SUSTAINABLE URBAN DEVELOPMENT BASED ON BIOMIMICRY CONCEPT

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF URBAN AND RURAL PLANNING

By

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DEDICATED

TO

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CERTIFICATE

Certified that the report entitled **"SUSTAINABLE URBAN DEVELOPMENT BASED ON BIOMIMICRY CONCEPT"**, which has been submitted by **Mr. AMAL SHUKLA**, for partial fulfillment of the requirement for the award of the degree of **Master of urban and Rural Planning**, submitted in the Department of Architecture and Planning, Indian Institute of Technology Roorkee, is his own work done by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted by him for the award of any degree of this or any institute.

Date: 15 June 2012

Place: Roorkee

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CANDIDATES DECLARATION

I hereby certify that this report entitled **"PLANNING FOR OPTIMUM TRANSPORTATION SYSTEM OF PATNA CITY, BIHAR STATE"**, which has been submitted in partial fulfillment of the requirement for the award of the degree of **Master of urban and Rural Planning**, submitted in the Department of Architecture and Planning, Indian Institute of Technology Roorkee, is an authentic record of my own work carried out during the period from July 2011 to June 2012, under the supervision and guidance of **Dr. R.K. JAIN,** Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree of this or any other institute.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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Date: 15 June, 2012

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Place: Roorkee

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ABSTRACT

Can cities behave like Nature...???

Sustainability has always been an aim for any development to ensure our existence on the Earth. In early ages, finding shelter in caves and eating animals, sustained human life. Later agriculture and shelter became essential feature to provide sustainability. Gradually our activities changed and the changing "needs" transformed into "wants". Endless wants exploited more and more resources to fulfill our requirements. Each product was accompanied by its by-product or waste.

Today we realize that unplanned approach of consuming resources is responsible for over exploitation of resources, increased energy requirements and degradation of environment which are proving to be dangerous for our survival.

Pondering on this matrix we come up with an observation that sustainability meant different in early ages than what it means now. In other words, the means to achieve sustainability has changed from time to time, and thus we may conclude that sustainability is contextual. At present we need to realize that harming nature is our biggest mistake which now is at alarming stage. Nature is the only medium without which our survival is not possible therefore the human activities and development should be nature oriented. The best way to understand and live with nature is to observe and act like it, till the time we, and our cities behave like nature. The bottom line thus comes out to be: **To 'live in nature' or to 'live with nature' we should 'live like nature'.**

Sustainable development is a response to awareness, which attempts to find planning solutions that tend to engage the well-being and co-existence; based on three fundamental concepts; based on three fundamental concepts of objectives, means and end. The traditional planning concepts and their reinterpretations and limitations require the need to search for alternatives.

The paper attempts to study the efforts made to achieve nature like urban development, by introducing the concept of biomimicry and evolving thoughts to act like nature, by producing energy from renewable sources, optimization of transport system and services and efficient waste disposal and treatment.

1 CHAPTER I – INTRODUCTION

1.1 BACKGROUND

The need for finding long-term Sustainable design and development solutions; **which meets the needs of the present without compromising the ability of future generations to meet their own needs**, that warrant continuing human existence and well-being is far more compelling in these days of depleting resources and catastrophic climate change, than in the former days. Contrary to sustainability, facts like to live like Americans it will require five Earths to fulfill our supply of resources really are eye opener (Smail, August 2007). Unfortunately we have only one earth to live in, and therefore understanding of sustainability needs to be stressed on nature more.

Our way of producing energy or exploiting resources to achieve urban development is extremely inefficient which produces high amount of waste and pollution. Urban development's or our cities translate human activities and further their impacts for ages which should be nature oriented. By observing nature, the way it produces energy from renewable resources and where one's waste is another's food claiming to be no waste concept.

In this study efforts are made to achieve nature like urban development, introducing concept of Biomimicry. Evolving thoughts to act like nature, producing energy from renewable resources and treating waste to achieve urban development which makes no difference in nature even after its existence.

1.2 AIM

To achieve sustainable urban development based on biomimicry concept.

1.3 OBJECTIVES:

To achieve sustainable urban development which will :-

- Behave like nature in terms of functionality (resource conservation, energy generation, waste treatment and low carbon emissions).
- The development shall generate energy from renewable resources to fulfill all required energy demand of that development.
- The transportation within development shall be based on defined hierarchical pattern, and thus the growth will take place in desired pattern. As observed everywhere in nature for example- Foliage of tree or shape of a leaf.
- All the generated waste/water to be treated within the development itself.

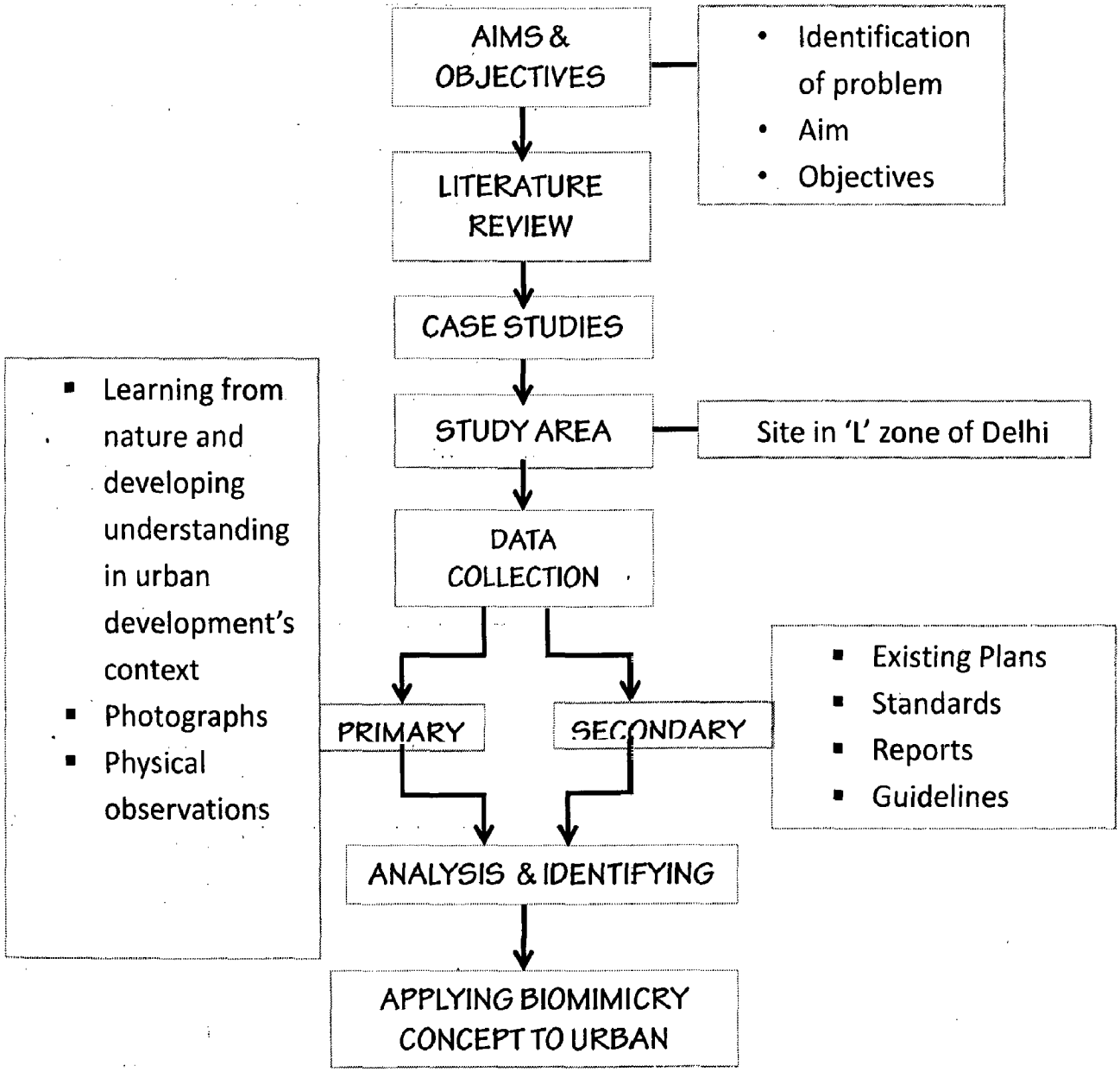
1.4 SCOPE:

- It has high scope as sustainability has become major challenge. Here efforts have been made at every scale of work. And thus this study can prove itself to be one of the best solutions to problem like climate change, scarcity of resources, ecological footprint, etc.
- Lessons or principles of Biomimicry can be observed, understood and can be applied on global context to achieve nature oriented developments (to make difference in large scale).

1.5 LIMITATIONS:

As this thesis is based on a new concept and lessons derived from nature itself, it may not compliment already made laws and bye-laws or master plan.

1.6 METHEDOLOGY



1.7 Concept of Sustainability

Sustainable development is defined as

"Development that meet the needs of the present without compromising the ability of future generations to meet their own needs".(Development, 1987)

Built forms contribute to the impact of development on global ecosystems. It is therefore, important to study the impact of built forms on the totality of the environment. One should take care of it at various stages of development. Developments should be facilitated taking into consideration the entirety of the systems; resource, energy and transport, waster etc. and population of the Nation, along with the specific characteristics of the region being developed.

Sustainable development describes the fact that we receive what we need, from the nature; it also talks about mitigation and adaptation. Mitigation of the toxic, greenhouse gases like CO_2 which saves environment, and adaptation of the future context with climate change and other challenges. Sustainable development, then, is afar sighted positive response to awareness that everything we need is received from nature, not a prescriptive formula just for our survival. In other words, the goal of sustainable design is to find development solutions that warrant the well-being and coexistence of constituent groups. Therefore, a conceptual approach to framework is to be developed in order to meet the goal of well - being and coexistence in an effort to attain sustainability. These relate to the environmental responsibilities, creating environmental awareness, explaining the building ecosystem and designing sustainable built forms for future.

In early human history, the use of fire and desire for specific foods may have altered the natural composition of plant and animal communities(Scholars, 2003).Between 8,000 and 10,000 years ago, Agrarian communities emerged which depended largely on their environment and the creation of a "structure of permanence(Clarke, 1977)Since then whole globe is trying to achieve sustainability to ensure their existence. But it seems harder we are trying to achieve sustainability the tougher it is becoming to achieve it. There are number of such planning and development failures all over the world which challenge to handle the situation prevailing. Not to go any far to recall our own cities and their problems will make picture clear. Starting from resources, such as water, electricity, transport, social infrastructure and environmental quality etc. people are not satisfied with the living conditions.

Thus in search of sustainability we need to take a pause and think, where actually our blind short term solutions are leading us to. We need to go to our basics; basics of what actually we are, and where we are heading towards.

The answer is we are just a negligible contribution to nature, to which everything belongs. We simply forgot our nest to which we belong, and knowingly or unknowingly we started damaging our own home, our shelter, and our living conditions. We need to evolve a new concept so as to develop better understanding of whole process.

1.8 NEED FOR ALTERNATIVE CONCEPTS

"We cannot solve the problems by the same thinking that created them".

-Albert Einstein

It is important to understand the limitation of traditional design models to generate unique built forms that meet the requirements of sustainable developments. Mostly, the inability in the traditional models is manifest by way of stereotyped inherent thinking which leads to typical designs. As we are still unable to produce nature conscious developments, environmental aspect is degrading from bad to worse. It is worthwhile to ponder the words of Albert Einstein "We cannot solve the problems by the same thinking that created them". Due to the lack of novelty in conceptualization and approach, such designs offer very little scope for sustainable solutions such as optimization and lowering of energy and resource consumption. This problem of stereotype could be resolved creatively by a search for alternate models in designs. Nature, at this stage, presents itself with harmonious designs that are sustainable, self-supporting and self-organizing. Solutions that are found in the harmonious natural systems are always in evolution, perfecting and adapting to their contexts. Thus, what is seen today has been working over billions of years for evolving a reliable and sustainable model. Adoption of these evolved models in human designs would facilitate the making of future systems better sustainable; environmentally, ecologically and economically. Hence, Biomimicing reveals itself as a fine model to follow in the generation of alternative sustainable design solutions (Phillips, 2009).

2 CHAPTER II - BIOMIMICRY: COPYING NATURE

"Imitation is highest form of flattery."

It is new scientific discipline seeking to build artificial systems based on biological ones. The practice of developing sustainable human technologies inspired by nature, sometimes called Biomimetics or Bionics. It is basically biologically inspired engineering (Benyus, 2001).

Biomimicry is a new science that studies nature's best ideas and principles and imitates these designs and processes to solve human problems. In other words Biomimicry leads to innovations inspired by nature. Though some of nature's basic configurations and designs can be copied, most ideas from nature are best adapted when they serve as inspiration for human-made designs and productions. Adaptation of natural systems and organisms has facilitated better understanding of related phenomena and principles in the design of novel designs, devices with better features and capability.

For example,

- There exists the evident, inspirational link between the design of tongs and bird's beaks. (Martin Reuss, 2010)
- The same inspiration is evident in the foldable hand-held fan design and the peacock feather display; a magnificent attempt to impress the female (Dr. Abraham George, 2011).

One of the important features of nature is its evolution by responding to the system needs and generating

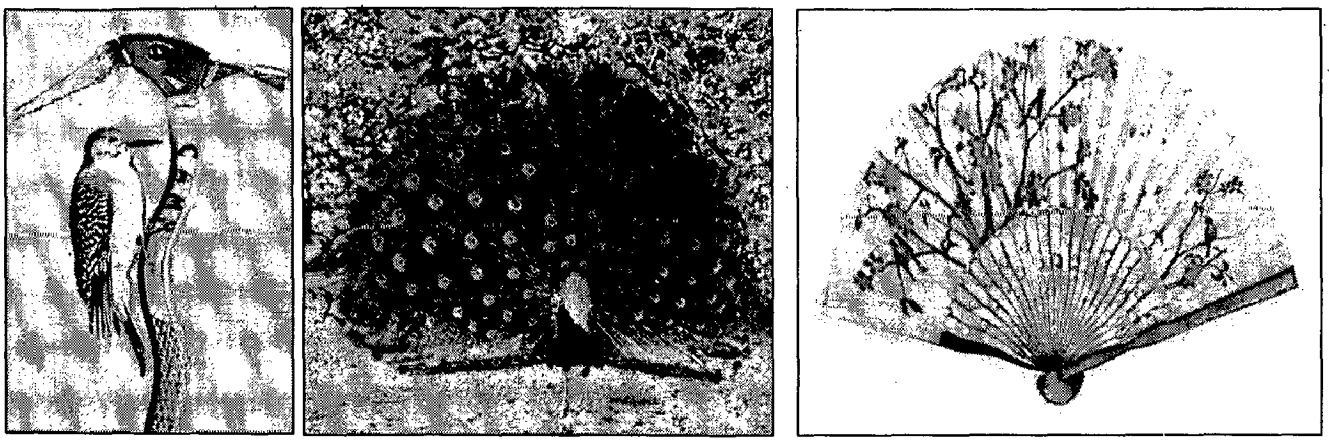


Figure 2-1: Draws inspirational link between nature and man-made items

solutions that work. Nature remains in an open, dynamic system establishing balance and continuous modification in all its productions. Each of the successful natural creation that passes to the following generation has to withstand the test of survival, establishing the best fit for the following generation. Nature's experiments generate information that is coded in genes and transferred to the following generation through the process of self-replication. Nature thus, is perfecting models worth copying and inspiring novel engineering methods, processes, materials, algorithms, and designs. In a similar way production of designs and the elements and their organization in the design produced shall remain in a continuum of evolutionary changes, permitting adaptation and attainment of the best fit. Imitating nature may be done at various levels beginning with the full and complete appearance of the natural system to its every system detail in part or full. On the other extreme, natural models are interpreted and transformed in the making of human- made designs. Such mimicking of life-systems demands the full capacity and intelligence of humans (Phillips, 2009).

2.1.1 Why Biomimicry?

"Those who are inspired by model other than "NATURE", a mistress above all masters are laboring in vain."

-Leonardo Da Vinci

"People are entitled to a healthy and productive life in harmony with nature"
(Rio declaration)

Biomimicry looks to nature and natural systems for inspiration. After millions of years of tinkering, Nature has worked out some effective processes. In nature, there is no such thing as waste — anything

left over from one animal or plant is food for another species. Inefficiency doesn't last long in nature, existence of fittest is truth. Our experiences account only for few thousands of years but that of nature is 4.5 billion years. Thus continuous process to achieve better and sustainable nature is what we have as an experience to learn.(Dr. Abraham George, 2011)

A very different approach to look at this (process of development in nature) is its simple example of Homosapien's development. At one point when it became difficult for our four footed ancestors to survive, gradually modification took place and two limbs were made free to protect, to attack, to hold, to construct etc. and like this nature was proving herself best or perfect again.

Relationship of human being with nature can be evidenced since ancient times. Rituals which they used to perform were ecologically symbolic and related. Rituals such as group pantomimes of rolling in dust, acrobating in water, walking on burning ambers, swinging upside down in burning ashes, depending on sun or moon for any activity etc. affirm their connectivity from nature (Jain, 2009).

Thus as an ecological being we should understand and learn from NATURE.

2.1.2 HOW IT WORKS

A thought to Biomimicry

At very basic level Biomimicry can be classified into 2 initial phenomenon with which it starts

1) Observing nature and then connecting to existing technology or problem. Observing nature's any phenomenon and getting inspired by that, finally mimicking to attain product based on same principles. Example Lotus paint, swimsuit etc.(Benyus J. M., 2002)

Figure 2-3:Lotus paints (Benyus J. M., 2002)

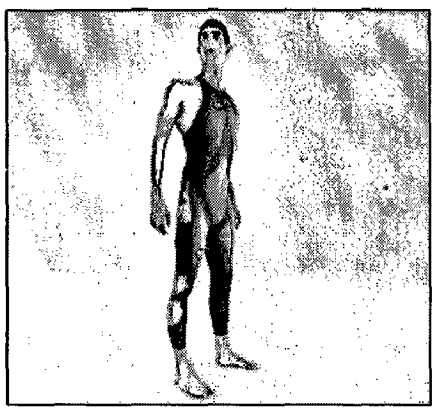


Figure 2-2: Shark swimsuit (Benyus J. M., 2002)

2) Studies an existing design problem then turning back to nature for help or inspiration. Now here in this case you wish to design something and you ask nature "how it would do". This process becomes challenging as first you have to find out what is most appropriate inspiration with in nature which can guide to achieve your desired product. Example Eastgate building(Benyus J. M., 2002)

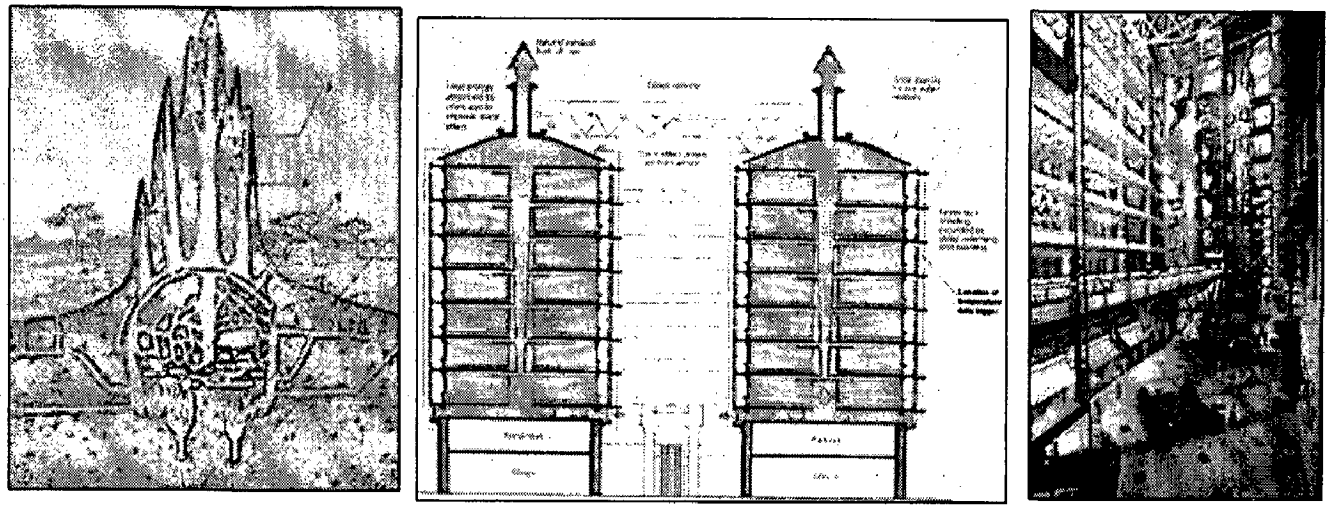


Figure 2-4: Eastgate Building, Harare, Zimbabwe

In any case, if we are designing, planning or developing any product based on Biomimicry we are considering nature as our inspiration. Further, how it should be perceived is illustrated by the help of (M) principles:

2.1.3 Principle of 3Ms

Model

Accept nature as the standard and imitate its system designs, processes and strategies at any level as deem fit, to live sustainably. Investigations of such natural systems reveal the details of system composition and their organization at the general level and the details of elements, processes and strategies at the specific level. Biomimic designer has the freedom of choice to operate at the level of optimum advantage, in tune with the technological capabilities and resource s available(Benyus J. M., 2002).

Mentor

Nature is the finest teacher and mentor for the designers of all times. Genius designers like Leonardo da Vinci, mathematician Fibonacci to architect F.L. Wright have looked to nature inspiration, ordering and performance of their productions. Learning from the vast 3.85 billion years of research experience gained through the nature's lab and evolutionary process would immensely benefit the future designers. One has to be therefore, intelligent enough to understand, interpret and adopt the nature's time tested, creative and sustainable solutions and ordered processes f or sustainability individual built forms or in collective urban forms.(Benyus J. M., 2002)

Measure

Biomimic designers view nature as an ecological and sustainable standard and accept what it does. Nature with its organisms maintains sustainability and survival through constant adaptation and satisfying of just needs without causing congestion and contamination. Unlike organisms, humans plunder the nature for pleasure and satisfy their greed, causing imbalance and violent repercussions at times. Human adaptations rarely follow biological laws; instead, attempt to change the very constraints that force their own adaptation. Hence, the antithesis of biological laws is prescribed in the industrial, financial and civil systems. It is worthwhile to recall the statement of Mahatma Gandhi *"The nature has enough to satisfy our need but not greed"*. It is therefore, imperative for a Biomimic designer to comply with nature's standards in the maintenance of sustainability and adapt to the forces of natural transformation rather than aggressive living.(Benyus J. M., 2002)

2.1.4 Biomimicry in planning

Relationship of man with nature can be evidenced since ancient times. The five elements of nature were signified by settlement system. It was perhaps this that the five cities namely, Indraprasth, Bagpat, Panipat, Sonipat, and Tilpat signified the five elements of nature, namely, air, vegetation, water, fire and earth. (Jain, 2009)

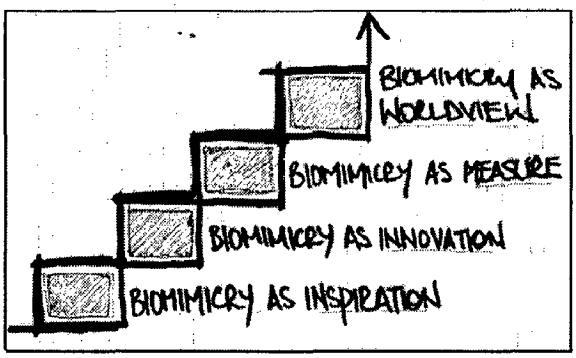


Figure 2-5: Biomimicry as inspiration

As of now we understood how much important is to achieve sustainability through Biomimicry, and some basic principles and strategies to attain it. No doubt all this was understood long back and since then it is practiced, for example Frank Lloyd Wright's organic architecture. Since then nature became inspiring and guiding subject for many developments, innovations and resulted out in some very fine piece of product design or architecture marvel

But as now we are very much concerned about our planet earth, the whole living system, as constituents are getting polluted resulting out in phenomenon like global warming and climate change.

