system where mobility is such that citizens shift from a car or private vehicle dominant transport system to public transport that reduces the costs faced by many industrialized countries today.[27]

Figure No:36 Sustainable Transit

Figure No:37 Sustainable Streets

Figure No:38 Sustainable Vehicles

[27] UNESCAP (2012), "*Low Carbon Green Growth Road Map for Asian and The Pacific – Urban Transport*", Transport Research Laboratory, United Nations publication.

- ***Set up a well-established and reliable public transport system***, tailored to the population and area of the city. This could include metro rail, mono rail, BRT, Lite BRT, Bus system, minibus system, trams, rope ways system, boat-jetty network or a combination of them depending on their feasibility.
- ***Ensure multimodal integration*** while developing transport plans and projects. Indian cities have a large mix of transport modes being used; they should ensure that networks are completed using multimodal integration and that all existing modes are considered and included when planning for a new system. Information and telecommunications systems should be used to support this integration.
- ***Apply Transit Oriented Development principles,*** integrating land use and transport, to ensure that vehicular miles traveled are minimized. ***45% of jobs are within walking distance*** as shown in the ***Figure No: 39***. While ***80% of the jobs are within walk able distance*** as shown in the ***Figure No: 40***. This is attained by rearranging the land uses in a transit oriented development.

Figure No: 39 Unfocused Density

Figure No: 40 Transit-Oriented Density

- Compact urban development is ***best form of development in minimizing travel distances.*** It brings ***activities closer together, making them more accessible*** by foot or by bicycle, without any need to use a car as shown the ***Figure No: 41 & 42***.

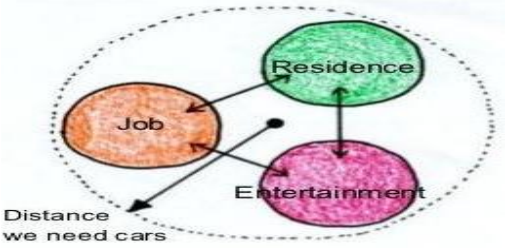


Figure No: 41 Scattered Development makes People to Depend on their Private Vehicles

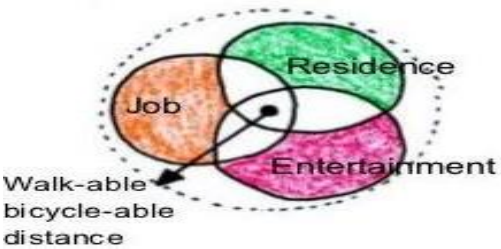


Figure No: 42 Compact Development Encourages People to Walk or Use Bicycles

- ***Promote clean fuel based vehicles***, such as CNG, hybrid, electric, etc., by offering subsidies or providing better infrastructure.
- ***Promote Non-motorized transport*** and offer a good network of footpaths and good infrastructure to enable safe cycling and other NMT modes.
- ***Transit systems are often not close enough to origins (generators) or destinations*** (attractors) to make walking / cycling between the uses comfortable. Develop interconnected streets and blocks system with routes providing **direct connections** between origins and destinations as in ***Figure No: 43***. ***Pathway between adjacent buildings*** can reduce the lengthy approach and facilitate pedestrian movement as shown in ***Figure No: 44 & 45.***

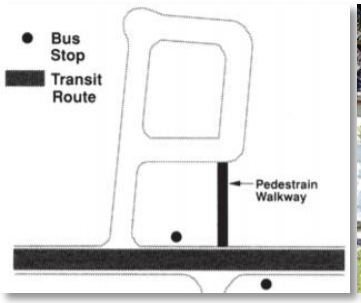


Figure No: 43 Shortest Transit Route should be Opted

Figure No: 44 Pathways between Adjacent Streets

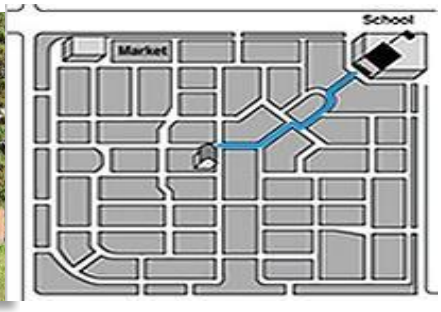


Figure No: 45 Pedestrian routes should be direct and easily accessible from every corner of the sector