This consistent acceleration of environment pollution is making survival challenging every minute and making difficult for us to adapt. To mitigate such deadly by-products and to save guard our future survival it is essential to improve situation in large scale. Product design man architecture may inspire, may look attractive, may spread awareness, but it is important to transcend our scale, which is now planning and designing of our cities and communities.

Janine Benyus:

"I'm really interested in Biomimicry at the level of cities. Our biologists at the Biomimicry Guild are working with HOK, the world's largest architectural and engineering firm, on master-planning cites. Planning is basically like setting up the DNA, the coding of the cities.

Figure 2-6:JanineBenyus

We said to ourselves (and this is back to 'nature as a measure' question): 'How could a city perform like an ecosystem - like the native ecosystem that would be there if we weren't there?' The goals are very locally informed by the ecological land type.

Ecologists, who have a very specific idea about performance in the ecological realm, can calculate ecosystem services as a metric - how many tons of carbon does a forest sequester a year, how many millimeters of soil are created, how much water is filtered and how much is absorbed in a storm, for instance.

We call these metrics 'ecological performance standards' and say that the city as a whole has to meet or exceed that level of service. It sounds obvious - that a city should perform at least as well as the ecosystem that it replaced - but this is a very aspirational goal."(Benyus J. M., 2002)

3 CHAPTER III – LITERATURE STUDY

3.1 TOWARDS SUSTAINABLE DEVELOPMENT BASED ON BIOMIMICRY CONCEPT

Together with dynamics of change, population pressure, and land speculation, the resultant built form of Indian cities today is complex, unstructured and chaotic. It no more reflects a rational response and ambient to its environmental context. The situation is reaching a crises stage and a sustainable and ecological relationship with built form is missing in coming settlements. Harmony or environmental balance has no meaning in blindly coming up developments and production. There is complete disintegration and fragmentation at all levels: individual, social, physical, and environmental not only locally but at global scale. Thus while planning for any settlement or urban development every individual, their activities, which includes their consumption of resources/requirements to distribution of same till waste generation, are to be smoothly governed.

Now the whole process starting from utilization of resources to generation of waste depends on the users. As many users are there, resources required and waste generation will also be in same proportion. Here resources which are limited should define the size of population to which it can serve.

"Size" here signifies the population, their requirements (based on their social and economic activities), and the size of unwanted elements which will be produced. For existence of any living organism it is mandatory that what all it needs, should be present in its surroundings. When context comes over to human beings, their settlements, then the requirements are the resources such as water, energy, transport, economy, pollution free environment etc. Straight away question comes that, what "size" of population will require how much "size" or resources? The primary step then becomes whether that context has potential to fulfill their resource requirement??? This can be better understood by terms carrying capacity and human load.

3.2 CARRYING CAPACITY AND ECOLOGICAL FOOTPRINT

"An environment's carrying capacity is its maximum persistently supportable load."
-Catton 1986

Carrying capacity is usually defined as the maximum population of a given species that can be supported indefinitely in a defined habitat without permanently impairing the productivity of that habitat. There are underground reserves of non-renewable resources which are unevenly distributed all around the globe. Land is one of the tangible and visible resource over which urban development takes place. Developments possess human population whose size determines the amount of resources or energy required. Resources or energy requirement is first process for development which nature terms as food.

Why carrying capacity?

According to Garrett Hardin (1991), "**carrying capacity is the fundamental basis for demographic accounting.**" From an ecological viewpoint, adequate land and concomitant productive natural capital are fundamental to aim for existence of human civilization on Earth. However, the human population and average consumption, both at present are increasing while the total area of productive land and stocks of natural capital are fixed or decaying. These conflicting trends demand a revival of carrying capacity analysis in sustainable development planning.

3.2.1 Role of trade and technology

Introduction of technological advancement made extraction and exploitation of resources easy.

Production of usable goods and services from natural reserves became easy. This in turn increased rate of utilization of products achieved out of non-renewable stocks. In addition to this trade made import and export of products and services possible. This further increased the consumption rate. Technology made possible to achieve products more efficiently, and trade made it easy to transport, this in combination increased carrying capacity at any region.

Now, this increase in carrying capacity is more illusionary than real-world. Fact that amount of natural reserves is constant on earth at a given time. They are in fixed quantity wherever located on globe. And therefore practically trade and technological advancement works against law of conservation of natural reserves or non-renewable resources on earth.

Thus ***Role of Trade and Technology*** *has* ***transformed the guiding factor from Resources available to Resources Required.***

It means that we need not to worry about the available resources in any specific area (though fact remains that resources are constant globally) to fulfill the requirements of people; rather we need to know how much resources will be required for the given population.

Our next challenge is to recognize this phenomenon and reduce their resource consumption by all possible means. The resources which are utilized by any person accounts for reduction of same in global parameters which can be better understood in terms of Ecological footprint.

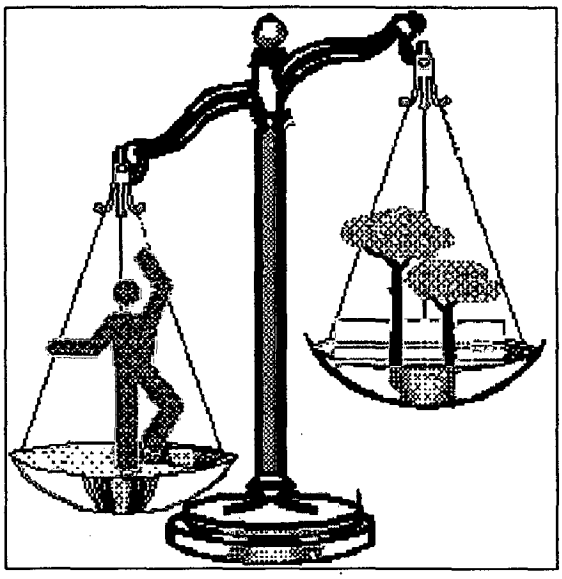


Figure 3-1: Conceptual representation of Carrying Capacity

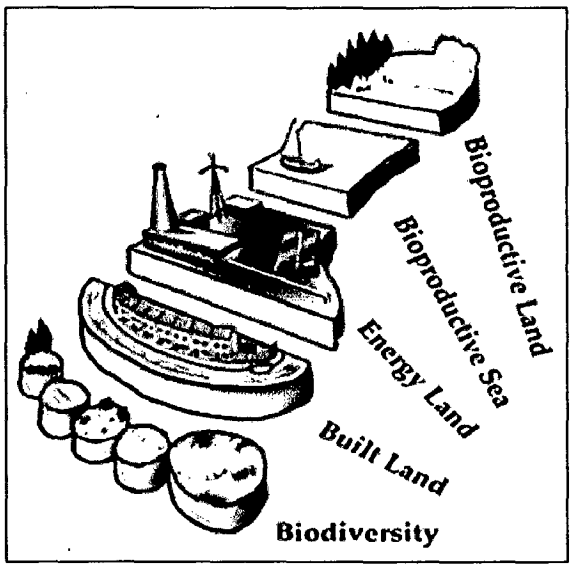


Figure 3-2: Conceptual representation of Ecological Footprint

3.2.2 Ecological Footprints

Ecological Footprint- The corresponding area of productive land and aquatic ecosystems required to produce the resources used, and to assimilate the wastes produced, by a defined population at a specified material standard of living, wherever on Earth that land may be located.

For example Ecological Footprint of the Netherlands

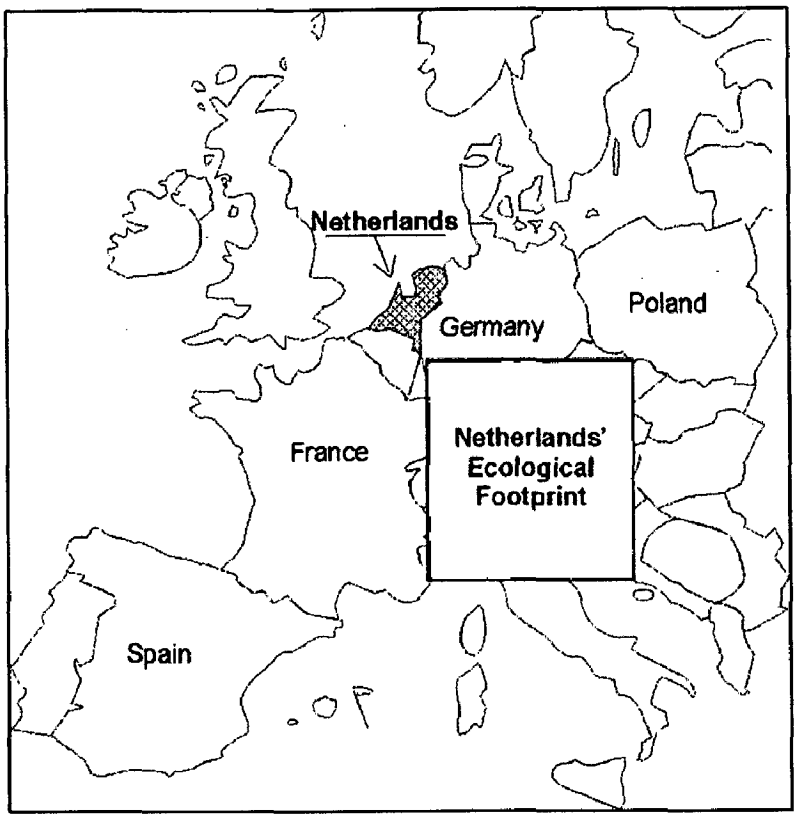


Figure 3-3:Map showing Ecological Footprint of Netherlands (Rees, 1996)

With an area of 33,920 square kilometers and a human population density of 440/km2, the Netherlands depends on the ecological productivity (carrying capacity) of an area almost 15 times larger than the entire country.

Thus to achieve Sustainable Developments for Settlements, the appropriate carrying capacity of Ecological Footprint based planning should be evolved. Sustainability in terms of Resource Saving Efficient functioning and waste management should be aimed by working out for Nature Oriented Development. Design which conserves resources, protects nature by not producing waste, pollution and ultimately by not degrading environment.

Efforts to achieve the Nature Oriented Design can be evolved by observing Nature's components and making them behave as natural as they can. In other words this is same what is popularly known as Biomimicry. The efforts can be made in the following manner:

3.3 NATURE ORIENTED URBAN DEVELOPMENTS

The planning and designing for any sustainable settlement should be evolved in its ecological context, covering the following basic components:

1. Spatio gravitational context
2. Thermo atmospheric
3. Urban Landscape And Water
4. Vegetation and organic life
5. Sonic

Recognizing the fact that human life, the built form and environment are intricately inter-linked, and inter-dependent, 'nature oriented design' comprising of the following basic premises can be evolved:

3.3.1 Spatio-gravitational context:

i. City structure commensurate with the dynamics of growth, decentralization of activities, economy of scale and better quality of life.
ii. Higher level of mixed land use based on environmental and performance criteria.
iii. High density, incremental and compact pattern of community residential development.
iv. A coherent urban form, controlled streetscape, enveloping of inner city areas, landmarks, nodes, pedestrian precincts, chowks and squares.
v. Wider variety, intermixing of socio cultural activities: relationship of commercial and public activities with public transportation and morphology of city/centre shopping.
vi. Built form in regional, historical, socio-cultural context and particular potential of an area.
vii. Exclusion of environmental endangering land uses.

3.3.2 Thermo-atmospheric:

i. **Climate**: It is essential to consider climatic conditions while designing any development. Exposure to sun, air movement, and shade should be provided according to the contextual need of any region. Relation among open spaces and built structure should approach towards livable and encourage co-existence with nature. Three dimensional structures should be designed with respect to human scale to produce functional urban form.
ii. **Air pollution and transport**: Transport in cities usually contributes nearly two- thirds of the total air pollution in the form of suspended particle matter. This is causing a serious threat to the environment and health of the people. The objective should be to provide access to the people and places by 'Green' of urban transport .these include walking, bicycling, intermediate public transport modes, exclusive bus ways, dedicates bike tracks,

CNG powered vehicles ,trains etc. Inherent with this is the aim to curtail the need for commuting and to shorten the distances by various strategies, such as decentralization of work centers, urban form, and by telecommunications, electronic mail, mixed land use zoning, etc. the alternative modes of transport need not be high cost and high technology solutions, but there are several low cost and high technology solutions, but there are several low cost options, which can be explored. Polluting and life endangering transport modes have to be discouraged, while environment friendly modes need to be given centre-stage.

iii. **Decentralized services and Recycling**: in the context of emerging environmental awareness, the need to save air, water and land from pollution is major concern. Drinking water, sanitation, solid waste treatment and drainage are few important aspects of the environment. The performance of present sanitation system needs to be reassessed with reference to the environment, hygiene and their accessibility. Various alternative technologies, based on decentralized services, like Extended aeration Technique, Bio gas Production, Bubble Diffusion Process, Floatation, Anaerobic reactors etc. ,which are already in vogue, should be explored for urban sanitation.

Widespread method of land filling for solid waste disposal is an environmental disaster. Decentralized system based on recycling, energy generation and organic decomposition were explored for solid waste treatment. Bio reactors composting and vessel system, vermin composting etc. are new generation technologies which can be employed for treatment of urban solid waste.

3.3.3 Urban Landscape and Water

Tress have significant value in oxygenation and air replenishment by converting, carbon dioxide into timber. One hectare of green space with trees provides an equivalent area of 5 hectare. The studies indicate the existence of parks; lawns and tress effectively lower temperature by 3° to 5°C, with relative humidity increase by 5 to 10 % (Jain, 2009).

The city should have variety of open spaces at the rate about 2 sqmtr, per person at housing area level (tot lots, having parks, courts), 2 sqmtr at neighborhood level (playground, neighborhood parks, etc.), 2 sqmtr at zonal and district level, 2 sqmtr at city level, totally to about 8 to 10 sqmtr per person (Jain, 2009).

The earlier studies believed that an area of 30 to 40 sqmtr supplied the oxygen requirement of one man. However this is to be relating to type of plants, pollution level and micro climate. Empirical studies have been carried out which prove the effectiveness of plants as "filter" to suspended particulate matter (SPM) and noise. Through its dense canopy, vegetation could substantially absorb particulate matter. The green belt around the city could decrease the SPM by nearly 15 times. Plants have been classified on the basis of average area covered by shade and leaf size (Jain, 2009).

Basic principles:

Land and water have uterine relationship, both in terms of form and function. Men have always strived to integrate the use of water for improving the environment, microclimate and aesthetics, beside its use of

drinking, survival and production. However, sometimes the balance seems to be getting disrupted. This requires a reorientation of planning and landscape development based on following basic principles.

- Linking of natural water body /river with the population by access and landscape development.
- Control of pollution of water from industry, drainage, sewerage, Fly ash, garbage and waste dumping.
- A drainage and flood control strategy linked with water supply.
- Control of unauthorized development and land uses which are incongruous with the environment, e.g. Sanitary landfills, industry, thermal power stations, etc.
- Watershed planning; the revival of the age old concept of watershed development, harvesting, conservation of rainwater and recharging the underground water.
- Conservation of surface water source: the rivers and water bodies in urban areas usually have high level of pollution, which is mainly from the untreated sewer and waste from adjacent industrial areas. Besides, the enforcement of water pollution control act, and environment based strategy of land use is essential for their improvement.
- Climate: Exposure to sun, air movement, and shade should be provided according to the contextual need of any region. Relation among open spaces and built structure should approach towards livable and encourage co-existence with nature.
- Greenways for Drainage: The development of greenways around natural water drainage corridors and harvesting of rainwater in balancing lakes and ponds can be new frontier in city development. Instead of resorting to conventional drainage, the concept of "zero runoff" should be adopted by using a series of retention ponds. Such ponds, reservoirs and sediment traps are located in the catchment zones on low lying ground, which is earmark for greenery. The system offers distinct advantages over conventional drainage system.

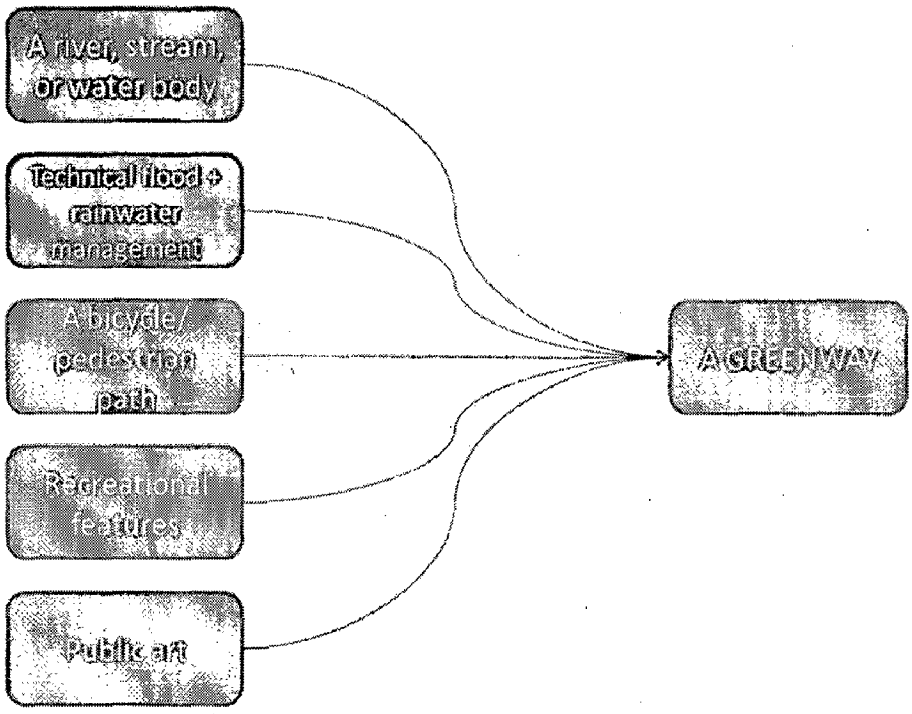


Figure 3-4: Diagrammatic representation of concept of Green ways

3.3.3.1 Water conservation and saving needs following actions:

- Reduce demand
- Try to ensure that the quality of the water is as high as required for the use but no higher.
- Organize the site so that as much as of the rainwater falling on to it as possible can be used sensibly.
- Even if water recycling is not incorporated at the outset of the project, allow for its incorporation (in terms of space for storage, pipes, etc.) at a later date.
- Consider rainwater recycling and bath-water recycling for all new projects.
- Choose vegetation that does not need irrigation in the summer.
- Water is physically and psychically nourishing -design with it.

3.3.4 Vegetation and organic life:

i. Lung Spaces: for the urban area, about one-fourth of the total area should be available for Recreational land use, which includes district / regional parks, urban forest, etc. besides this; about 10% to 15 % of the area should be planned for neighborhood parks and playgrounds within the residential area. In a city about 10 sq mtr of recreational area per capita should be reserved as open space. A system of landscaped linkages connecting various parts of the city, neighborhoods and important monument should be planned. The garden, both at community and dwelling scale should provide a sense of oasis and shelter form oppressive climate. Peripheral green belts should be utilized as wind breakers , filters of dust storms and as transition zones

ii. Green ways for drainage: the development of green ways along natural drainage corridors and harvesting of rainwater in balancing lakes and ponds has been a new frontier in water management. Instead of resorting to conventional drainage, the concept of "zero run- off" may be adopted by using a series of retention ponds. Such ponds, reservoirs and sediment traps can be located in the catchment zones on low lying grounds, which is earmarked for greenery. This system offers distinct advantages over conventional drainage system, such as :

   a) A much quicker, efficient economical process of drainage
   b) Continuous replenishment and enrichment of underground water table and augmentation of water reserves.
   c) Availability of rolling greens and recreational areas.
   d) Improving the micro climate.
   e) Ensuring an environmental sustainable development.

This way the city would have floating greens and interconnected parkways; these linear connecting green trails bring landscape in the midst of concrete jungle. There is no need for elaborating gardening greenways, but their wild, simple, and natural stretch by its trail could be one of the cheapest form of drainage and recreation. These natural corridors filter water run-off before it enters the river, protect biodiversity and preserve woodland habitat. These act as air filters for widespread vehicular pollution.

They interrupt monotony of built form and tie the neighborhoods together. A connected spinal system of greenways would act as green belt and recreational reservoirs.

3.3.5 Sound

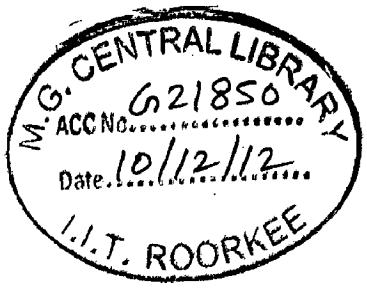
Noise is emerging as major pollutant in the Indian cities. Its high intensity is constant source of pain and disturbance and cause of health hazard. Against a permissible level of 50 to 60 dB, the sound level invariably exceeds 80 dB (Jain, 2009). Faulty and leaking silencers, over-use of motor horns, screeching tires, rattling bodies of vehicles playing on rough roads accentuate noise level from the traffic. Besides this the noise from commercial and industrial activities in residential zones, unabated sound amplifiers, and generator sets and fire crackers often disturb the peace in urban areas.

It is not only the question of discipline, civic sense and enforcement that help in reduction of average noise levels, but also an aspect of urban form and land use planning. Landscape and green buffers can immensely reduce noise levels. It is not desirable to locate residential areas along major arteries and non-residential activities inside the residential localities that would invite outside traffic. By proper land use planning, mixed land use, location of public and semi-public spaces and commercial activities along major transport arteries, a buffer zone can be introduces for residential zone. The green buffer with thin buffer trees, land formations, mounds, embankments, etc. would provide effective barriers to spread of noise. The urban form articulates the environment and vice versa. It is necessary to readdress the planning process taking a dynamic and holistic approach, where human element, physical environment and built-form synthesize into a workable equation. The old paradigm of development needs to be reformed within the larger goods of human satisfaction, environmental conservation and minimal consumption.

4 CHAPTER IV- TRANSLATING NATURE IN TERMS OF URBAN DEVELOPMENT

Now if urban development is translated in terms of nature, it will be simplified by the help of nature's basic principles. Broadly classifying **nature's working** as:

- It generates its own food
- Circulates through whole body and gains energy out of it, and
- Produces waste which becomes other's food.



In terms of urban development these parameters can be

- Allocating and generating resources and energy out of it
- Provision of services and transportation to whole system, and
- Waste management.

4.1 RESOURCES

First step regarding resource consumption should be to reduce, reduce the consumption of process which involves more resources. Reduction in consumption of resources does not means reduction in quantity only, but mainly reduction of ecological footprints. For example, if nature is producing any material in abundance, which is environment friendly too, then to use it in same rate in which it is produced is not objectionable. On the other hand if any product is produced by nature whose usage is not environment friendly, one should avoid its consumption, no matter at whatever rate it is produced. Thus as now concept of carrying capacity, role of technology and ecological foot print is clear, major focus should be given to "Ecological Footprint".

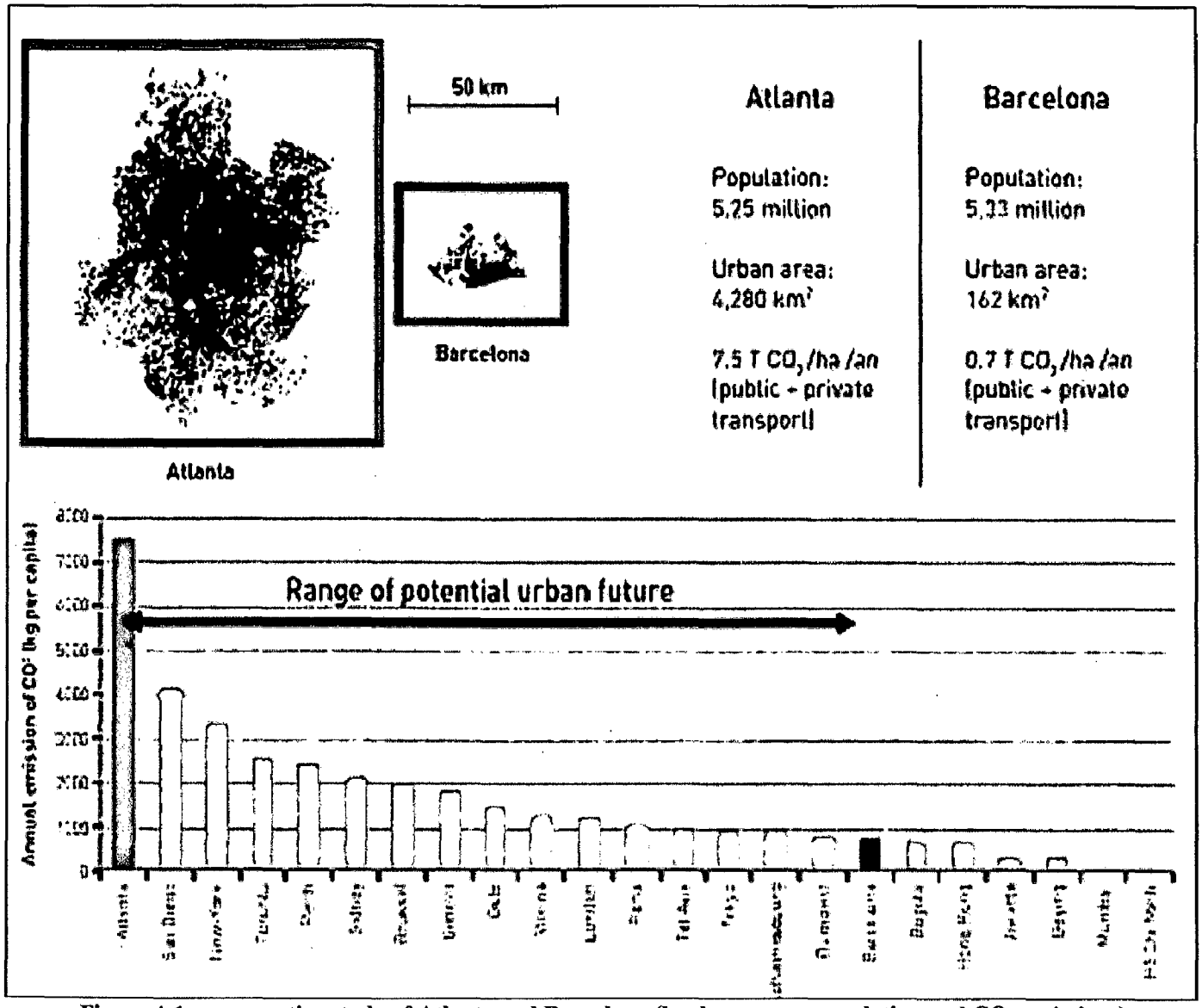


Figure 4-1: comparative study of Atlanta and Barcelona (land resource, population and CO_2 emissions)

For example, an interesting map above showing the built-up area of Atlanta and Barcelona, represented at same scale:

In above given fig. Atlanta and Barcelona has been shown on same scale .In this illustration it is shown that Barcelona accommodates 5.33 million populations, with having resource provision of only 162 sq. km. On the other hand Atlanta which has 4.280 sq. km of land resource accommodates only 5.25 million of population. Is becomes not only interesting but also raises questions; how and why this vast difference in per capita resource consumption exists.

Both countries cater almost same population (Barcelona more) where land area occupied by Atlanta is more than 26 times of Barcelona.

Not only this (resource consumption) but CO_2 emission by Public Private Transport is 7.57 CO_2/Ha/ annum and .77 CO_2/ Ha/ annum in Atlanta and Barcelona respectively.

Thus it is quite evident that high density, settlements, cities of developments consumes less of resources (land resources) and produce considerably less amount of CO_2or waste.

Resources can be broadly classified into renewable and non-renewable resources. To attain Sustainability it is mandatory to depend only on renewable resources as much as possible. Renewable source of energy whose basis is sun's energy is very powerful source; the effort should be made to utilize it as much as possible. Energy from sun, wind and other form of renewable energy should be incorporated in designs and developments of any settlement. Technology and scientific advancement should be made to transform this energy in usable form.

4.2 ENERGY

Energy is very essential part in any development to take place; it works as major ingredient for city to grow. It acts like food for any urban development or any city. To save environment and to act like nature energy should be extracted mostly out of renewable resources.

If we look nature for this purpose, trees, plants, animals, aquatic life or any other natural process. Basic source of energy is sun, which is renewable source of energy. All naturally growing processes gain energy from sun (directly or in directly). Trees which grow by the process of photosynthesis make fruits, vegetables which feed herbivorous to grow, which become food for carnivorous, and finally medium for bacteria to grow. Thus in nature constantly things are under process to transfer energy from renewable resources toother living organisms.

In following figure we see that highly uneven spread of per-capita energy consumption is prevailing all over the globe. This gives a clear idea that an inefficient system of energy consumption exists.

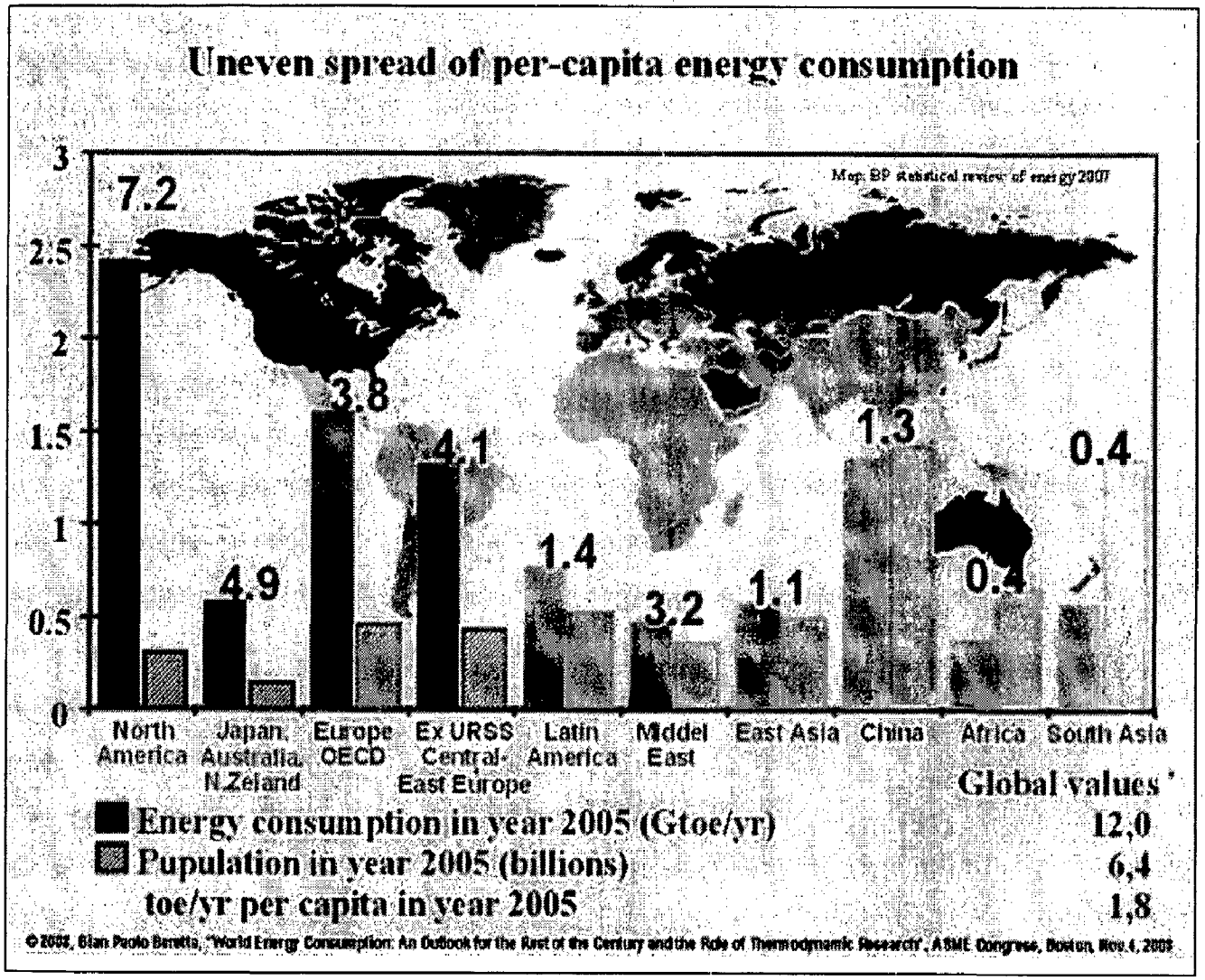


Figure 4-2: Uneven spread of per capita energy consumption

The United States was self-sufficient in energy until the late 1950s when energy consumption began to outpace domestic production. At that point, the Nation began to import more energy to meet its needs. In 2009, net imported energy accounted for 24 percent of all energy consumed.

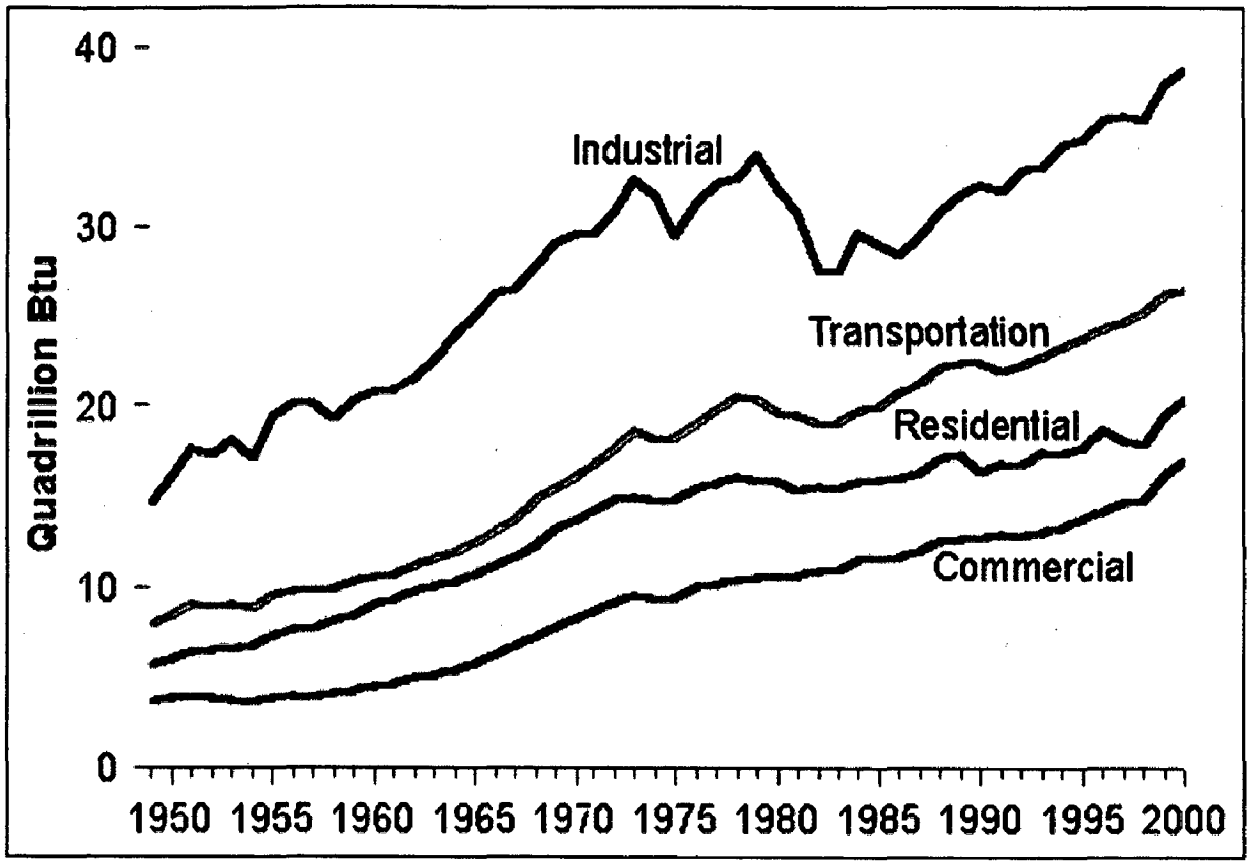


Figure 4-3: Energy in the United States: 1635-2000 Energy Information AgencySeptember 2003

This matter requires immediate attention and for this we need to understand the reason behind such uneven spread of energy consumption. The basic four sectors, transportation, industrial, residential and commercial consume high amount of energy.

Reason behind considerable difference in energy consumption are-behavioral and urban structure as the main cause (refer figure above).

I. **Human activities**
II. **Type of urban development** (refer graph above)

Understanding them and solving the cause one by one in required. First, to control energy and environmental impact due to human activities ecological taxation should be introduced:

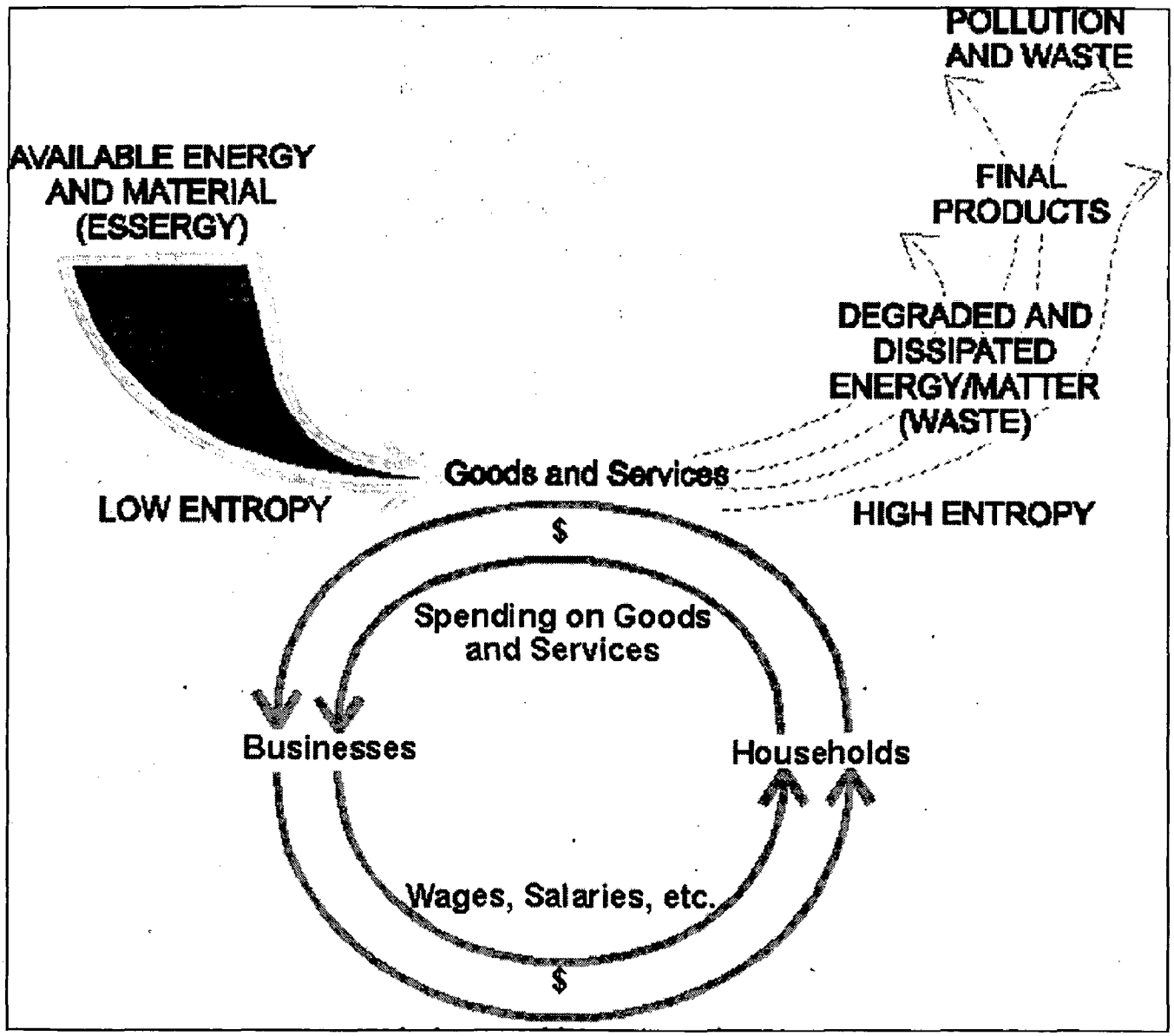


Figure 4-4:Shows cyclic process (Rees, 1996)

The solution to this lies on socio-economic behavior of people. Always tangible/visible product is seen by the public. If any product has ecological benefits also it can't be measured and thus economic importance becomes influencing factor to quantify that product.

Let us say there exists a product "A" which utilizes 70% of raw matter into product ant 30% of it as waste or by-product (which has negative impact on environment). On the other hand there is product "B" which utilizes 90% of raw material and generates 10% of waste. Due to advanced technology and efficiency product "B" is expensive, but it environment conscious process. People in mass will go for product "A" which is cheaper but invisible cost which they are paying is of environment degradation.

Here government or political body is required to play a decisive role. A body should examine it from the point of environment, and it should charge high amount of tax from producers which do not concern about environment. Ultimately when product "B" will appear cheap then only people will vote for it. Introduction of this tax should be termed as "ecological taxation".

All four major economic sectors of the economy recorded tremendous growth in their use of energy. The industrial sector used the biggest share of total energy which can be tackled through "ecological taxation" as explained before. Other impacts which are due to urban development are more complex but understanding and making changes can make considerable differences.

4.2.1 Renewable sources of Energy

It is the fossil fuels that we are utilizing to produce energy on which we highly depend on. The natural stocks took billions of years to achieve such a huge potential to fulfill our demands. Natural reserves within the earth and earth itself including air, water, soil and vegetation have continuously gained energy from sun for billions of years. We should realize that main source lies with sun. Sun only by photosynthesis generates vegetation, sun only evaporates water, sun only gives kinetic energy to wind and sun only helps to generate oxygen and helps the survival of the entire life in this world etc.to ensure our sustainable existence we should stop exploiting natural reserves and focus more towards utilizing energy directly from renewable resources, basically solar energy should be harnessed wherever possible to generate energy

Harnessing of Renewable energy aims not only in increasing energy generation but also helping restore pollution- free environment. It is estimated that India has potential of generating more than 100000 MW from non –conventional sources of energy. The concept of Renewable Energy Vision 2010 targets for an installed renewable energy capacity of 3000MW and disbursement of Rs. 13880 crores in the form of financial assistance for development of renewable resources of power (Jain, 2009).

4.2.1.1 Energy efficiency

Energy should be majorly extracted from sun, because sun is the only main source behind renewable and non-renewable source of energy. After realizing this fact it is important to utilize it to fulfill our requirement of energy. No doubt that quantity of energy which sun releases is far more than our needs. The efforts should be made to efficiently convert energy from sun to our require form. This efficient conversion accompanied by efficient supply and efficient usage will solve our energy crisis issue to large extend.

4.2.1.2 Solar Energy

Country like India which lies in tropical region are blessed with direct radiation from sun. This claims its high potential of renewable source of energy. Regions having similar context (hot-arid regions, latitude 15 and 35 north or south) can produce 500kW of energy per day from surface that is exposed to sun for 8 hours in a day. This can produce energy for more than 3000 hours annually, even in warm-humid regions 2300 hours of solar energy can be received and utilized. (Jain, 2009).

4.2.1.3 Wind Energy

Wind represents the conversion of sun's heat into kinetic energy. Wind power, which is inexhaustible, and non-polluting, is a promising way out of energy crisis. It is estimated that 4 % of the solar energy is converted into wind energy. It is estimated that wind energy potential of India is 45000 MW. It can be tapped wherever there is there is desirable wind speed of 20 km/hr or more. The MNES had plan of plan to add another 100 MW of wind energy during the 9^{th} five year plan. (Jain, 2009).

4.3 URBAN TRANSPORT:

The growth of urban population in India has been phenomenal during the course of last century. While the population of India has grown by four times from 19-01 to 2011, its urban population has increased by eleven times, from 25 million to 85 million over the same time period.

It is estimated that the urban population of India will be 500 million by 2016. The total population in million plus cities increase to 145 million in 2001, and there were about 60 million two wheelers and 8 million cars in metropolitan cities. Increased use of personalize motor vehicles is chocking the already congested roads. An inefficient urban transport system, empedius the growth of urban economy and leads to several problems like air pollution, high incidence of traffic accidents, etc.

The link between transportation an environmental quality has been long recognized, although the preparation relationship has changed overtime. Concerns at local level like noise, air pollution, and loss of green space, traffic delays and accidents have transcended to the fundamental issue of survival of ecological system.

Another intrusting graph below shows the relationship between population density and per-capita energy requirement.

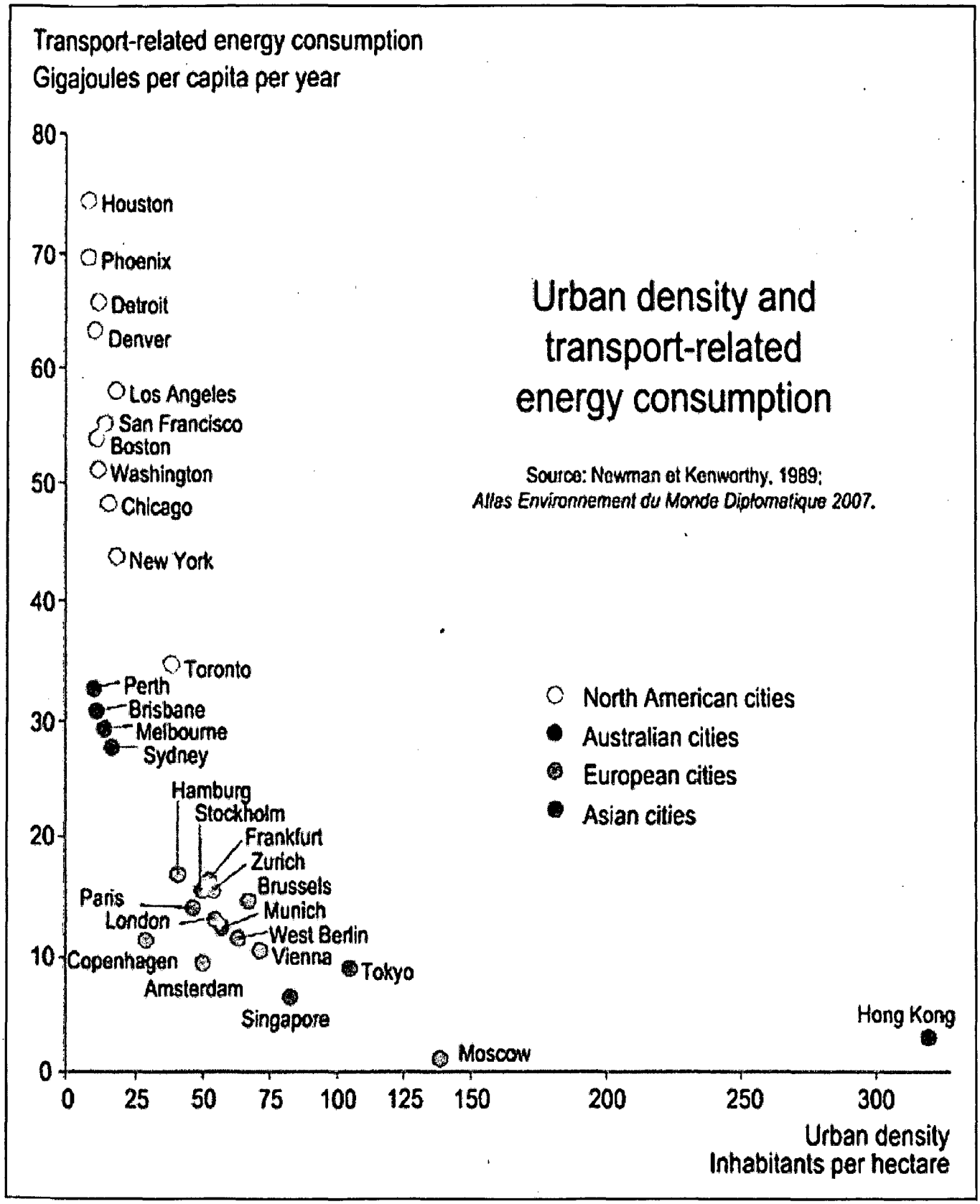


Figure 4-5:urban density and transport-related energy consumption (Kenworthy, 2007)

In reference to graph above, cities with more density ex. Hong Kong, Moscow, Singapore etc. consume comparatively very less per capita. On the contrary to it cities having low population density consume high amount of per capita energy ex. Houston, Phoenix etc.