- ***Restrict polluting vehicles*** in certain areas, such as city Centres, squares, market places, heritage and environmental precincts by charging extremely high parking/stopping/entry fees.
- ***Organize parking of private vehicles*** applying differential parking fees keeping in mind local land prices and how they want flow of private vehicles to be maintained in certain areas. This can also be done by charging one time standard fee from all households depending on the specification of the car and numbers of owned.
- Protected bicycle as shown in ***Figure No: 46***

Figure No: 46 Protected Bike Lane Using Planters

lanes are sidewalks for bicycles created by using planters (Portland), parked cars (Chicago) or flex posts (Austin) to separate the bicycle and auto traffic on busy streets.

7.1.6 Water and Sanitation

The Urban Water and Sanitation Sector include municipal services such as supply of water, and collection and treatment of waste water and faecal sludge. This includes the provision and operation of facilities to ensure that proper quantity and quality of water is delivered to cities and the sewage discharged from urban communities is properly collected, transported, and treated to the required degree and disposed-off/reused without causing any health or environmental problems.

- ***Undertake Integrated Urban Water Resource Management:***
  - i. Focusing on efficient and sustainable management of water resources with reduced losses, management of basins and natural drains to prevent development/encroachments and flash flood situations, and exploring alternative sources of water, like runoff through rainwater harvesting and reuse and recycling of wastewater.
  - ii. Integration of plans/schemes for water, wastewater and drainage at the institutional level is required.

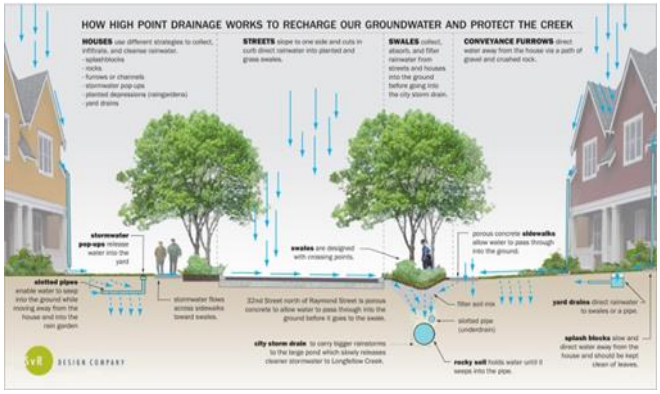
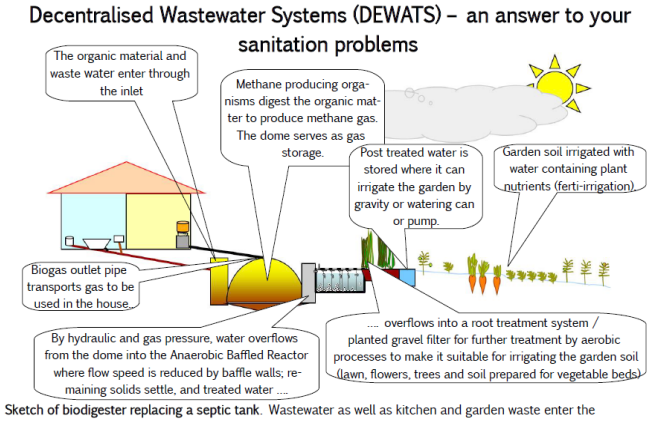


Figure No: 47 Integrated Urban Water Resource Management



Sketch of biodigester replacing a septic tank. Wastewater as well as kitchen and garden waste enter the digester and are broken down to biogas and fertile water.
Advantages: No more emptying of septic tank. Reuse of all water in the garden. Less cost on cooking energy.