Thus, high density development, compact city and Smart growth practice advocates mixed use practice as much has been written all over about the myths of conventional planning. It has been accepted world over that higher densities does not over burden services and it does not require more infrastructure support.

It has also been established that higher densities does not create congestion and is better environmentally. It is globally accepted that mixed land use (MLU) helps on revitalizing community life and attracts pedestrian back on the street. It is also established that in today's service economy communities find that by MLU's they are able to balance the quality for life criteria to determine where people will settle.

Contrary to prevailing beliefs, car use is much higher in cities that have strict zoning and very little mixing of business areas with residential areas. So, Houston in U.S.A. with wide roads, low density (9 person per hectare) and separation of residential areas, has very high use of cars (25400 km per person per year) and long average travel time (90 min) compared to Honkong which has a density low car use (1300 km per person per year) and low travel time (40 min).thus it can be concluded that

- Private car use can be reduced with mixed land use policies.
- Provision of efficient public transport and taxi/free wheelers.
- Services can reduce private vehicle use.
- Public transportation is not very successful if we do not have mixed landuse policies in a city along with high density living.

Observation clearly states Cycles, as mode of commuting, are non- polluting and environment friendly. They have added advantage over motorized vehicles Cycles are space saving, occupying one sixth of car space. Whereas car can cater to 120 to 220 per mtr width of roads, cycles can carry 1500 persons (Jain, 2009). It is also time saving, flexible and gives personal freedom due to its size and flexibility. It is accessible in narrow streets undulating terrain and difficult areas

4.3.1 Greening of urban transport

The challenge of urban transport can be substantially met by recapturing the streets for pedestrians, cyclist and fuel-efficient, low speed two wheelers. After decades of efforts to travel faster and further, the objective now must be to provide access to people and place by 'green' modes of urban transport, which include communications, walking, bicycling, intermediate public transport modes and trains. Inherent with it is the aim to curtail the need for commuting and shorten the distances by various strategies, such as telecommunication, electronic mail, mixed land use zoning etc. polluting and life-endangering transport modes have to be discouraged and relegate in the margin, while environment-friendly modes of transport need to be given Centre-stage. It is necessary to develop ecologically sound, extensive and well equipped public transport system that is not a source of physical injury, or air and noise pollution. The provision of 'Green Lungs', 'pedestrian precincts' and 'exclusive bicycle tracks' facilities are integral to the development of transport system. As such the 'greening of urban transport', has to become a basic objective of city development and transportation planning.

This transportation heading deals with mode for commuters to travel as well as transportation of infrastructure services which are provided to households. Transportation at present is the biggest problem in urban areas. Population is increasing exponentially in urban areas, due to fact that economic activities invite migration. To travel faster and farther every individual tend to possess car or bike (motor vehicle), which adds to already congested roads. It gives rise to many problems such as- pollution, more energy requirement, noise pollution, vehicle dominance which kills pedestrian friendly environment, parking, traffic, irritation etc.

Now, again to resolve this problem if we go back to nature; we find that Nature has resolved this transportation issue beautifully, actually it channelized this flow of nutrients first and according to it further growth was decided. Example river (with its tributaries and distributaries), veins in leaf or human body, they follow path of least resistance and hierarchy. Hierarchy is the key to any distribution from source to end. Leaf or tree for example has thick stem (initial carrier or nutrition) and further it is divided into branches and further to thinner channels. A very clear volumetric idea of nutrients can be understood in hierarchical distribution can be seen.

Important thing which came across this 'learning from nature's process' was that it follows one way movement. It should go on with flow, it should follow path of least resistance. Consider our arteries and veins; one performs to distribute blood through whole body and another collects it back to heart. They both reach to every part of body but blood movement within them is defined, is one way. This reduces or even eradicates all possibilities of congestion and blockage, and thus smooth flow can be achieved at continual pace. Thus two important things can be concluded; one, flow should be in hierarchical form from source to end. Second, flow should be defined, in order and should never clatter.

But now if we consider an urban transport and services, things are much more complex. It is not only the hierarchy of roads or infrastructure services but also hierarchy of modes within them. Several categories in transportation modes are there, consider basic two- vehicular and pedestrian.. To the distances where pedestrian are comfortable and are preferred, there vehicular are not chosen. On the other hand, distances where vehicles are preferred, pedestrians find difficult to reach there. Thus, desirability is vice versa, and thus relationship is clear. Hierarchy of Vehicular and pedestrian are inversely proportional to each other. After evolving relationship among them (vehicular and pedestrian mode) which is- they both are inversely proportional to each other. This may mean that everywhere roads should be of same width, only type of mode will define its hierarchy. To understand this in depth we should consider another aspect of transportation; which is duration for space consumption by any mode is occupied for. And thus, volumetric allotment of space will be based on space and time occupied by vehicles and pedestrians (and all other modes).

This has been implemented in given proposal in such a manner that it becomes pedestrian friendly development. Distances up to which pedestrian feel comfortable (up to 200 mtr), have been given provided pedestrian oriented environment. And the distances which can only be covered by the help of vehicles, are vehicular movement oriented. Intermediate movements are designed accordingly.

4.3.2 "Stagnation leads to contamination"

For planning for urban development, functionality becomes the major issue. Basically, how to plan for infrastructure services and transport? Thinking on same lines made me ponder on Dr. Raiiv Chittranshi's (doctor/surgeon) line "stagnation leads to contamination". His line was in context to healthy human body, but yes, this line gave biological answer to the question. Going back to nature and asking solution for same cleared whole picture. Though all systems are beautifully and functionally integrated to each other in nature, but every unit performs its function individually with full efficiency. The integration of systems and performing best in isolation are the key to ensure best functionality within any development.

Thus, this led to design transportation and services which are connected to every household. Separate service corridor has been designed to cater whole site. It may involve initial high amount of capital but will have least amount in managing and maintaining it. Such better way to provide services is far better than conventional one where cities like Kanpur, Lucknow (existence dates more than 100 yrs.) and many other are always under construction to cope up with backlog, which creates problem continuously. Every new day roads are dug to manage, to maintain and to provide service, which adds to problem of transport.

Another very important process which nature teaches is that in Nature things grow; things grow in proportion in a living body. For example if we consider a baby who has bones, nerves, and whole body structure, as and when he/she grows his/her size of bones, nerves and whole body also grows; that to in same proportion to carry out functions in similar manner. To provide strength bones grow, to provide nutrition nerves grow and similarly whole body. Same happens with plants while growing and becoming trees, its stem broadens.

The point here is that why even after increasing density or F.A.R. of any urban area, the size of roads and infrastructure remains same??? Volume of commuters increase in same proportion too and thus ability to transport (people and services) should also increase. This can be achieved it two ways-

- By increasing the surface area of roads. Or
- By increasing ability to travel faster.

Increasing surface area simply will lead to broaden the roads which will cater more traffic. But implementing this strategy becomes almost impossible in already developed urban areas. Due to the fact that buildings very soon occupy areas adjacent to roads, thus scope of widening them is lost. Yes we can go three dimensional in this case by developing layer of commuting medium. For example fly overs and metro-lines up to some extent.

Another solution to resolve this transportation issue can be by introducing efficiency to travel faster on same existing space. This can be done only by the help of public transport oriented development. In this context, technology can play important role; by introducing modes which can transport mass by occupying less space on roads for less time. Best example here too is metro rail, as they carry large amount of mass by consuming less space (average per capita space) for lesser lime.

Thus in our planning approach we should incorporate such flexibility. Scope of such understanding and innovations should be given respect to achieve sustainable development.

4.4 WASTE MANAGEMENT

For solid waste management the best what we can do is explained in simple manner in the graphic below:

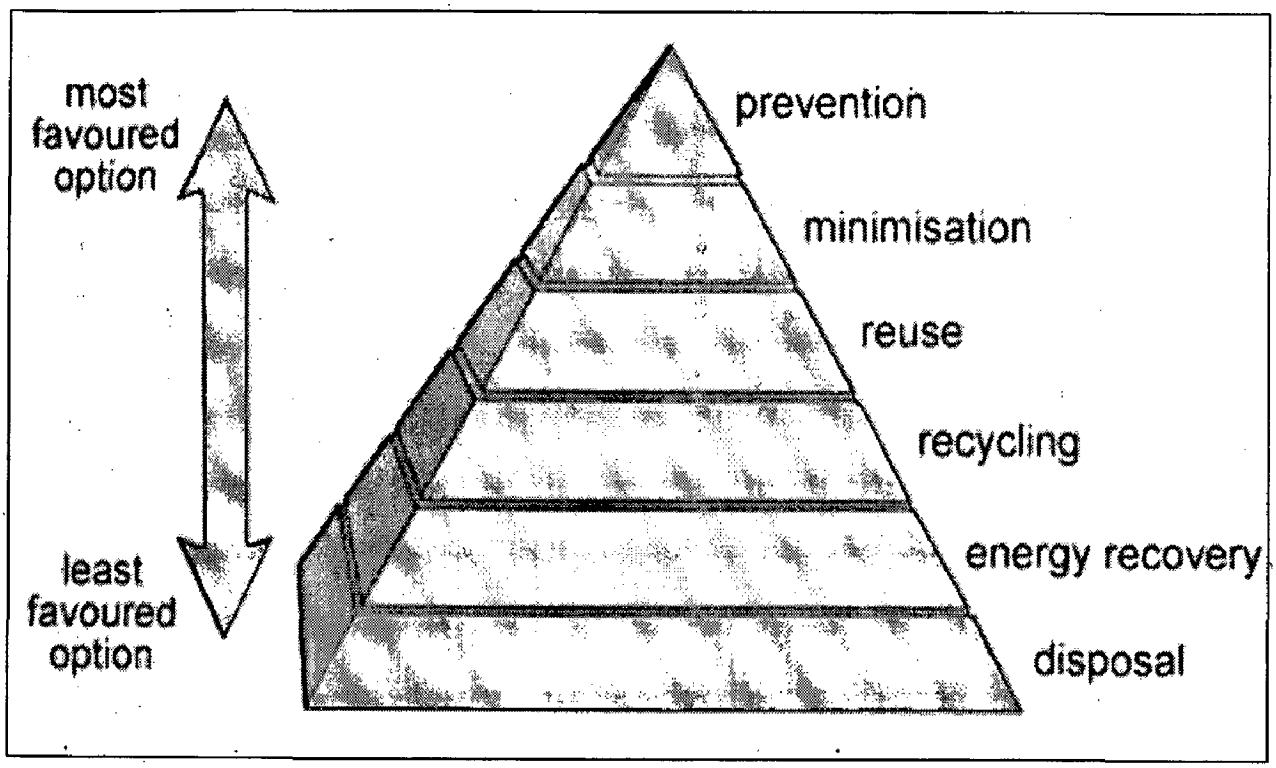


Figure 4-6: Creating Up cycling

Creative Up cycling; the graph above form it is showing teaches the behavioral response towards waste management. In pyramid form top most point is depicting most preferred practice and base as least preferred practice (Intermediate stages respectively).prevention to generate waste should be in our habit. After that minimization of waste generation, followed by reuse of the waste should be incorporated. Then even if waste is produced, it should be recycled and next step should be to incinerate and generate energy out of it. If no option remains among all mentioned above, then last action should be to dispose off the waste, which is finally of no use.

Least waste generation and treatment of same to achieve "zero waste" or example of "waste to resource" till we say **"Don't waste Waste"**

5 CHAPTER V - CASE STUDIES:

5.1 ENERGY PRODUCTION BY THE MEANS OF RENEWABLE RESOURCES

5.1.1 Roof-top solar scheme to be emulated in Rajkot, Surat, Vadodara and Bhavnagar (admin, April 17, 2012)

In a yet more stride in Gujarat's bid to become a solar capital, the Chief Minister Narendra Modi will dedicate 600 MW solar power generation capacity to the nation on April 19 at Charanka village of Patan district.

It is noteworthy that Gujarat government has come up with various initiatives in the field on non-conventional energy sources with a view to promote environment-friendly industrial development. Gujarat was the first state to launch a full-fledged climate department and launched a comprehensive solar policy in 2009 to address growing environmental concerns

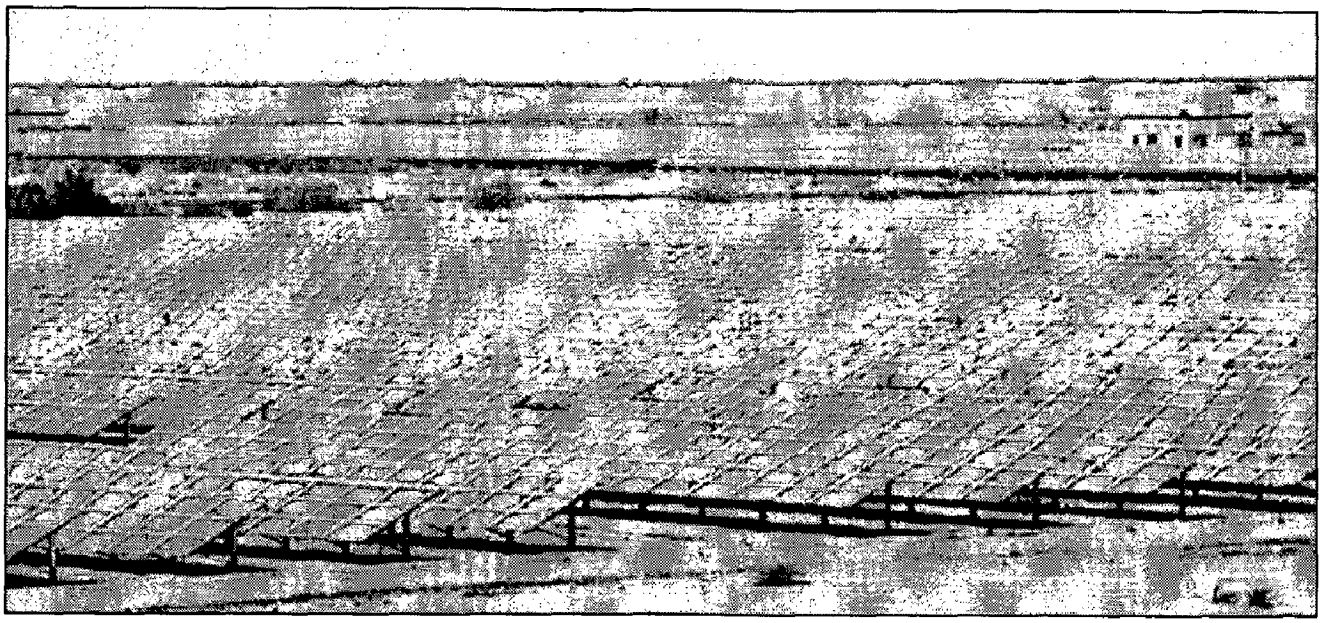


Figure 5-1:Usage of Solar panels in gujrat to generate energy from renewable resource

With an aim to make Gandhinagar as solar city, state government has come up with roof-top solar power generation scheme. Under this scheme, the State has planned to generate five megawatt of solar power by putting solar panels on about 50 state government buildings and on 500 private buildings.

Apart from this, the State government has also come with the initiatives for exploiting the wind and tidal energies in line with its approach of promoting renewable energy sources in the power generation.

5.1.2 State pulls off rare feat in reaping Sun, saving water (Nair, 2012)

Gujarat has piped Punjab in setting up the country's first canal-based solar power projectby executing a 1-MW (Mega Watt) project on one of the branch canals of the Narmada canal network in the state.

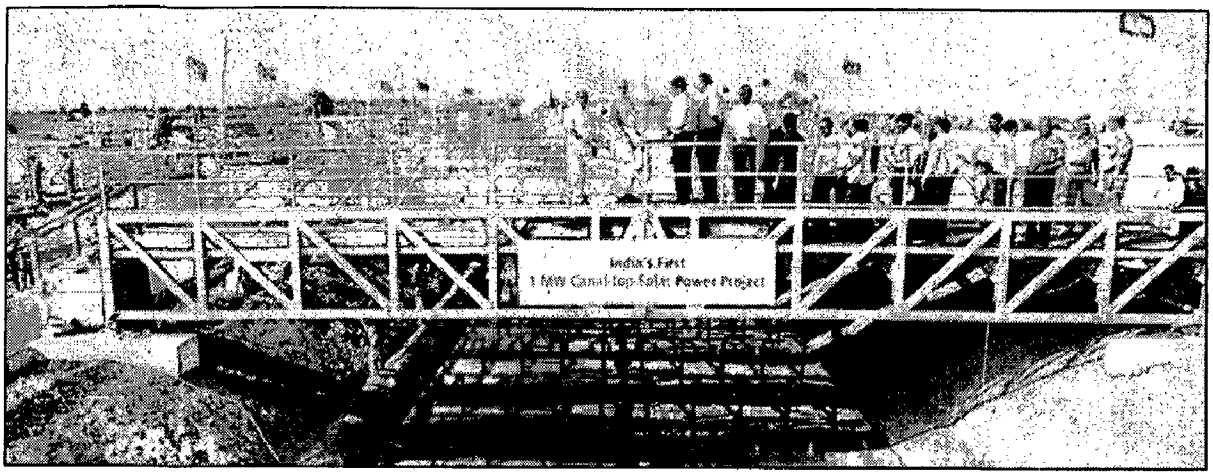


Figure 5-2:Mr.Narendra Modi(C.M. of Gujarat) inaugurating solar panel's installation over drains in Gujarat

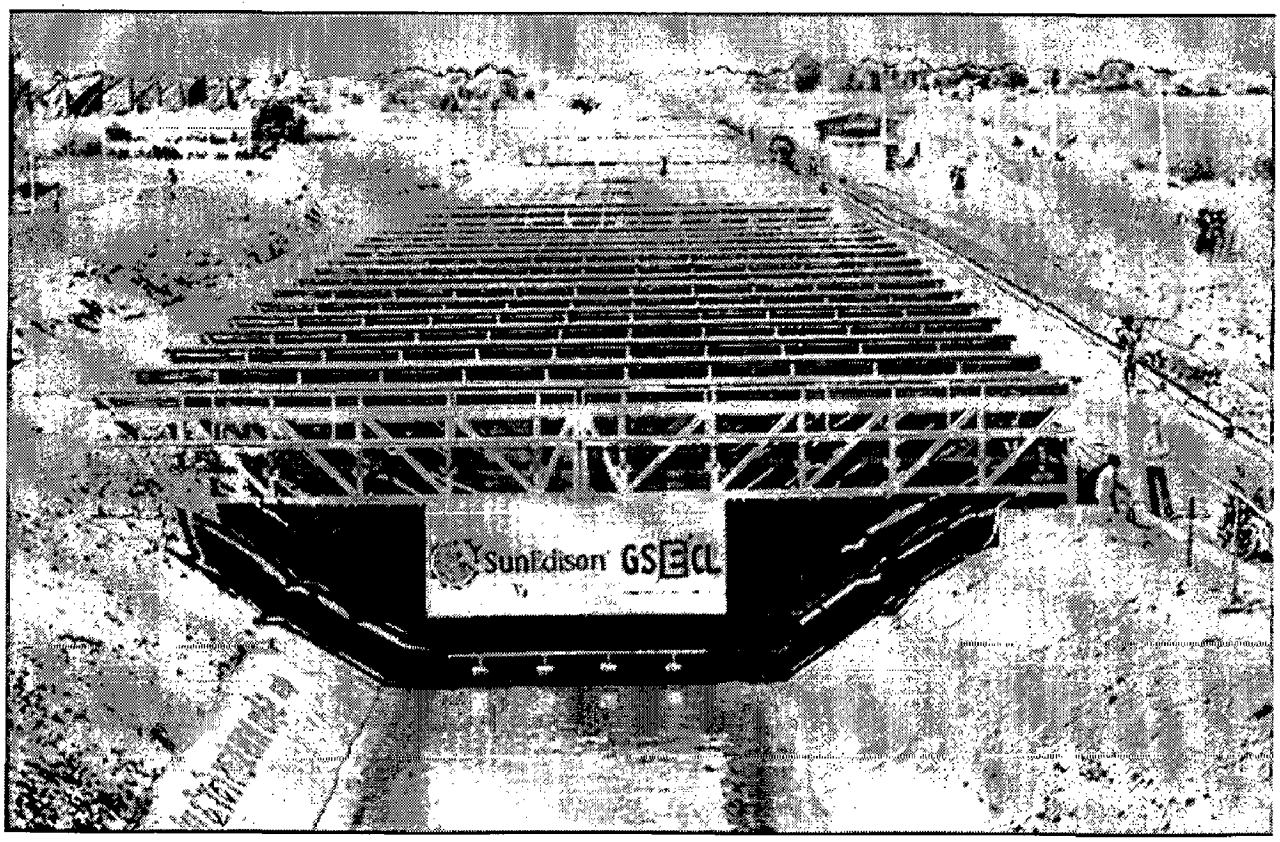


Figure 5-3: solar panel's installation over drains in Gujarat

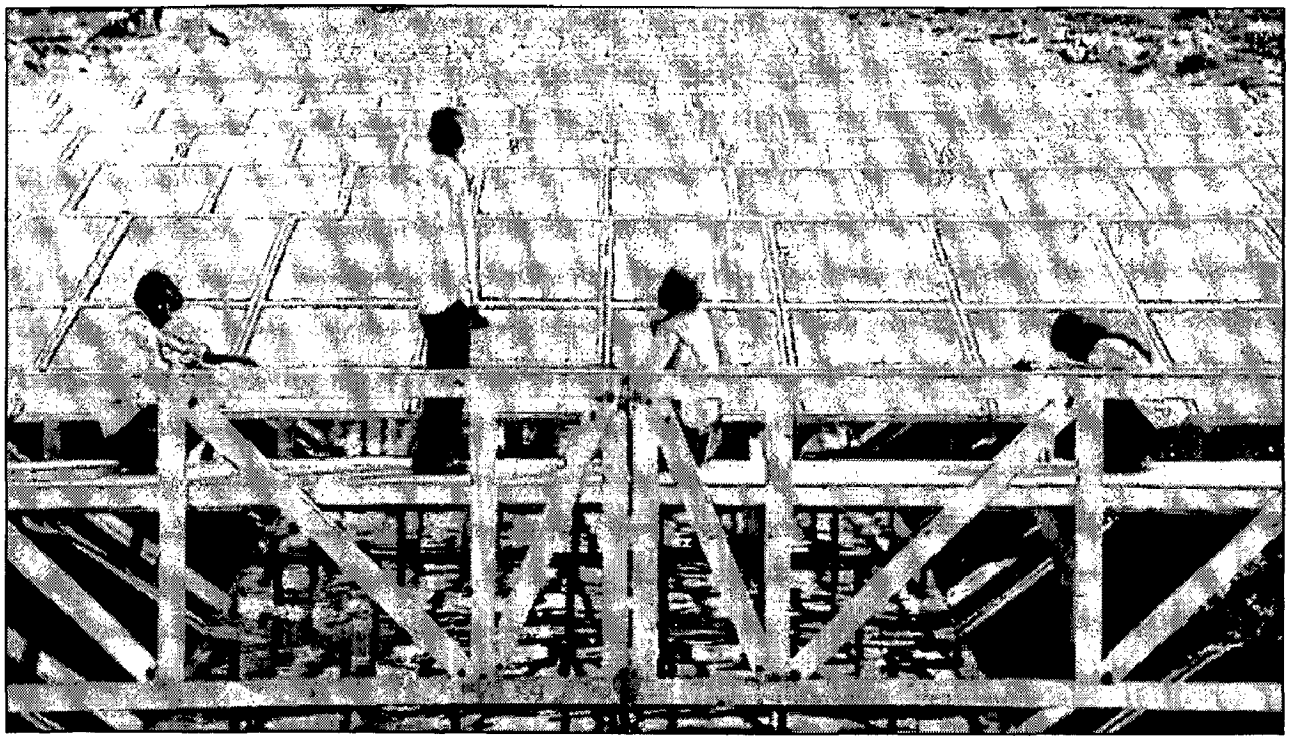


Figure 5-4: *Indian workers give the finishing touches to India's first 1MW canal-top solar power plant at Chandrasan village of Mehsana district, some 45 kms from Ahmedabad on World Earth Day, April 22, 2012. This solar power plant on a 750 metre stretch of the Sanand Branch Canal of SardarSarovar Project will generate some 1.6 million units of clean electricity per year and will also prevent evaporation of some 90 lakh litres of water per year from the canal. The project has been developed by the Gujarat State Electricity Corporation Limited (GSECL) and is scheduled to be dedicated by Gujarat state Chief Minister, NarendraModi on April 24, 2012.*

The project, which started functioning on February 22, 2012, on the Sanand branch canal near Chandrasan village of Mehsana district, was completed in six months, well ahead of a similar 1-MW project in Punjab, where an official nod was given by the Punjab government in June 2011.

"Though the project in Punjab got the necessary clearances in June last year, it has not progressed much beyond the DPR (Detailed Project Report) stage," an official told The Indian Express. The state governments in Gujarat and Punjab — the two states have 19,000 km and 14,000 km of canal network respectively — plan to take the canal-based solar projects ahead once the 1 MW pilot projects succeed.

The Gujarat project, which has already generated 1.99 lakh units of electricity since February this year, will be officially "dedicated to the nation" in an elaborate ceremony chaired by Chief Minister Narendra Modi at the project site on Tuesday.

This canal-based solar project executed by Sun Edison in Gujarat. According to official estimates, 1 MW of solar project requires 5-7 acres of land.

"We are the first state to implement such a unique project," said Gurdeep Singh, managing director of the Gujarat State Electricity Corporation Ltd,

Solar panels installed over 750-meter-long stretch of the Narmada branch canal will have a capacity to generate 16 lakh units of electricity annually. It will also prevent evaporation of 90 lakh litres of water. The electricity generated here is fed to the grid of the Uttar Gujarat UrjaVikas Nigam ltd, which supplies power to north Gujarat.

"Even if 10% of the existing canal network can be used for setting up solar power plants, it will have a potential to install power generation capacity of 2,200 MW. This can eliminate the need of 11,000 acres of land that would have been required otherwise," Singh said.

"On an average, these canal-based solar power projects exhibit peak performance for 5.5 hours (11 am to 4.30 pm) daily for 300 days of light in a year. The power generation is optimum if the canals are facing south," said Jaideep Singh Chowdhary, head, marketing and communications wing of Sun Edison, which has installed over 45 MW of solar power generation capacity in Gujarat.

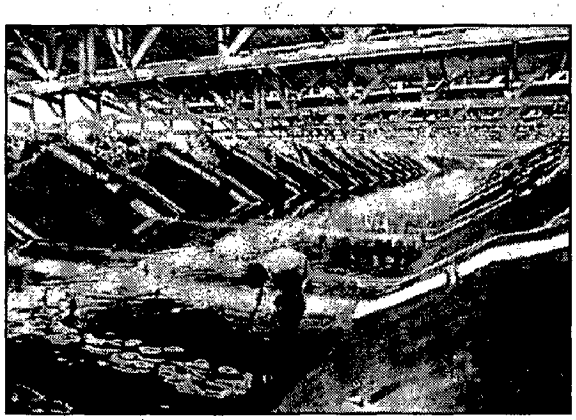


Figure 5-5: Man working under the installed solar panels over the Narmada branch drain

Case study:

5.2 SOL MATES: BIKE PATH MAKES CLEAN ENERGY FROM FLAT SURFACES (FOUNDATION, 2011)

February 12, 2011 by the green children foundation Solar power could be the ticket to clean, renewable energy for future generations, but getting a solar energy infrastructure up and running is no small task. The TNO Research Institute .in cooperation with the Province of North Holland, Imtech and the Ooms Avenhorn Group, has come up with a novel way to collect solar power while encouraging commuters to use emissions-free transportation: they are building a solar cycle path.

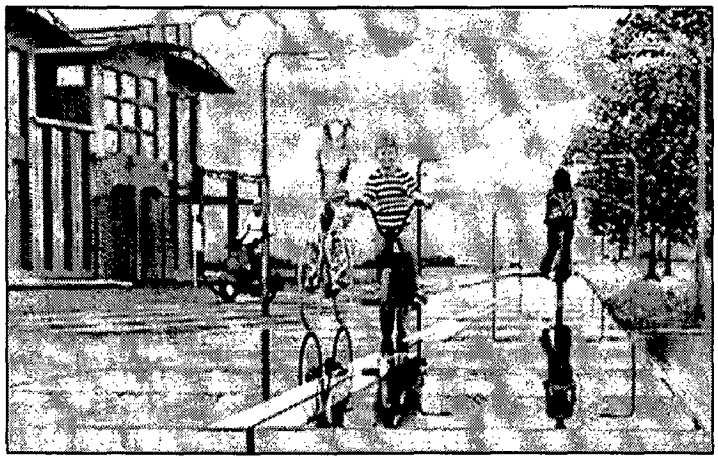


Figure 5-6: Bike ways uses solar energy(foundation, 2011)

The bike path is scheduled to be constructed in the town of Krommenie, which is near Amsterdam. It is called SolaRoad, and it will combine the best aspects of earth-friendly transportation and eco-friendly energy. The modular bike path will be made of concrete blocks measuring 1.5 X 2.5 meters and topped with crystal silicon solar cells. Atop the solar cells is a layer of clear protective glass that will let the sun shine through.

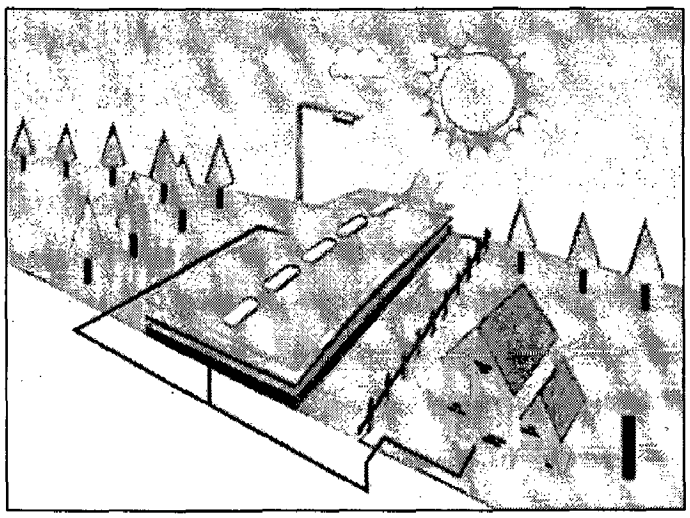


Figure 5-7: Roads, Bikeways using solar energy(foundation, 2011)

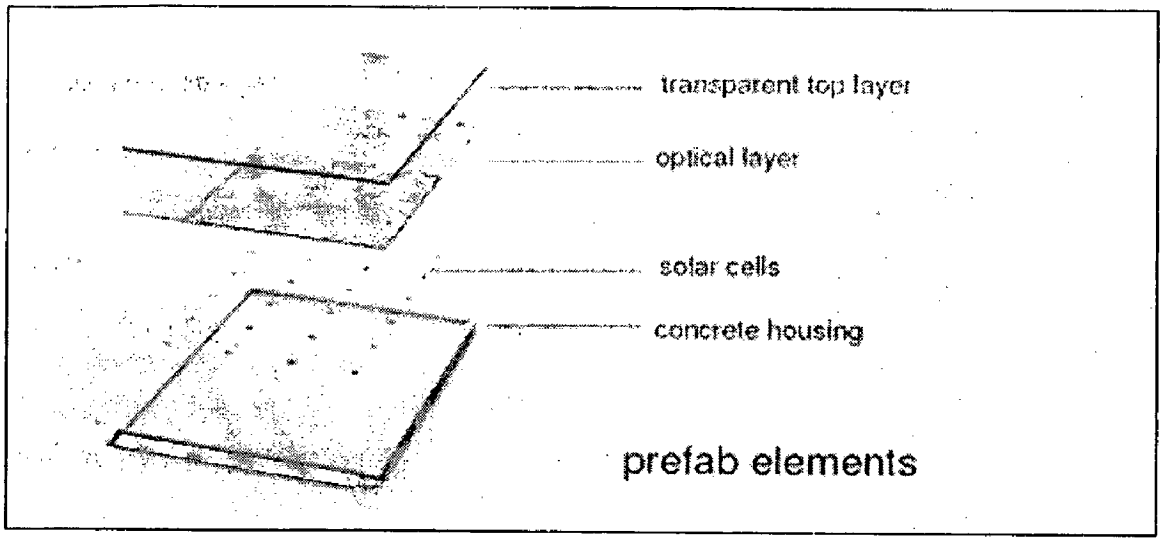


Figure 5-8:RoadLayering;elements used

SolaRoad is still in development currently, and many criteria need to be met before such a project can be successfully rolled out for the public. The path would have to be sturdy enough to deal with constant traffic, yet effective as a solar collector. The prototype path being built in Krommenie should be completed in 2012 and will teach the project's coordinators about the needs and challenges associated with the undertaking.

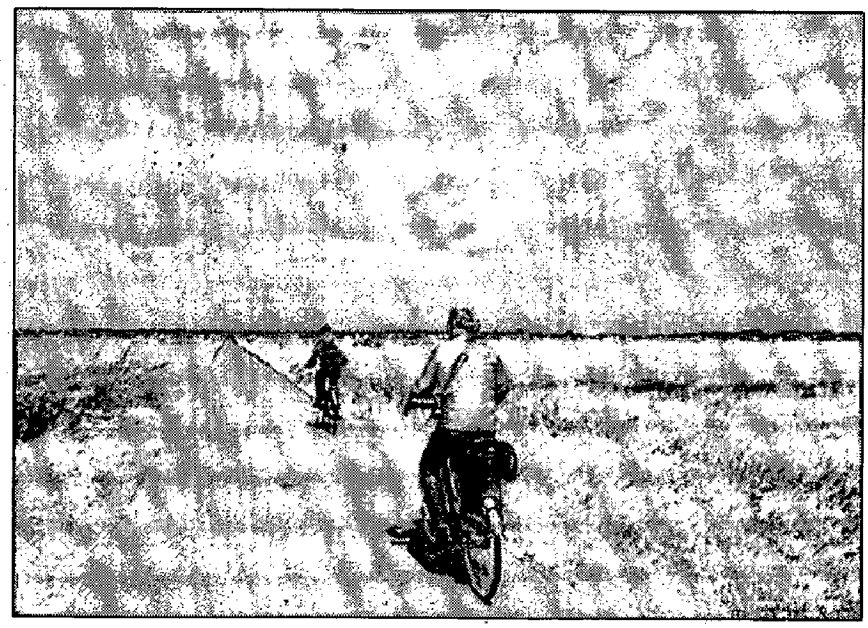


Figure 5-9:Beginning of a new system of solar energy-producing roads, bike paths; All images via: TNO

Once successfully installed, SolaRoads can be used to power street lights, traffic lights and even homes. They can produce up to 50 kWh per square meter per year, so the more bike paths constructed, the more clean energy will be available to a city. It's a winning prospect for everyone involved, so the hope is that the prototype in Krommenie will be just the beginning of a whole system of solar energy-producing roads, bike paths and other flat surfaces.

5.3 Driving Co2 Reduction by Integrating Transport and Urban Design Strategies- BENTLEY TECHNOLOGICAL PRECINCT

Site lies in the Town of Victoria Park and city of south Perth.

5.3.1.1 Role of Bentley technology precinct

Strategic specialized center with principle focus on an institutional or economic activity.
High density development to help cater for the increase in population expected in Perth, and to be designed on transit oriented design (TOD) principles to provide easier access to and from the center. With these objectives this vision was designed.

5.3.1.2 Applying ASIF2 and DDD

The Avoid, Shift, Improve, and Finance (ASIF2) paradigm and Density, Diversity, Design (DDD) model are applied to the Bentley technology precinct for all three scenarios.

Applying ASIF and DDD

'avoiding' carbon emissions, Reduce trip generation and subsequently it will reduce carbon emissions.

'shifting', changes in land-use, encouraging work and living in close proximity.

'Improvements' in transport patterns and usage would be achieved through introduction of bus-only lanes.

'funding' of BRT would be done by paid parking.

Density would be achieved in the precinct by an overall increase in zoning within the precinct.

Diversity would be achieved in the precinct by encouraging both land use and population diversity.

Design guidelines ensuring a pedestrian friendly environment would be encouraged.

5.4 Can Sewage Save The World? (KANELLOS, 2009)

"The dirtier the better,"

says Director of the NSF STC Water CAMPWS at the University of Illinois.

An excellent study worked over on natural phenomenon of treating waste as resource was done. A water recycling project at the University of Illinois could turn wastewater into methane, water and minerals. After analysing the potential of elements present in waste water in isolation. These elements were extracted out of it. Obviously if water is dirtier, it contains more material which is making it impure. This in different point of view contains more resources if extracted out of it rather than throwing it away. This led to set up a process which not only extracts required elements out of waste water but also purifies water.

Further he adds up

"If you can show people they can make money from purifying water, they will beat a path to your door,"

5.5 SEWAGE TO DRINKING WATER: SINGAPORE PAVES THE WAY (KANELLOS, 2009)

The scarcity of essential resource that is water, this need of drinking water led to technological innovation. In Singapore drinking water is no more available. It imports required amount of potable water from neighbouring country Malaysia. This import was very expensive till they introduced water treatment plant.

Singapore has installed a water purification system that will process 2,500 gallons worth of waste water and effluent streams – i.e., sewage – a day and turn it into drinking water.

If we continue to exploit our resources, the day is not far when world will be thirsty to have water. Thus we should take care of global reserves of non-renewable resources. Innovations such as to treat waste and transform it into usable form is now the need of the hour. If Singapore can do we can as well.

5.6 Integrated Planning For Wastewater Treatment And Recycling For A Small Community Development (CALDWELL, OCTOBER 28, 2005.)

ABSTRACT

Integrated water resource planning was conducted for Olowalu Town, a proposed development in western Maui, Hawaii. Total water needs, which can be supplied by a combination of diverted surface water, well water, recycled water and captured storm water, are estimated at between 1 and 2 mgd. The Olowalu development will generate approximately 0.5 million gallons per day
(mgd) of municipal wastewater. That wastewater can be recycled for beneficial use and irrigate between 80 and 120 acres depending on the amount of storage provided and the type of water reuse.

INTRODUCTION

A new development is being proposed by Olowalu Town, LLC in West Maui, Hawaii. The project site is approximately 4 miles south of Lahaina and comprises approximately 700 acres of the Olowalu area. The site was previously used as a sugar cane plantation.
Brown and Caldwell estimated that the potable water demand will be approximately 0.6 mgd.
This value represents the typical drinking water quality demand for inside residential/commercial use and is based on 1,500 residential units with a per unit daily usage of 400 gallons. Typical
Non potable usage for outside water use, including irrigation, assumes 150 to 400 acres of irrigated area and a non-potable demand ranging from 600 to 1,600 acre-ft/yr or 0.5 to 1.4 mgd
(Brown and Caldwell, 2005).
A typical wastewater flow per capita in Maui is 137 gallons per day (gal/d). For the ultimate
1,500 residences and a typical 2.5 persons per residence, the daily wastewater generation would be approximately 500,000 gal/d or 0.5 mgd. For purposes of this evaluation an expected average daily flow of 0.5 mgd was used.

WATER SUPPLY ALTERNATIVES

The water supply alternatives for the development include stream diversion and groundwater.

Historically, the sugar cane plantation was irrigated with surface water diverted from Olowalu stream, which flows into the ocean and has cultural value as a flowing stream. Other sources of supply for non-potable demands include recycled water and captured storm water.

Olowalu is on the arid side of the island, so an integrated water supply is envisioned as being environmentally sound. The groundwater aquifer has at least a 3mgd capacity and could supply the potable water demands of the project. The stream diversion used in the past has more than enough flow capacity for the potable needs but conflicts with the cultural value placed on a flowing stream as a fishery.

To minimize the diversion of stream flow, the potable supply would focus on groundwater while the non-potable supply would be provided by a combination of recycled water and captured storm water. Storage of recycled water and storm water would be used to meet dry season non potable demands.

WASTEWATER TREATMENT ALTERNATIVES

Wastewater will be managed onsite for individual residential lots in the low density areas provided that at least 0.25 acres are available on the lot. For medium density residential areas, the wastewater will be treated in interceptor tanks and collected using effluent sewers. Effluent sewers, primarily small diameter gravity sewers, will be utilized by following the terrain of the former plantation and having a minimal depth of burial. For this case, treatment of wastewater will occur in cluster systems using recirculating gravel filters, vertical flow wetlands, or biotextile filters, and then filtered through cloth filters, disinfected and reused locally.

Recirculating Gravel Filters

The recirculating gravel filter (RGF) evolved from the intermittent sand filter (ISF), in order to achieve better control of the dosing for higher rates. The filter medium usually consists of fine gravel. The RGF has been used for flow rates up to 1.0 mgd. The RGF is commonly used to treat septic tank effluent. They have also been used prior to ultraviolet (UV) disinfection for water reuse (Crites, et al., 1997).

The operation is similar to the ISF with the exception of a portion of the treated effluent which is returned to a recirculation tank where it is used to dilute the incoming effluent. By diluting the effluent higher application rates can be used. A schematic of a RGF is shown in following Figure.

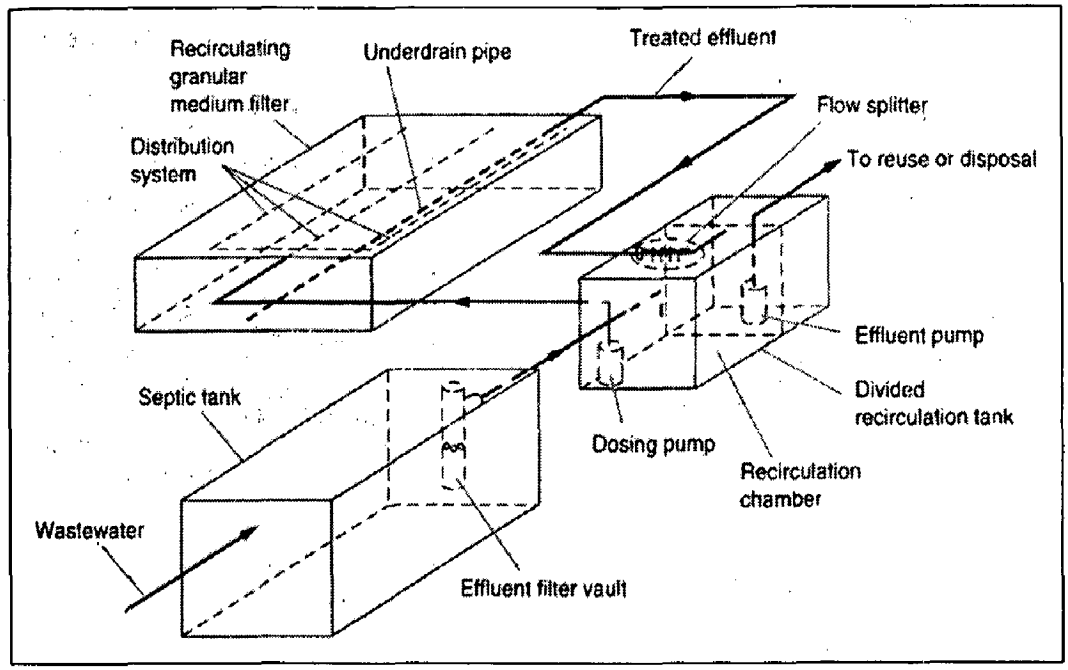


Figure 5-10 complete set up of water purification system**(Ron Crites, 2006)**

The RGF bed can be one third the size of an ISF for treating the same flow. An added expense comes from the additional recirculating tank. Although gravel media is more expensive than sand, the expected life for the media is longer and it will not clog from biological growth if properly designed and operated.

Vertical Flow Wetlands

Vertical flow wetlands are similar to recirculating gravel filters (see Figure 2), except that emergent plants are added to the surface. Primary effluent (usually from a septic tank) is required prior to discharge to the vertical flow wetlands. Treatment occurs as the water percolates through the sand and gravel to the under drains. A schematic of vertical flow wetlands is shown in Figure.

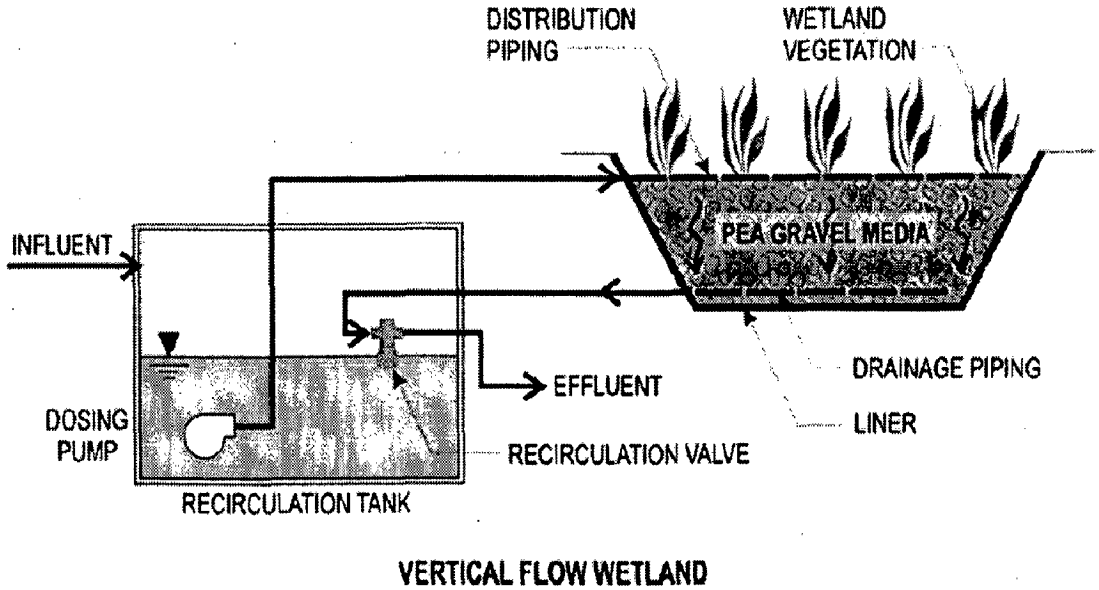


Figure 5-11: diagrammatic representation of vertical flow wetlands**(Caldwell, October 28, 2005.)**

Vertical flow wetlands will achieve advanced secondary effluent quality. The vertical flow wetlands effluent will be nitrified and contain less than 10 mg/L of biochemical oxygen demand (BOD) and total suspended solids (TSS). They have been used in Europe for many years and recently in North America to achieve secondary treatment. To achieve Hawaii water reuse standards, sand filtration and UV disinfection need to be added. Hawaii requires the effluent from filtration to contain less than 2 units of turbidity at all times.