Figure No: 48 DEWATS Process

- ***Promote decentralized green solutions:***
  - i. Household or community scale low cost decentralized or on-site technologies such as DEWATS as shown in ***Figure No: 48*** and waterless toilets should be

promoted in Unserved and poor settlements or in areas with low population where centralized systems are not feasible.

ii. Small scale decentralized water and wastewater treatment systems can be located in catchments areas to provide safe drinking water and ensure safe disposal of wastewater and faecal sludge. Such systems can be integrated into the centralized system at a later stage.

iii. Redesigning cities to function more like forests so water is absorbed back into grounds, in addition to treating storm water through traditional means, will solve storm water problem worldwide as shown in the ***Figure No:49***

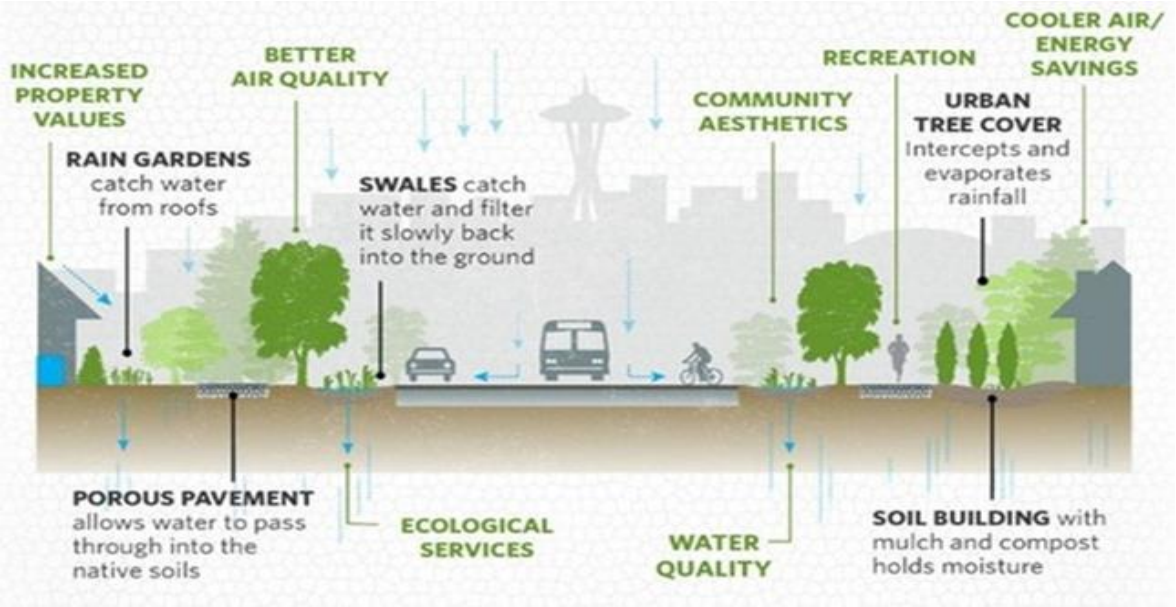


Figure No:49 Green Storm Water Management

- ***Promote water efficiency:***

i. Through metering of connections and differential volumetric tariffs across consumer categories, supported by enabling frameworks such as local metering policies and guidelines.

ii. Efficiencies in urban water systems can be improved through the use of technologies such as GIS and SCADA and by undertaking periodic water audits and leakage mapping exercises.

iii. Water efficient devices such as low flush toilets and low flow shower heads/faucets can be promoted in buildings through incentives schemes, mandates and retrofit programs.

iv. Enforcing water use standards and offering incentives for water intensive sectors can help to promote efficient water use.

v. Net Zero Water Building Concept: The goal of net zero water is to preserve the quantity and quality of natural water resources with minimal deterioration, depletion, and rerouting of water by utilizing potential alternative water sources and water efficiency measures to minimize the use of supplied freshwater. This principle can be expanded to the campus level as shown in ***Figure No: 50***. A net zero water building (constructed or renovated) is designed to:

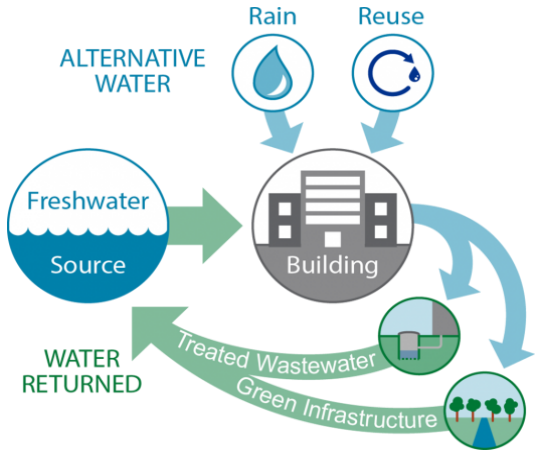


Figure No: 50 Net Zero Water Building Concept

- ✓ Minimize total water consumption.
- ✓ Maximize alternative water sources where alternative water includes: Harvested rainwater, storm water, sump-pump (foundation) water, Gray water, Air-cooling condensate, Rejected water from water purification systems, Reclaimed wastewater and Water derived from other water reuse strategies.
- ✓ Minimize wastewater discharge from the building and return water to the original water source.[28]