Biotextile filter

The biotextile filter (also known as the textile bioreactor) was developed as an alternative to sand and gravel filters. They use non-woven textile chips (small pieces of cut textile with greater than 80 percent pore space) instead of a granular medium. Because of the large pore space of the textile chips, hydraulic loading rates can be increased significantly, thus reducing space requirements for the filter. The textile filter can operate as a single-pass or a recirculating filter.

A schematic of a textile packed-bed filter is shown in Figure.

The largest pre-fabricated biotextile filter made is a 2,500 gpd system by Orenco called the Advantex 100. An installation of 45 units in parallel is operational for a flow of 112,500 gpd.

The solids trapped in the media will build up, but the expected life of the media is 3 to 5 years.

Because the textile chips are inert, the media can be rinsed and then reused.

High Density Options

For the high density areas, two alternative systems for wastewater treatment were evaluated:

1) The membrane bioreactor (MBR) and
2) The vertical flow wetlands.

If the entire development is sewered to a centralized treatment site;a 0.5 mgd treatment system would be needed. The area needed would range from 0.5 acres for the MBR alternative to 1.6 acres for the vertical flow wetlands alternative.

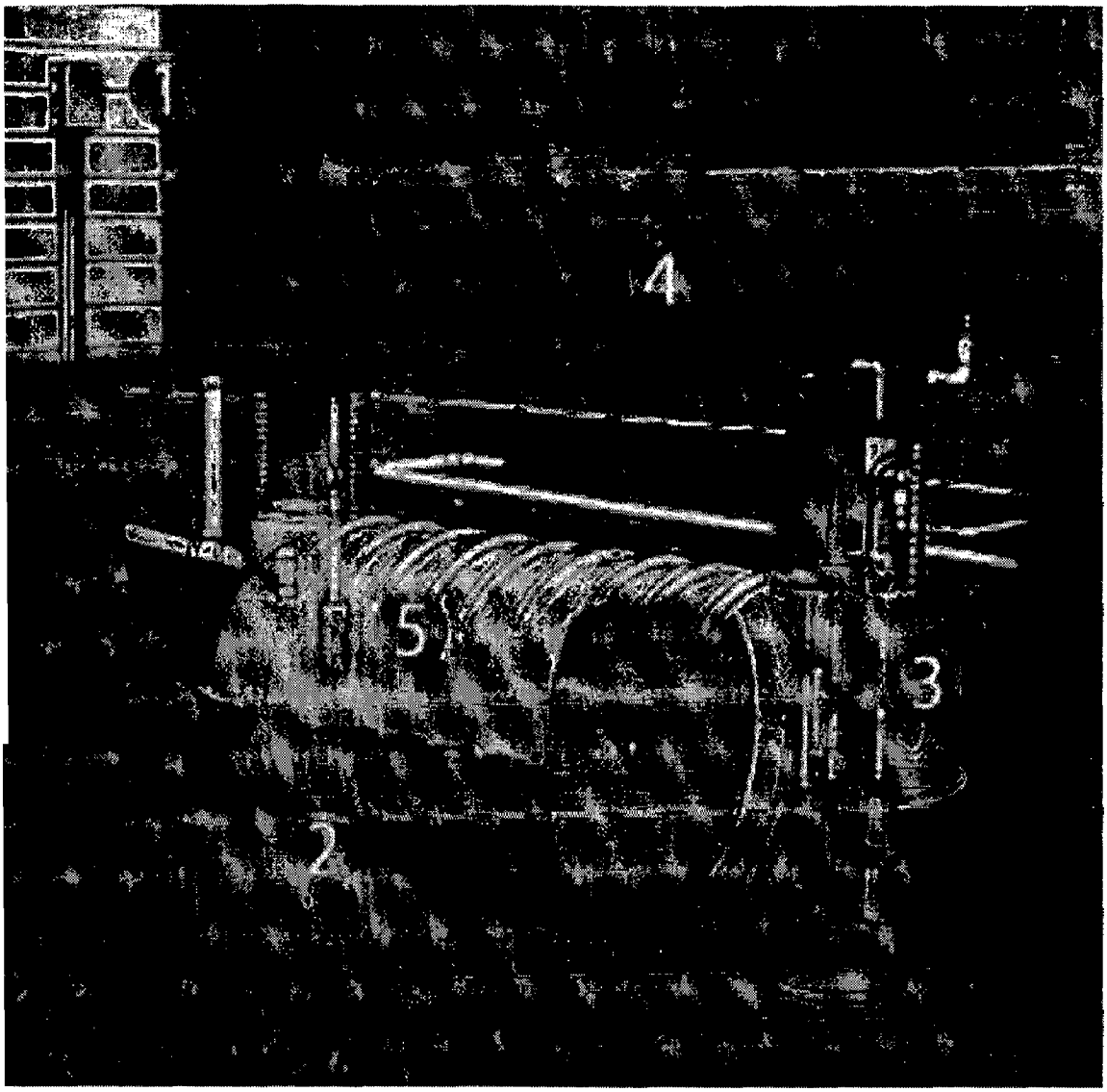


Figure 5-12: water treatment system for high density areas**(Ron Crites, 2006)**

In above figure – Schematic of a Biotextile Filter: Advantex Filter from Orenco Systems, Inc. showing

1. Monitoring system,
2. Processing tank,
3. Biotube pumping package,
4. Advantex filter, and
5. Recirculating splitter valve.

Land Requirements

Because of the high value of land on the island, the amount of land required for wastewater treatment was determined to be a significant criterion for evaluating alternatives. The area required for treatment for each of the technologies is presented in following table including the footprint for a 0.5 mgd facility.

Summary of Area Requirements for Treatment Options:

Treatment Option	Area required, square feet per gallon	Approximate site area for a 0.5 mgd facility, acres
Individual onsite leachfields	9.0	--
Recirculating gravel filters	0.20	--
Biotextile filters (Advantex)	0.09	--
Vertical flow wetlands	0.14	1.6
MBR	0.04	0.5

Table 1: area requirement for treatment plants **(Ron Crites, 2006)**

Water Recycling Options

The potential uses of recycled water for the Olowalu project include landscape irrigation, crop irrigation, water source for green waste composting, dust control, and construction water. Maui County is a leader in Hawaii water recycling with many successful reuse projects. A summary of recycled water projects on Maui is presented in given table.

Summary of Water Recycling Projects on Maui:

Project	Description	Average flow, mgd
Monsanto Seed Corn	Agricultural reuse near Kihei	0.22
Monsanto facility at Kihei	Landscape irrigation, fire control, toilet/urinal flushing	0.015
Piilani schools, gardens and common areas	Landscape irrigation of schoolyards, medians and road shoulders	0.2
Bioreal, Inc.	Cooling of biodomes	0.1
Kaanapali resort	Golf course and landscape irrigation	1.2
Kihei	Golf course irrigation	0.5
Lanai	Golf course irrigation	0.25
Kalului, Kanaha Cultural Park	Native Hawaiian plants and coconut trees	0.02

Table 2: project wise description for waste water

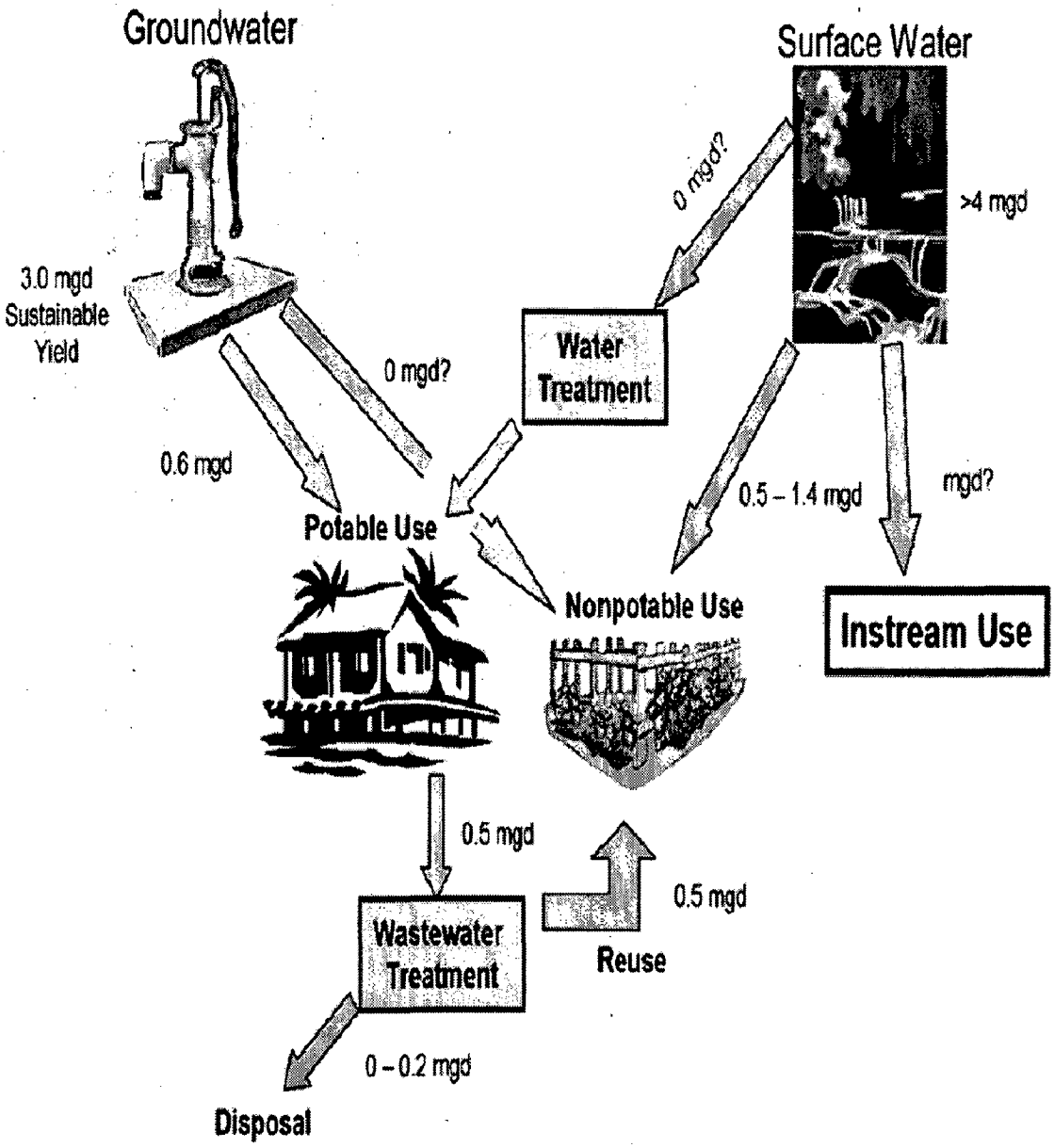
Integrated Water Resources Planning

A significant issue is the diversion of stream flow in the future because of concern about Hawaiian cultural practices. Keeping the stream flowing has great cultural and historical value.

Past land use has included a sugar cane plantation where over 700 acres were irrigated and much of the stream flow was diverted for that use. Therefore, if the municipal water supply can be supplied by

groundwater and if recycled water can supply a portion of the outdoor water needs for irrigation, the current amount of stream flow diverted for irrigation may be able to be reduced. The range of water needs that could be supplied from each source is shown graphically in following Figure.

Diagram of Sources of Supply Water for Olowalu Development (Brown and Caldwell, 2005)



RESULTS

In November 2005 an intensive town planning effort was conducted, led by the town planners DPZ. The town planners constructed alternative designs that divided approximately 1,500 residences into 3 pedestrian sheds. A pedestrian shed is a neighborhood in which a person can walk from the edge to the center of the neighborhood in 5 minutes. Indoor municipal water supply would be provided from the sustainable yield of the groundwater. A water recycling facility would be located in each of the 3 town areas near the largest demand for water recycling.

Storage for non-irrigation periods would be incorporated into existing and future reservoirs. The exact size and location of the storage reservoirs was deferred until later in the planning process.

For very wet conditions, a backup disposal system consisting of an injection well is planned.

The planning objectives for storm water would be to avoid erosion and keep developed-condition peak storm runoff to levels experienced pre-development. Low impact development practices would be followed to maximize storage and infiltration of peak flows and provide solids removal to the storm water that returns to the stream. Storm water would be treated in detention basins and reused to irrigated playgrounds and open spaces. Some portion of the storm water will be returned to the stream to allow it to flow to the ocean. Overall, the project would make appropriate use of all four sources of water for this sustainable development.

CONCLUSIONS

Integrated water resources planning resulted in appropriate use and reuse of water resources for the Olowalu project. To accommodate the cultural value placed on a flowing stream, groundwater was selected as the sources for potable supplies. For non-potable uses the combination of recycled water, captured storm water and minimal use of flows from Olowalu stream was preferred.

Recycled water will be provided by three separate decentralized water recycling facilities. For the two residential neighborhoods, the vertical flow wetlands are preferred. For the densely populated town center, an MBR facility is favored.

5.7 CASE STUDY ON DEVELOPMENTS ON AND AROUND DRAINS

Following are three case studies, here space on and around the drain has been used for public usage.

- DilliHaat in Delhi
- Kai TakNullah in Hong Kong and
- San Antorio River Walk, Texas

5.7.1 Dilli Haat, New Delhi

((htt)http://www.delhitourism.gov.in/delhitourism/tourist_place/dilli_haat.jsp)

The dilli haat was developed on a linear stretch of land covering a major mcd nallah. The site faces aurobindomarg, one of the south Delhi's arterial roads, near AIIMS crossing (now a flyover). Since the entire site is classified as reclaimed land, the far allowance is as low as 11%.

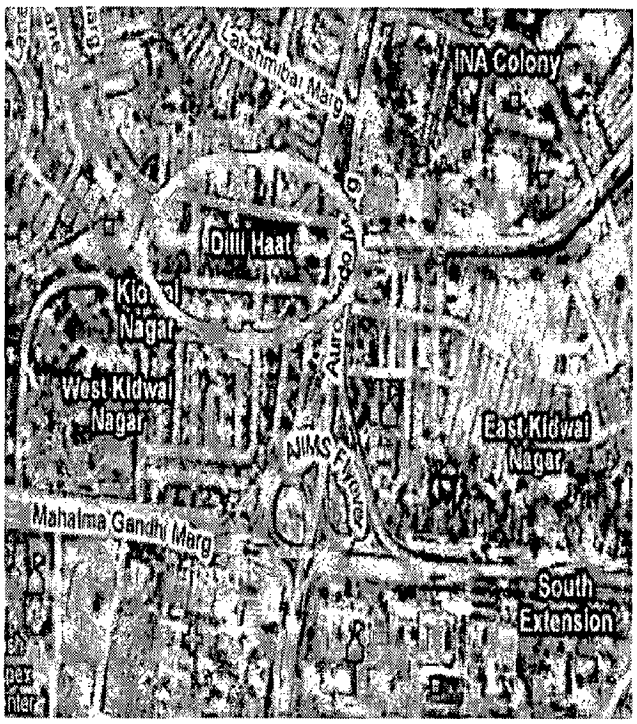


Figure 5-13: satellite imageshowing location of Dilli Haat

Architect: PradeepSachdeva
Location: Dilli Haat, aurobindomarg, New Delhi
Client: Delhi tourism & transportation development corporation
Date: 1992 - 1994
Area: 2.4 hectares (6 acres).
Built up area – 3200 sq m (11% of site)
Cost of project- Rs. 3 crores

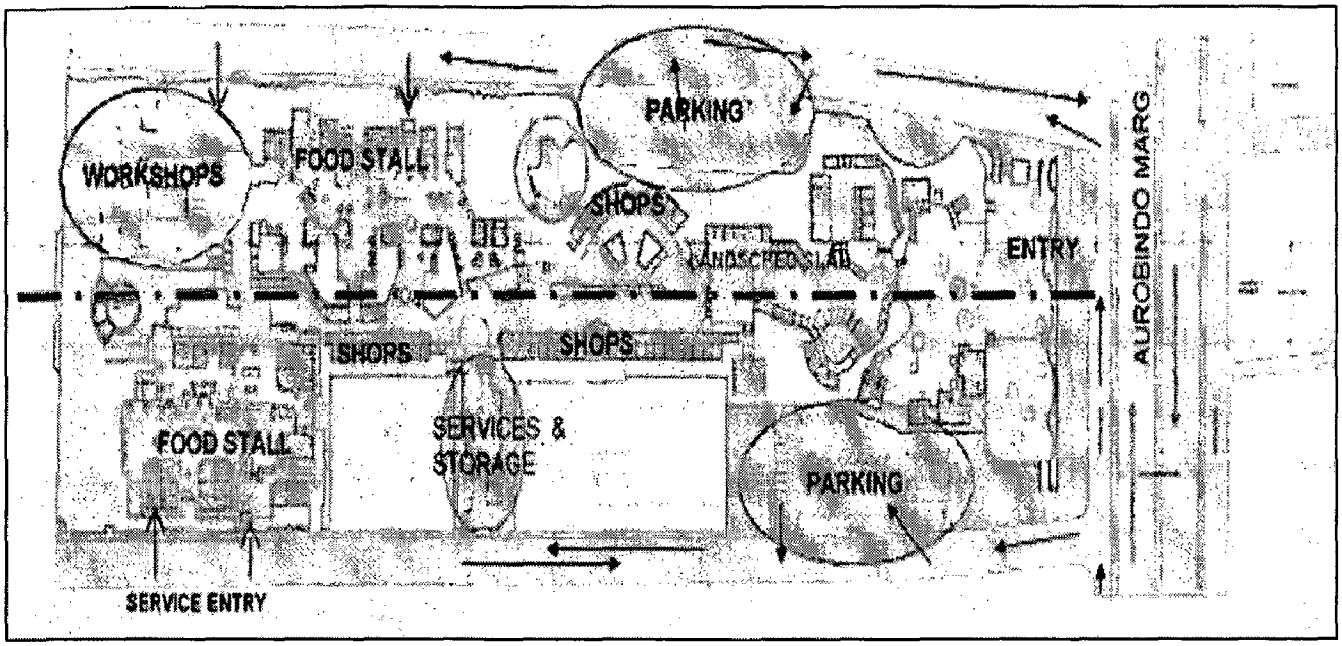


Figure 5-14 layout plan of DilliHaat

The 'Dilli Haat' - a food & crafts bazaar has emerged as one of Delhi's most loved urban leisure spaces. Designed to be a public space- it is a platform for showcasing regional crafts and food of India. The site was reclaimed by covering a storm water drain with a slab.Dilli Haat is a place of celebration; an ever-changing kaleidoscope of crafts and cuisines from different parts of India.

In 2003 Dilli Haat became one of the first public places in the country to be made completely barrier-free.

Date of completion- December, 1993

Primary users- crafts persons

Secondary users- visitors

Tertiary users- staff

Average no. Visitors visiting the Haat- 6000 visitors a day

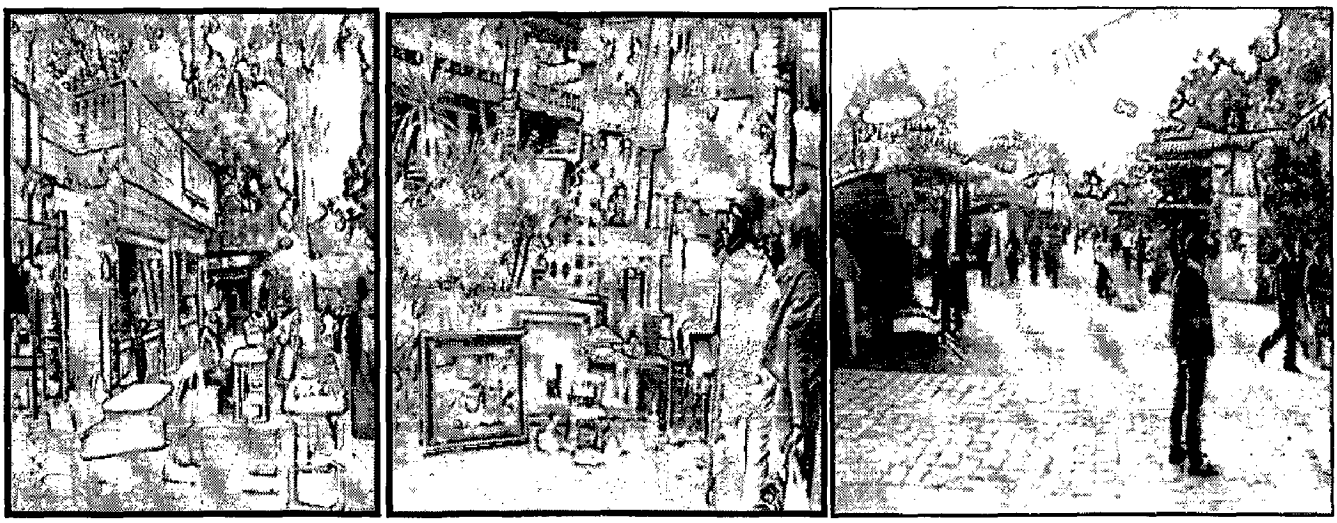


Figure 5-15 pictures showing DilliHaat

OBJECTIVES OF PROJECT-

- The Haat aims at providing additional marketing outlets to the genuine crafts person from handicrafts and handlooms sectors throughout the country on rotation basis in batches of 15 days duration. The project has the capacity to accommodate around 100 craftsperson at the time in pucca shops, exhibition halls, platforms, open grounds etc.
- To provide visitors a variety of ethnic wares and cuisine, in a skillfully crafted rural setting
- To promote the direct interaction between visitors and artisans

The *DilliHaat* is a joint project of Delhi tourism & Transportation Corporation and NDMC sponsored by the office of DC (handicrafts) & DC (handlooms) ministry of textile department of tourism

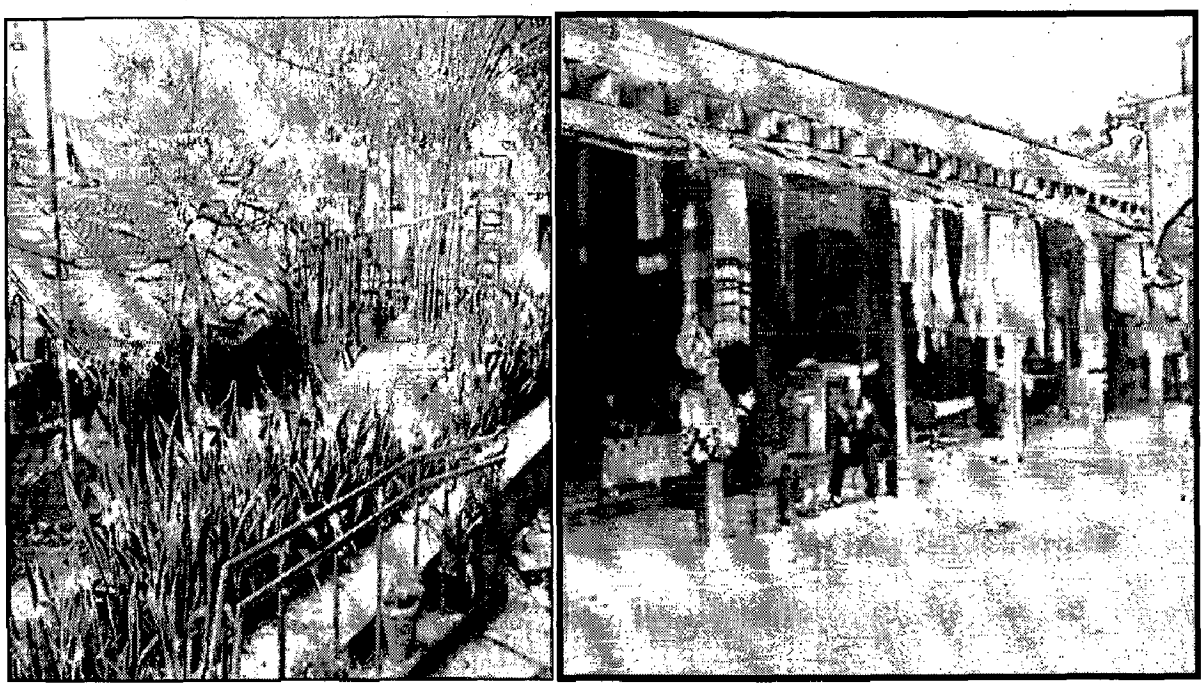


Figure 5-16: Images showing Shops and landscape in Dilli Haat

Gov. of India, with opening of the food and craft bazaar, *Dilli Haat* on the southern fringe of the colonial Delhi, an entirely new building type has emerged- "the ethnic mall".

Emerging over the last decade this type of complex has the origin in trade fairs, craft festivals and cultural events with ethnic flavors.

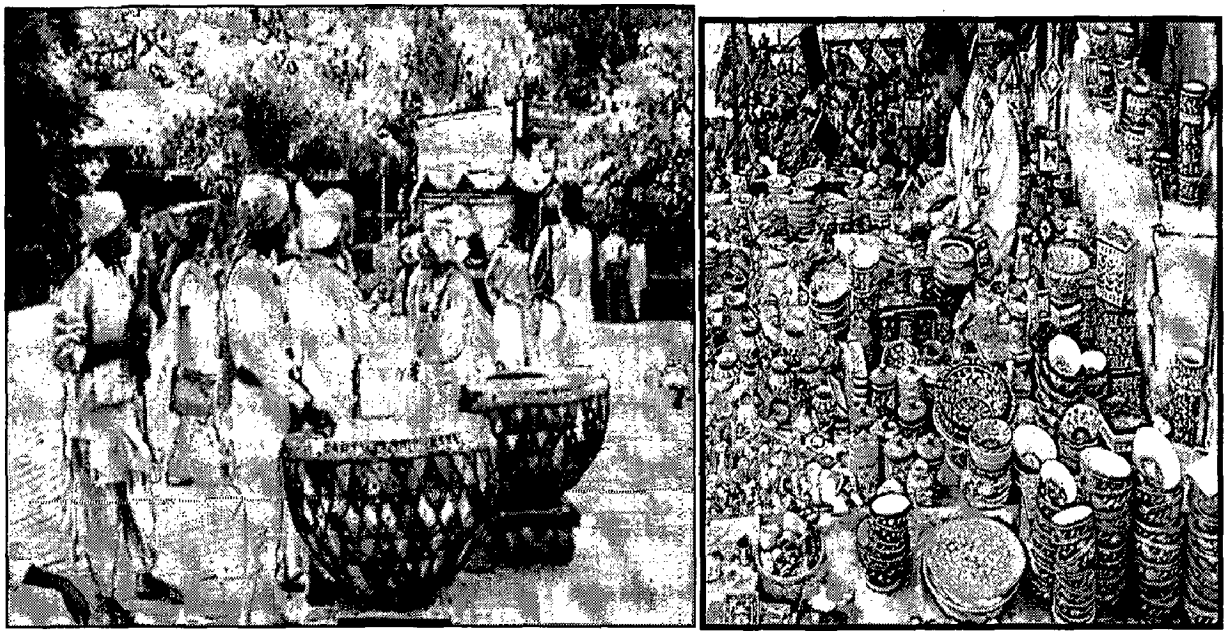


Figure 5-17 activities performed in DilliHaat

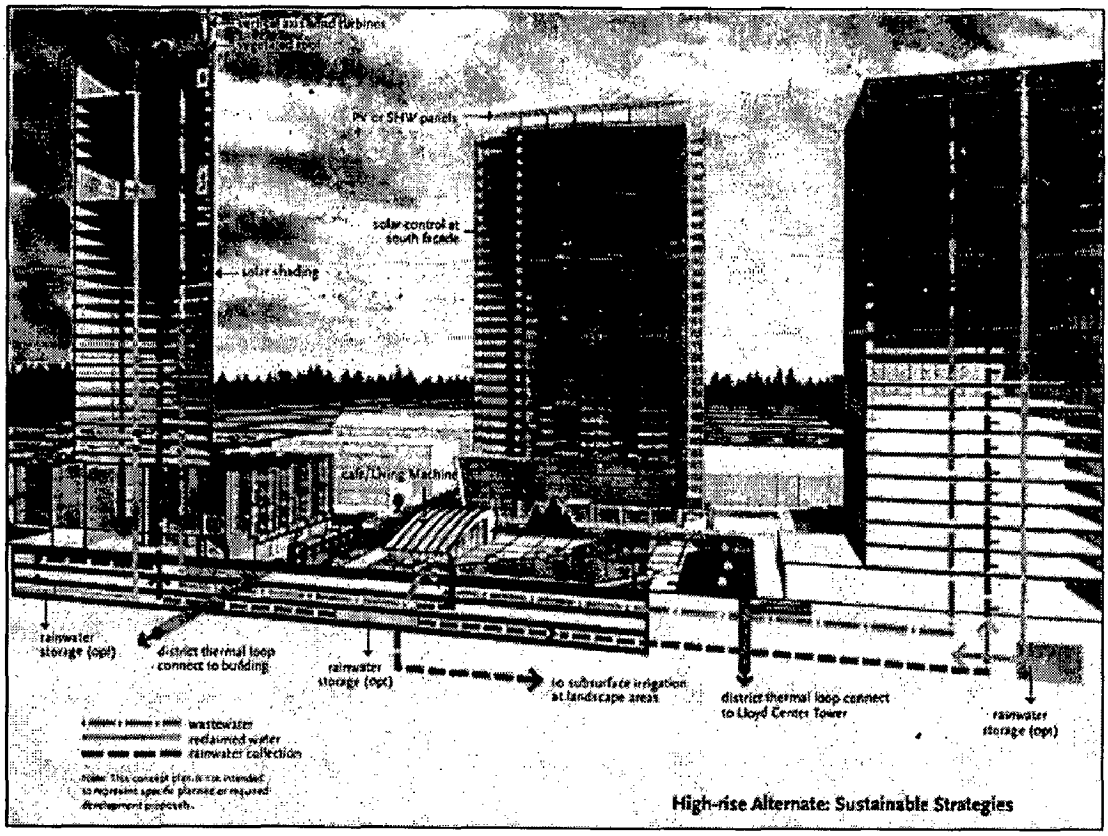
India is a diverse nation, not even a months of trade; can capture all of it. Spend a few hours in DilliHaat instead. Very rarely can one place encapsulate the myriad moods of ethnic India the way DilliHaat does. A take-off from traditional "bazaar", where local artisans sell their merchandise.DilliHaat's unusual rural setting offers the visitor a fascinating glimpse of India through its array of crafts, food and folk performances...something you can go home and preserve for eternity.

5.8 BIOMIMICRY CHALLENGE: TOA USES FUNGI TO REIMAGINE SUSTAINABLE NEIGHBORHOODS (O.M., 2010)

Biomimicry in District Planning:

TOA Uses Fungi to Reimagine Sustainable Neighborhoods: This is an example of how a natural phenomenon of a living body helped to propose ecodistrict in 35-block study in the Lloyd District, in northeast Portland

Ideas included water independence by using water immediately available from rain or ground. Greenways for natural animal habitats were allotted. A catalyst project of a high-rise district in the center of the neighborhood that featured green buildings, water harvesting and mixed land use was designed.



Now here the Challenge was to examine how to create connections between many ecodistricts. How do borders actually function in nature? How do independent beings come together to form a bigger entity?

"We tried not to jump to any conclusions, All solutions had to come from the site."

says Rovalo (biologist in their planning team)

The idea of funding for ecodistricts was not allocated on a square-foot or per-foot denomination because of the fact that nature does not work in this manner. Removing this constraint from the process allowed them to come up with more innovative ways for expending energy and denoting funding.

"The environment was really leading our discussion. You can refer to different things and point to them--that doesn't happen in the office. It's a creative way of exploring and it was really an exploration."

says Rodriguez

The solutions that proved most insightful came from mycelium or fungi, as well as their more common relatives, mushrooms. **"fairy ring"**

Figure 5-18: Growth of Mycelium on grassland create a complex network of relations

This exchange of natural resources, energy, materials and nutrients easily **translated to "money"** and became an economic model for the designers.

Amount of funding--50%--was allotted to focus on the borders of the ecodistricts

"Borders shouldn't be the abrupt transition that most cities have created between areas. They can allow a lot of exchange between levels and create different dynamics."

says Rodríguez

The second concept was the idea to leave some spaces within an ecodistrict empty, so a neighborhood can decide later what is needed and fill it in.The team was extremely inspired by this idea, denoting 20% of resources to such spaces.

"Nature allows for empty spaces. These are empty spaces that don't necessarily have a function, but they are left there for someone else to take over."

says Rodríguez

Satellite nodes which provide back-up to sustainable development were given space in fringe areas that occur outside the Ecodistrict. TOA proposed that 10% of funding be allocated to these projects.

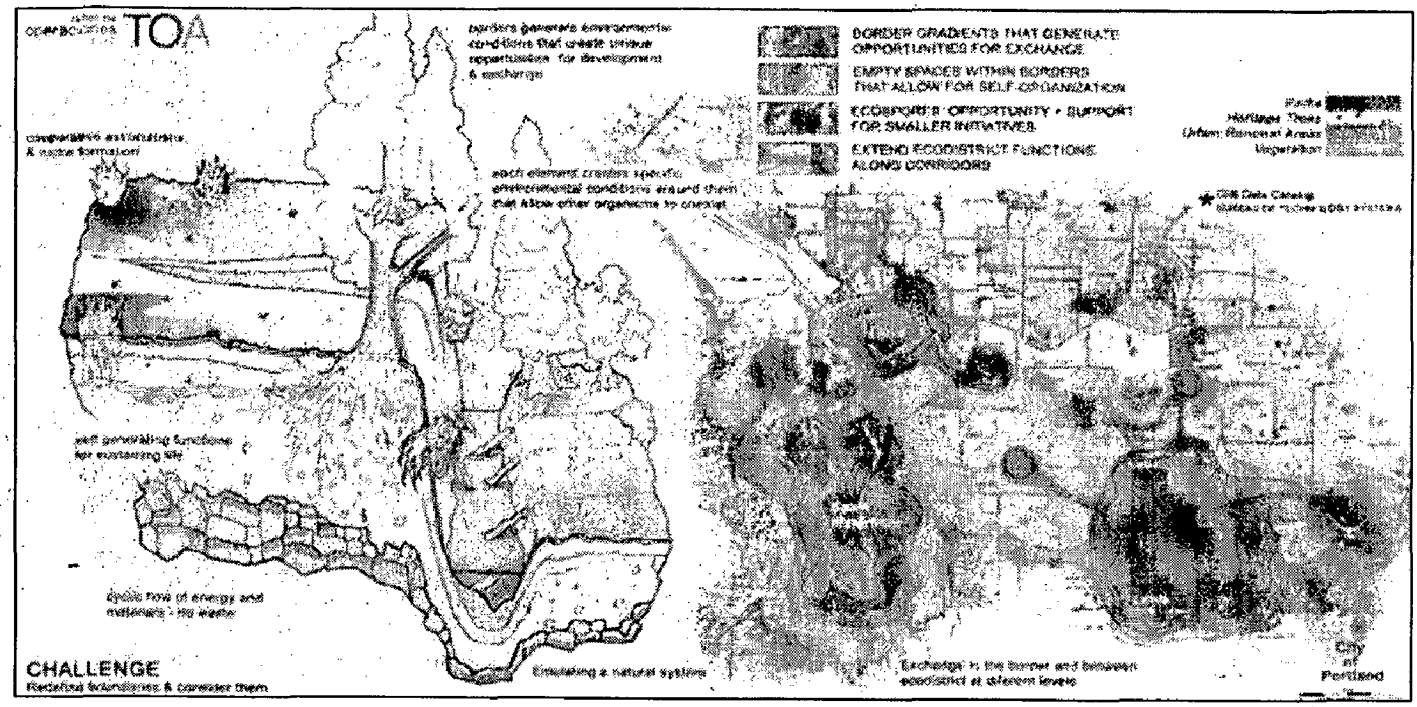


Figure 5-19: Proposed Eco district for Lloyd District, Portland

6 CHAPTER VI – STUDY AREA

6.1 URBAN DEVELOPMENT IN DELHI 'L'- ZONE

Concerning site, for development of a sustainable urban settlement based on biomimicry concept is chosen to be in Delhi, India

Figure 6-1: site lies in Delhi, India

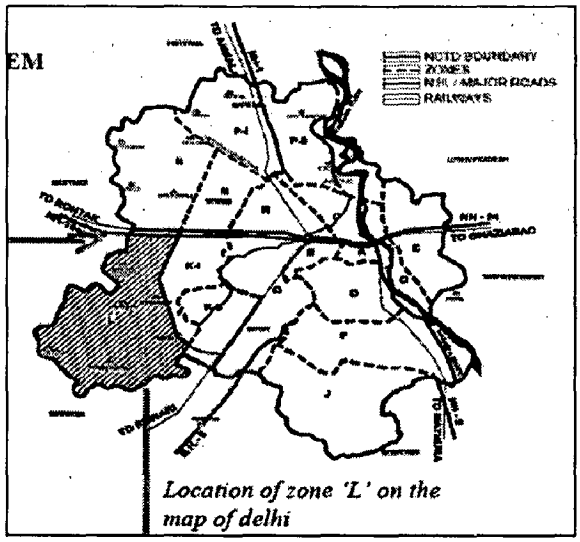


Figure 6-2: location of L zone in Delhi

Coming over to selected context, proposal for urban development based on Biomimicry concept for site in 'L' zone, Delhi, along NH 10, and comprises with total area of 402 hectare

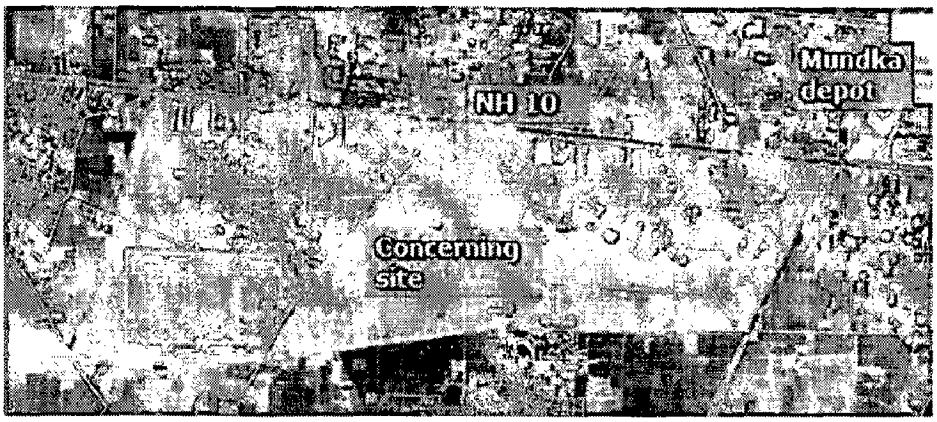


Figure 6-4: Concerning Site

Need to develop an urban settlement which acts like Nature, initial efforts were to select site for such a new extraordinary development. Delhi, capital of India is the place which always is an example of

advancement every new day, and has space for every new invitation for development. Delhi always welcomes economic activity and thus has resources for initial infrastructure.

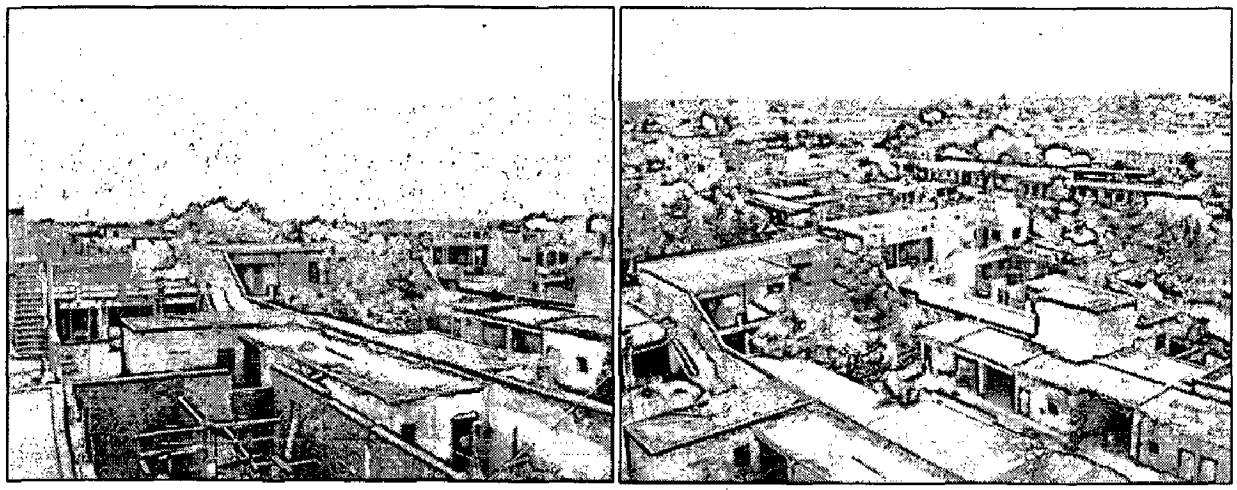


Figure 6-5 site, existing village (abadi area)

The already settled areas were not planned well during their initial stages. Developments were rigid which had no or less scope of flexibility and advancement to cope up with existing or future changes (changes in social, cultural, economic, physical, political, and environmental). This problem led to the selection of site which is being introduced as virgin land for urban expansion.

The search came to an end after finalizing site in 'L' zone Delhi. Here new developments are coming up rapidly. The concerning site stands just after Mundka depot (at present it acts as location to travel for commuters).

Figure 6-2 site, existing village (abadi area)

The fact that Delhi is capital, it will be served huge amounts of funds for development. Lot of economic activities and presence of higher facilities invite people from other places, thus due to migration Delhi need s development to cater the inflow of population. Most important reason is that at present we find unending problems in existing settlements and almost every city is suffering from one problem or the other. The reason behind this is that they are developed and redeveloped as and when immediate attention

is required. This brings up short term solutions, which are not only temporary but also, exaggerate problems for long term solutions, e.g. Kanpur city; digging of roads to provide services has become never ending process. Not only services are delayed, but they remain always incompetent to fulfill the requirements. Also frequent road digging creates problem to another subsystem (transport department).

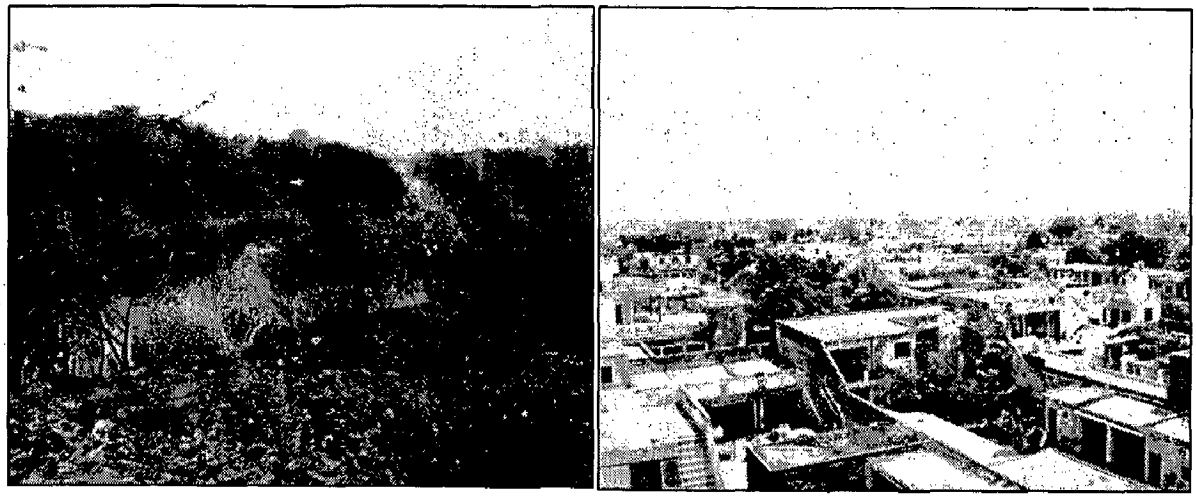


Figure 6-3 site (nullah; delhi's drain entering into the site from north side)

Concerning site has total area of 402.64 hectares; it is located along the National Highway 10 falling in zone 'L'.As aim is to develop sustainable urban development which utilizes least energy, produces least waste and acts efficiently in terms of resource consumption. An environment conscious settlement takes care of time, money and energy efficiency.

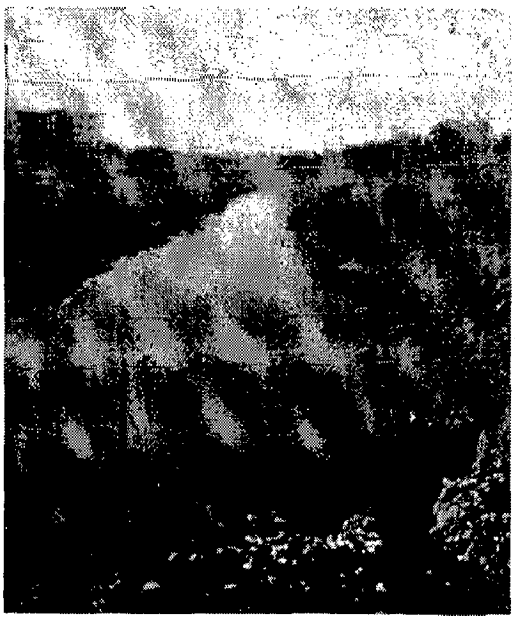
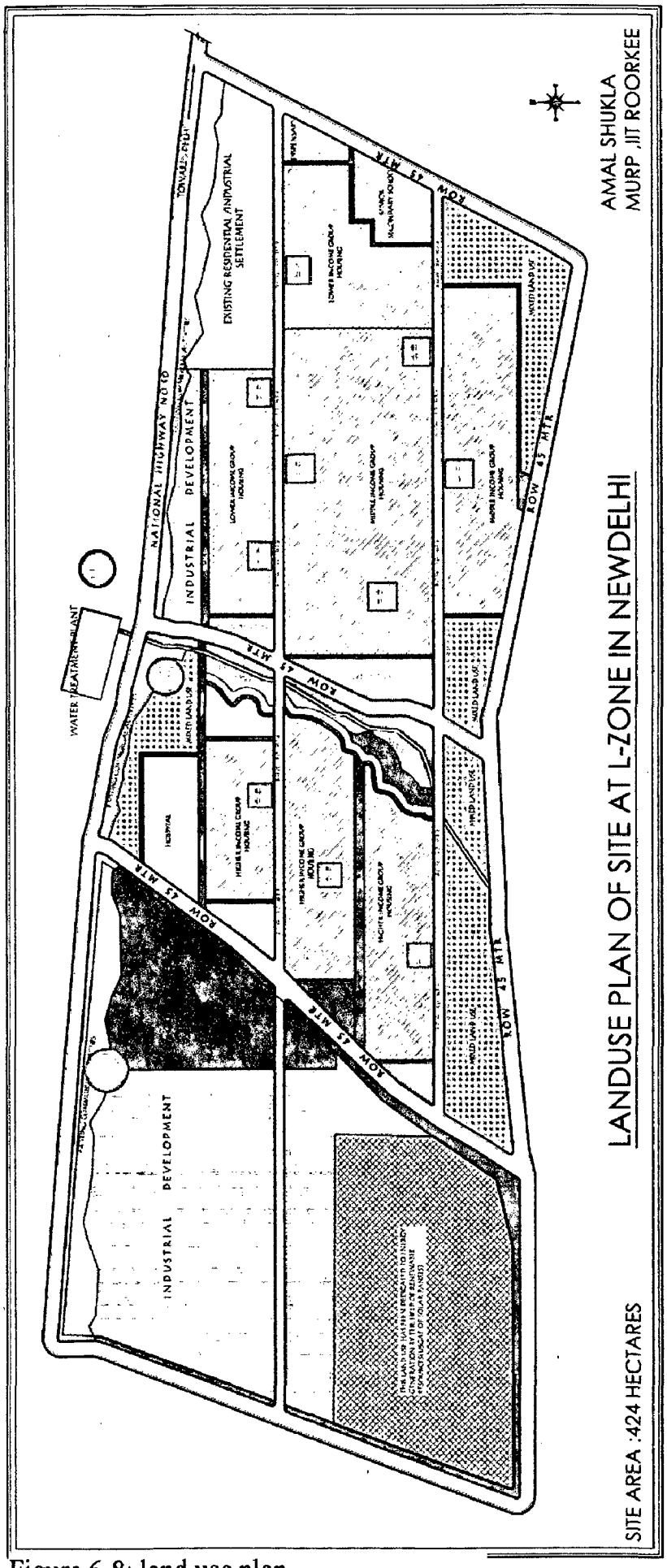


Figure 6-6: existing drain

Figure 6-7: existing drain

Studies reveal that such development should be higher density, compact and public transport oriented. As a result the solution comes up to be a pedestrian friendly urban settlement. This sets an example of practically functional development with considerable high density development. It has land use as shown in figure: .