[28] "Net Zero Water Building Strategies" retrieved from https://www.energy.gov/eere/femp/net-zero-water-building-strategies

- ***Promote rainwater harvesting and restrict groundwater use:***

i. Rainwater harvesting systems should be promoted to conserve freshwater resources, augment depleting groundwater reserves and counter frequent incidences of flooding.

ii. Strict enforcement of rainwater harvesting bye laws based on local conditions can boost deployment of rooftop harvesting systems in buildings.

Figure No: 51 Rain Barrel

iii. Rainwater harvesting structures or recharge wells can be mandated for certain land use types as feasible.

iv. Some of other concepts for harvesting the rain water that should be recommended at household level are:

a) ***Install rain barrel:*** The easiest way to harvest rain is through a rain barrel as shown in the ***Figure No: 51*** (make your own from a large trash can or an old drum) linked to a pipe fitted to collect rainwater from the rooftop and verandah of the house.

b) ***Create Rain Garden:*** A rain garden as shown in ***Figure No: 52 & 53*** is a settled landscape that uses native plants, local soil, and mulch to remove pollutants from water, and allows it to percolate into the ground.

Figure No:52 Rain Garden at Household Level

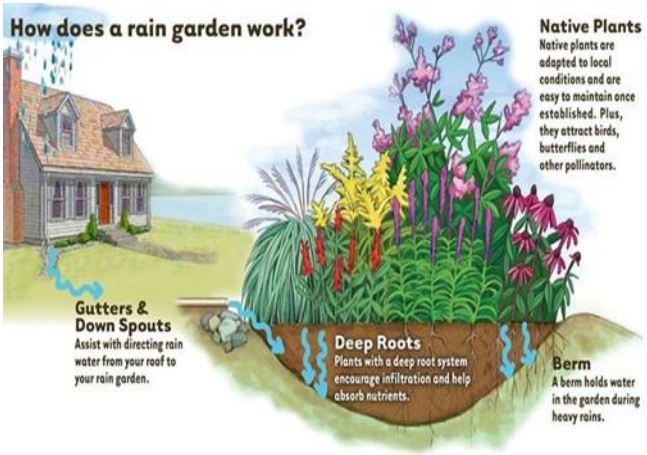


Figure No: 53 Process of Rain Garden

c) ***Rain chains*** are not only beautiful, simple to make requiring few tools and materials, but also a more attractive alternative to standard PVC (polyvinyl chloride) pipe downspouts. These fun, fashionable and environment-friendly accessories help avoid the runoff by transporting rainwater from the collecting pipe downwards to a drain or to a storage container.

Figure No: 54 Rain Chains

d) **Build a Rain Saucer:** This is a fastest way to collect rainwater without much hassle, rain saucers form a great free standing rain collection system which fill up surprisingly fast. Looking like an upside-down umbrella, the rain saucer unfolds to form a funnel which fills the containers with rainwater. Since this easy-to-deploy system catches rain straight from the sky, it also decreases the chances of contamination.

Figure No: 55 Build a Rain Saucer

e) **Naturally Recharge Wells and Bore wells:** Rooftop rainwater is led through pipes with a filter at the end to open dug wells for replenishing underground aquifers a good idea as it pushes back the surface water into the groundwater system.

Figure No: 56 Naturally Recharge Wells and Bore Wells

f) Usually, a recharge pit is one metre in diameter and six meters deep, lined with concrete rings having perforations. These perforations let filtered and de-silted water seep from the sides increasing the groundwater table.[29]

g) **Naturally Recharge Wells and Bore wells:** Rooftop rainwater is led through pipes with a filter at the end to open dug wells for replenishing underground aquifers. A recharge pit for bore wells is also a good idea as it pushes back the surface water into the groundwater

[29] Pal Sanchari, June (2016), "7 Great Techniques by Which You Can Easily Harvest Rainwater at Your Home This Monsoon"

system. Usually, a recharge pit is one metre in diameter and six meters deep, lined with concrete rings having perforations. These perforations let filtered and de-silted water seep from the sides increasing the groundwater table.[30]

h) Hydrological modeling and flood monitoring can help identify appropriate locations for RWH systems in the vicinity of vulnerable settlements.

i) Interventions such as rules, penalties and check meters installed at appropriate locations can help regulate groundwater extraction.

- ***Promote recycling and reuse of wastewater:***
    i. Help reduce freshwater demand and generate by-products, like biogas energy and manure.
    ii. Enforcement of bye laws/mandates and fiscal incentives can promote wastewater recycling and reuse in certain land use/building types for industrial uses, landscape irrigation, agricultural irrigation, use in fountains and fire protection.
    iii. This can be supported by quality standards and guidelines developed for wastewater reuse at the local level.
- ***Encourage private engagement and partnerships:***
    i. Private sector engagement should be promoted by putting in place local programs to leverage CSR initiatives for provision of decentralized green solutions.
    ii. City governments should put in place enabling frameworks such as PPP procedures or guidelines and look to partner with private sector across aspects of design, planning, construction, O&M, and billing for water and sanitation to help bridge the gap in terms of technical, technological, financial and human resource capacity.
- ***Promote community awareness and participation:***
    i. Through publicity campaigns, demonstration programs, pilot projects, workshops, school sanitation ratings etc.

[30] Pal Sanchari, June (2016), "7 Great Techniques by Which You Can Easily Harvest Rainwater at Your Home This Monsoon"

ii. Awareness can be the first step towards involving communities in planning, implementation and management of initiatives which contribute to strengthening ownership, addressing cultural/behavioral barriers, gaining feedback from direct beneficiary.

7.1.6 Solid Waste Management

Even with the most advanced regulations and policies, solid waste management is a sector that remains not well addressed in Indian cities and has considerable negative impacts on local environment and health. As cities grow, with rising urban population and per capita income, the waste produced in Indian cities will only increase. Looking at greener options for waste management in urban areas will help cities to reduce local impacts and grow in a green way.[31]

- ***Undertake integrated SWM plans/projects:***
  i. Promoting ISWM (as shown in ***Figure No: 58)*** activities benefits cities with cleaner and safe neighborhoods, higher resource use efficiency, resource augmenting, and savings in waste management costs due to reduced levels of final waste for disposal, as well as better business opportunities and economic growth.
  ii. ISWM follows a strategic approach to sustainable management of solid waste covering all sources and all aspects, such as generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency.

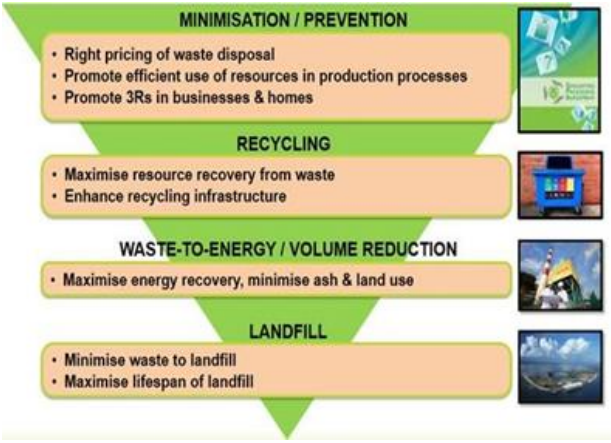


Figure No: 57 Solid Waste Management Hierarchy

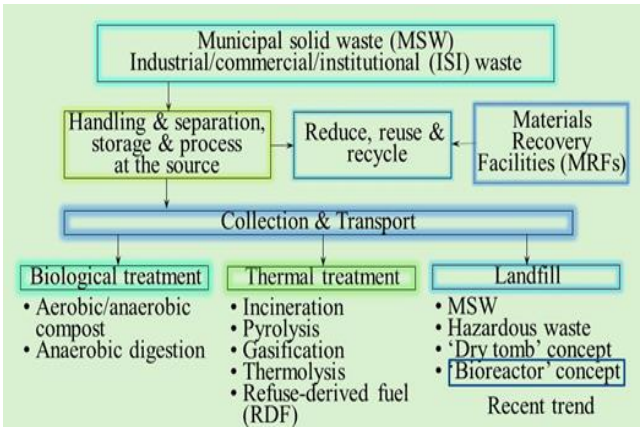


Figure No: 58 Integrated Solid Waste Management

[31] Ministry of Environment and Forest, Government of India (2000),"Solid Waste Management & Handling Rules".

- ***Promote segregation at source:***
    i. Segregation of waste should be promoted at household level in order to recycle dry waste easily and to use wet waste as compost. Segregation of waste can be done by using color coded bins as shown in ***Figure No: 59.***

    i. This initiative has to be promoted in all cities initially on a pilot basis and then extended to the whole city area, bringing advantages such as reduced impact on the waste collection and transportation, reduced dependency on natural resources and raw materials with excellence in reuse and recycling, and appropriate waste transported to the final disposal site.

Figure No: 59 Segregation of Waste Using Color Coded Bins

    ii. Door to door collection and segregation at source can be improved by involving Community Based Organizations (CBOs), Non-Governmental Organizations (NGOs), Residents Welfare Associations (RWAs), Rag pickers, etc.

- ***Local/Community level composting plants and waste processing plants:***
    i. Entertaining local composting at ward levels and mandating the composting plants in large townships, huge commercial complexes and hotels and restaurants reduces the amount of waste generated and benefits municipal corporations, saving time and money.
    ii. The authorities should involve private actors to educate the public on selecting the appropriate composting technologies for deriving benefits from the end product. Local/Community level waste processing plants have to be initiated for collecting recyclables.

- ***Creating wide-spread awareness on solid waste and its management:***
    i. Several awareness activities have to be taken up by urban local bodies to educate the public on advantages and consequences of proper and poor SWM.
    ii. It is important to educate municipal staff with inspirational and successful case studies from around the world, so that they can in turn raise awareness among the general public, using a variety of communication techniques.

iii. Raising awareness can result in increased use of city waste collection services by the public and private sectors, funding for waste management from local elected officials, adoption and enforcement of local waste management polices by local elected officials and public participation in organic diversion and recycling programs.

- ***Promoting Private Sector Engagement:***
  i. It is necessary for the urban local bodies to engage the private sector and change their role of being a "service provider" to that of a "facilitator of services".
  ii. Private sector participation brings finances for the modernization of SWM services, helps in providing efficient MSW management services and supports ULBs by promoting cost savings through the rising productivity of manpower and machinery.
  iii. Additional advantages of private sector participation include updated access to technology and expertise, higher levels of efficiency and accountability, focus on customer satisfaction, and access to finances for new investments.

7.2 Conclusion and Way Forward

This study provides an overview of Green Infrastructure which should be an important component of all development policies, with emphasis on retrofitting present urban environment with green infrastructure to counter urban challenges and act as a decisive step towards future sustainability However, this concept and its benefits are not widely known in many developing nations like India for sustainable development. It emphasis on the role of the government and non-government institutions that can help in raising awareness about the green infrastructure. International case studies show that green infrastructure can be planned based on the analysis of urban area and by identifying its potential within the existing developed urban areas. It is perceived that the benefits of green infrastructure will not only help in sustainable management but also results in a number of additional benefits to the communities in terms of ecological, social and economic functions. The list of strategies is based on the understating which cannot be accomplished without the involvement of citizens and other institutional support. Also, each city has its unique challenges and barriers and to overcome these challenges Green growth strategies are required to take actions accordingly.

Acknowledging that rivers perennial or seasonal/nallahs passing through towns/cities need to be planned and developed as a linear green and blue spaces with thick ornamental plants with proper landscaping and giving them semblance of Perennial River or creating artificial lakes. Leisure valley and Sukhna Lake of Chandigarh are the best example of this. Ghaggar a semi- perennial river passes through Pinjore/Panchkula which has good potentials of linear green and blue infrastructure. ITPI-HRC needs to take up Ghaggar riverfront development as study project.