-Figure 6-8: land use plan

Landuse:

TOTAL AREA	:	402Hectare
INDUSTRIAL	:	70Hectare
RESIDENTIAL	:	47 Hectare
GREEN/OPEN	:	44 Hectare
ENERGY	:	41 Hectare
ROADS	:	40Hectare
CIRCULATION	:	38 Hectare
CORE (mix land use)	:	28Hectare
RECREATIONAL	:	26 Hectare
PUBLIC/SEMI-PUBLIC	:	24 Hectare
PARKING	:	18 Hectare
PARK/GROUND	:	18 Hectare
DRAIN	:	6 Hectare

Roofs area (for installing solar panels): 33 Hectare

Delhi Development Authority, has already prepared a master plan for the chosen area and provided with the landuse, but as the matter of fact, Nature has no strict zoning, all behave as a unit, same should be applied to plan an urban settlement. Industries where manufacturing is done, commercial which serves supply and residential zone which consumes; are interdependent and should be interlinked, they do not need strict zoning. Basically reasons of separation are incompetency to tackle bye products of neighboring zone. For e.g. social activities, noise, waste, smell, pollution.

Possibility of merging can occur among residential and commercial, industrial and commercial, recreational and commercial, recreational and residential. All are interlinked and thus mixed landuse should be preferred.

In the given context for e.g. energy generation is linked to industrial zone and other zones industries on the other hand are directly connected to village population and lower income group and village population to provide employment. Village population and lower income group will act as human resource for industrial zone

Now a question comes that if nature does not have any right angles, rectangles or squares, then why city planning based on such shapes is considered to be the best? The answer probably lies in optimal use of land resource.

The **starting point** for planning and designing: Biomimicry based development is ecology and environment, for which comprehensive environmental guidelines, plan, parameters and programs need to be evolved and adopted. The urban pattern, linkages, density pattern, size of the settlement, etc. should be designed considering environment at priority. The aspect of energy, topography, climate, comfort, water, sanitation, drainage, solid waste management, pollution control, abatement and environmental management deserve much more attention than what is being given. Environmental guidelines, norms, standards and codes should be the main pillars or planning and designing. The system and hierarchy of the following should determine the physical form and community module, such as:

i. Resource conservation
ii. Energy generation from renewable sources
iii. Transportation and circulation(including parking, cycle ways and pedestrian precincts)
iv. Community facilities including Open spaces, parks, playgrounds,
v. Waste reduction, management and treatment to all possible limits.

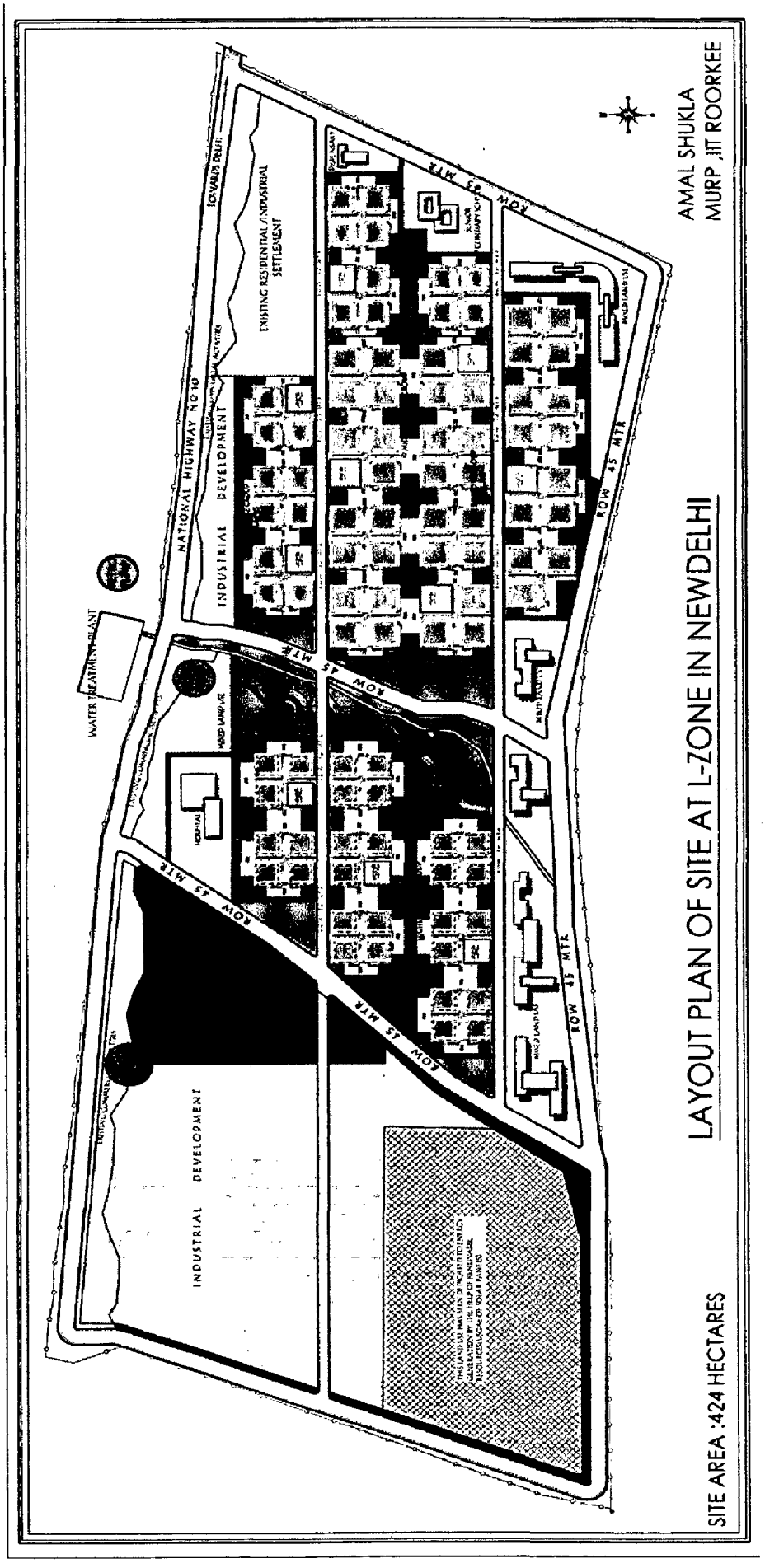


Figure 6-9: lay out plan

6.2 RESORUCES

This study has already discussed the concept of 'Ecological Taxation'. This Ecological Taxation should be introduced by the strong bodies to come up with it in fast manner. A group should be trained and created which after studying about any product, will be able to present its tangible, intangible and ecological aspects in terms of 'Value'. After achieving such data, body should fix its economic value for degrading environment which will be imposed on producers as an "ecological taxation". This tax will be then collected and will act as capital resource for environmental and ecological benefits. Thus, management and optimizing products which require resources depends mostly on human activities.

Land resource: Due to high density and compact development, land requirement reduces, thus land resource can be saved. As discussed earlier in previous chapters, in case of Barcelona and Atlanta, both serves to almost same population but Barcelona consumes 25 times less area than Atlanta.

Concerning site has land resource of 402 hectares in total. On the scale of zoning or land use allotment, minimum required interruption is done on existing landuse. Industrial is placed along NH10, Abadi area, low income group housing. Good connectivity with NH10 will help this zone to transfer goods and products easily to required places. Abadi area, low income group housing will provide human resource to the industrial zone and gain economy through that. So as the main components which are immediately relate to industries are taken care of.

6.3 ENERGY

nature energy generation is done from renewable resources, for example producers by the process of photosynthesis convert renewable energy from sun to other usable form of energy. This prime source of renewable energy from sun is considered for generating energy for energy requirement in the proposed settlement. Surfaces where direct sunlight is not required (parking, roads, roofs, etc.) can be utilized to generate electricity by the help of solar panels. Here, land use allotted to energy 42 hectare (for sub-station and administration) can produces 769 MW of energy/ annum.

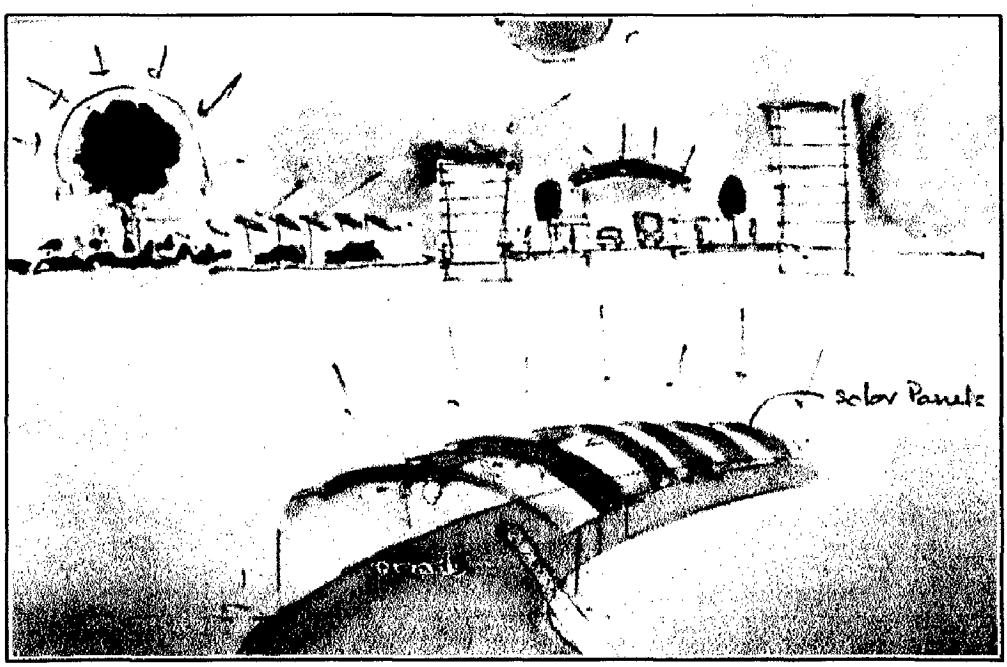


Figure 6-10: energy generation in nature & in an urban development

As a matter of fact our site has provision of only sun and wind energy as renewable source. To achieve most out of it is again an issue, for which simply looking back to our mentor nature is required.

Here Biomimicry teaches one more lesson that is: in nature every bit performs some job which counts for whole system. Nothing remains idle or jobless in nature's context, this is the reason it has no waste. In terms of an urban development, any land mass which remains idle or it does not utilizes nature's energy, it is waste. If any space is open to any source of energy, it should have capability to transform it and use it in required form. As trees, our body, or any other nature's part, are involved in doing their assigned function, similarly our developments should. Considering roads, or any land area which does not need any direct sunlight, can be covered by solar panels to produce power from solar energy. Roads, which are constructed for vehicles to move on it, it remains idle for most of the time and the space over it remains idle every time. Nature does not work in this casual or lazy manner. This thought led to think for what all can be done to utilize that space, without any time our basic requirement of energy came up with an answer.

Nature utilizes whole space as much as possible, for e.g. consider existence of trees , trees do exist but under them provision to grow grass herbs and shrubs still remains. Nature utilizes every bit of space in three dimensional reach. OR in other words nature does not waste any resource available. Thus observing the prime source of energy i.e. sun; which dissipates huge amount of energy constantly. Nature continuously gains energy out of it and produces its food e.g. vegetation on the other hand where cities and settlements also receive huge amount of energy by sun, but remain incompetent to produce their own food(electricity).Cities food is its energy requirement by the people to live in .

Now same line led to a thought that there are certain areas or surface areas where sun is not required directly instead it is better if not hit directly. Area where direct sun is not preferred or required may be pedestrian walkways, unused land areas, parking and roads. In concerning context additional land is available in the form of energy land use which is allotted for substation and management of power etc. Solar energy will be utilized to generate electrical energy in land which is already allotted for sub-station.

As this site lies in Hot Arid region (15-35 N) where more than 3000 hrsof radiation can be obtained from an open land which has substation can be covered by solar panels which can generate energy for the settlement/urban development around it. It has total surface area of 410,143 sqmtr. Data reveals that 100 sqmtr of solar energy produce 500 KWh of energy (Jain, 2009).Thus this given site can produce 769 MW per annum energy.

Working on same concept; roof having total surface area of 33hectarecan generate 617 MW per annum and parking having surface area of 17 hectare can also be utilized to install solar panels which will generate additional 319 MW of energy.

Wind can generate energy where it is at 20 km/hr or more. Wind turbines can be installed in medians of all major roads, as well as on roofs. Roads, over which vehicles run day and night, are capable of producing kinetic energy in air. Assume two way roads with a median of atleast1 meter width; both sides vehicles are moving at pace of at least 40 km/hr. Turbines are installed on median which rotate and generate energy by the help of wind blowing around it. This generated energy can be utilized to provide power to street lights etc. (depends on how much will be produced).

6.4 TRANSPORTATION

Roads are laid down based on hierarchical pattern which is nature way transport or distribute nutrition. Nature's way to distribute energy or nutrition can be observed in trees, leaf and even in human body in the form of nervous system.

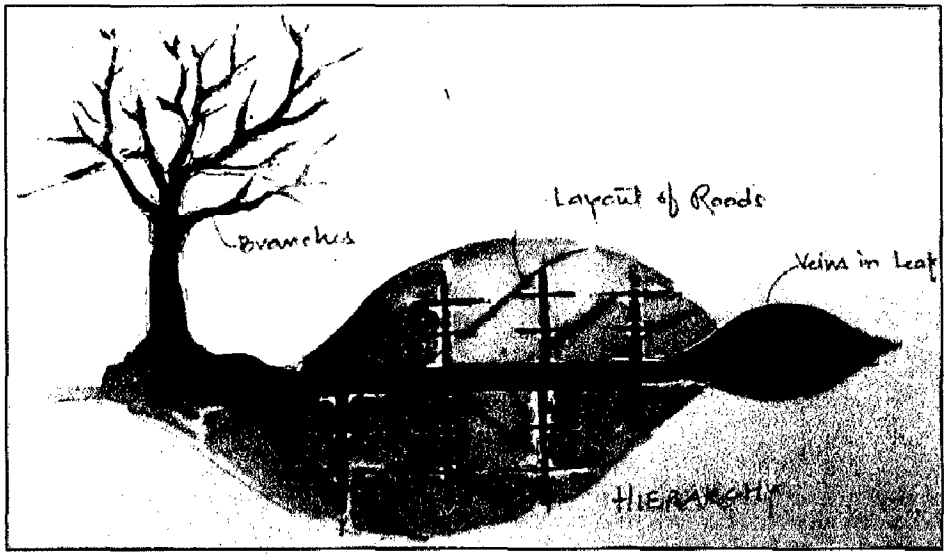


Figure 6-11: hierarchy & distribution of nutrition in nature evolves road network

The transportation in nature is carried out in a very interesting manner. It is always one-way directed (flow of rivers, blood in nerves), hierarchical in nature to extend its foliage (trees, tributaries and distributaries). Flow follows path of least resistance. Similarly, our transportation and services distribution should be designed in a settlement. In given proposal, roads are laid as veins in leaves. Cul-de-sec or dead ends have been provided to define the flow and to restrict the unwanted disturbance to move throughout the development. Whole of the development is accessible by pedestrian, or facilities are provided within walk able distances. Public transport is at approachable distance (maximum of 150 mtr) to pedestrian, this can only ensure efficiency in transportation. Efficiency in transportation can only overcome biological line "stagnation leads to contamination"; defined one way movement will lead to least resistant path to achieve smooth flow in transportation and services.

6.4.1 Roads

Dead ends or Cul- de-sec are provided so as to limit the extent which requires energy. This order and discipline will give no place to chaotic and haphazard movement only required people will enter in those road, and restrict through traffic, thus pressure will remain under limit or under control. Another lesson is of 'Stagnation leads to Contamination', as discussed earlier, two major roads passing by this zone are approachable by pedestrian. These major roads will be served by public transport such as buses, Autoes, Rickshaws which will prove to be an efficient way of commuting. Thus practically possible pedestrian

oriented development is achieved. Facilities are such provided that all daily requirements will be fulfilled by pedestrian approach only. Higher hierarchy facilities will only require vehicular movement.

6.5 HIGH DENSITY URBAN DEVELOPMENT

Examples quoted earlier (Atlanta and Barcelona, energy consumption and density graph) are evidences to prove that how high density and compact planning reduce consumption of land resource, energy, and other inputs in urban settlements. Resource consumption reduces considerably in higher density areas. Not only it reduces consumption of resources but also generates comparatively less waste (CO2 generation in Atlanta and Barcelona).

Nature also teaches that not a single patch is treated as unused space; every patch has its defined function. So, why to provide sprawled and unusable spaces, which do not have any function to perform? The challenge is to make settlement function properly. The best way to execute functionality in high density areas is by providing 'mixed land use'. Mixed land use with high density planning is solution to number of problems (environmental, social, and functional). This concept is well understood and applied in this proposed development.

More density can be translated as more number of consumers or users, which will need more products and facilities to live a quality life. This approach to facilities by more number of people will need more devotion towards transport. Now, mixed land use as the best solution can resolve the problem. The facilities can be provided to them in the same hierarchy in which they are required by the people. This means often required things or products can be places in immediate approach to them. This will reduce their time, energy money by travelling far. Thus placing facilities such as commercial, recreational, institutional and offices etc. at distance which is approachable by walk can reduce lot of pressure which any development produces. This will lead to less travel, thus less use of vehicles. People would prefer walking to facilitate themselves which will be environment friendly too. This will become the nature's way to work, to attain facilities, nutrients by reaching to them without degrading nature.

Now, this defines the movement of people for higher level of facilities up to certain level. These destinations will be distant and will need vehicles to commute. Here, our Public Transport Oriented Development approach will assist in smooth functioning of settlement.

By going vertical (to achieve high density) more land resource will be available as developments preferred are high rise, thus more area can be dedicated to green areas or breathing spaces within development. Ultimately, less use or resources, less use of vehicles, more open or green spaces will contribute to environment by CO_2 reduction and waste reduction.

Proposed development is designed for 122810 people. And the total area is 402 hectare thus the density of 305 person/hectare is achieved. This will not only reduce consumption of energy but also reduce the CO_2 generation.

The calculations are as following:

LIG POPULATION

No. of units per floor = 28
No. of floors = 9
No. of modules = 21
Person per unit dwelling = 5
Total LIG population = 26460

MIG POPULATION

No. of units per floor = 16
No. of floors = 14
No. of modules = 43
Person per unit dwelling = 5
Total MIG population = 48160

HIG POPULATION

No. of units per floor = 8
No. of floors = 19
No. of modules = 29
Person per unit dwelling = 5
Total MIG population = 22040

CORE AREA POPULATION

Core area = 28 hectare
% covered = 25%
FAR = 7 hectare
Dwelling per floor = 350
No. of floors = 15
Person per unit dwelling = 5
Total core area population = 25250

Assuming abadi area population = 900
(Assuming 50 people per hectare, abadi area = 18 hectare)
Total population = 122810
Total area of the site = 402

Density of the proposed site comes to be **305 person/ hectare**

6.6 WASTE MANAGEMENT

As a matter of fact given site consists of a drain which brings all waste water of west and central Delhi to this place. This Nullah can be treated so as to recover resource out of waste. It drains in site from north side; it gets way under national highway to enter in to site. Before this this waste water has a huge pond which stores water for time. This pond was the best place to treat waste water due to face that this place has no residential and public space. Thus while storing and treating this water if any undesired actions take place such as foul smell or mosquitos, it will not create any problem to residents around that area.

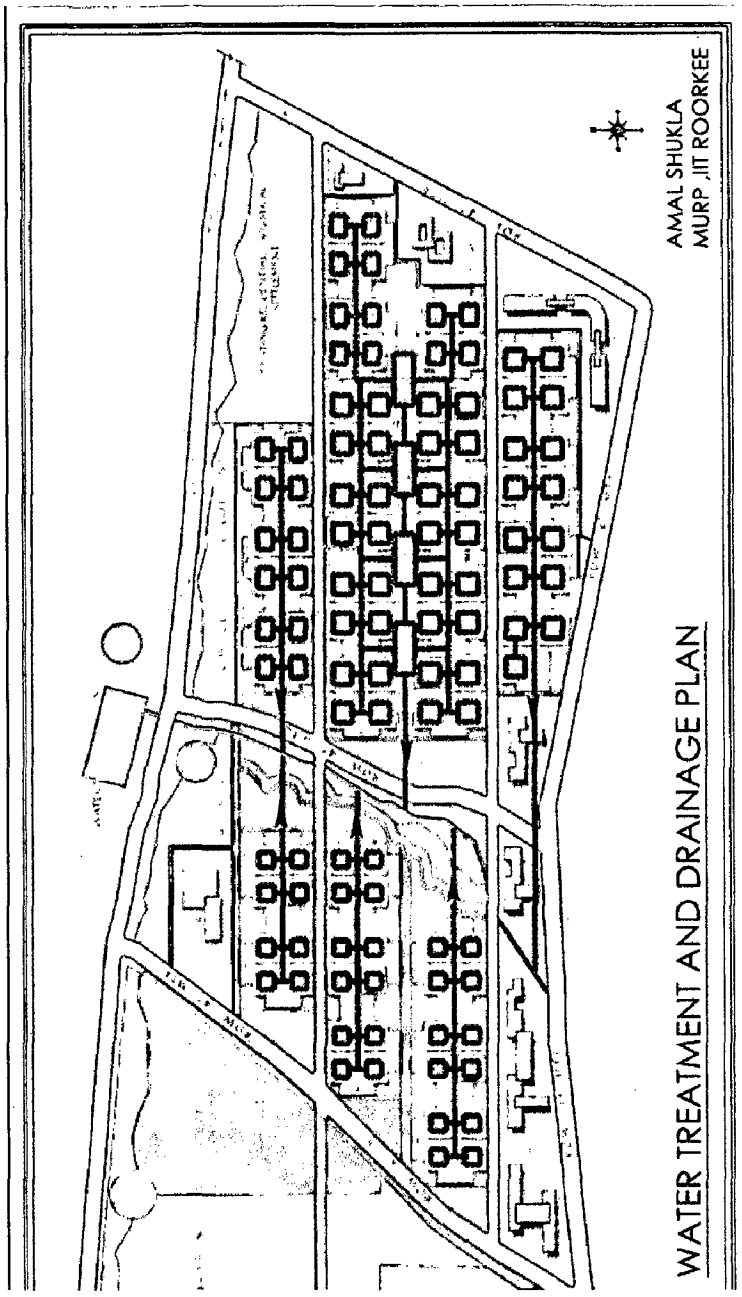


Figure 6-12: water treatment and drainage layout plan

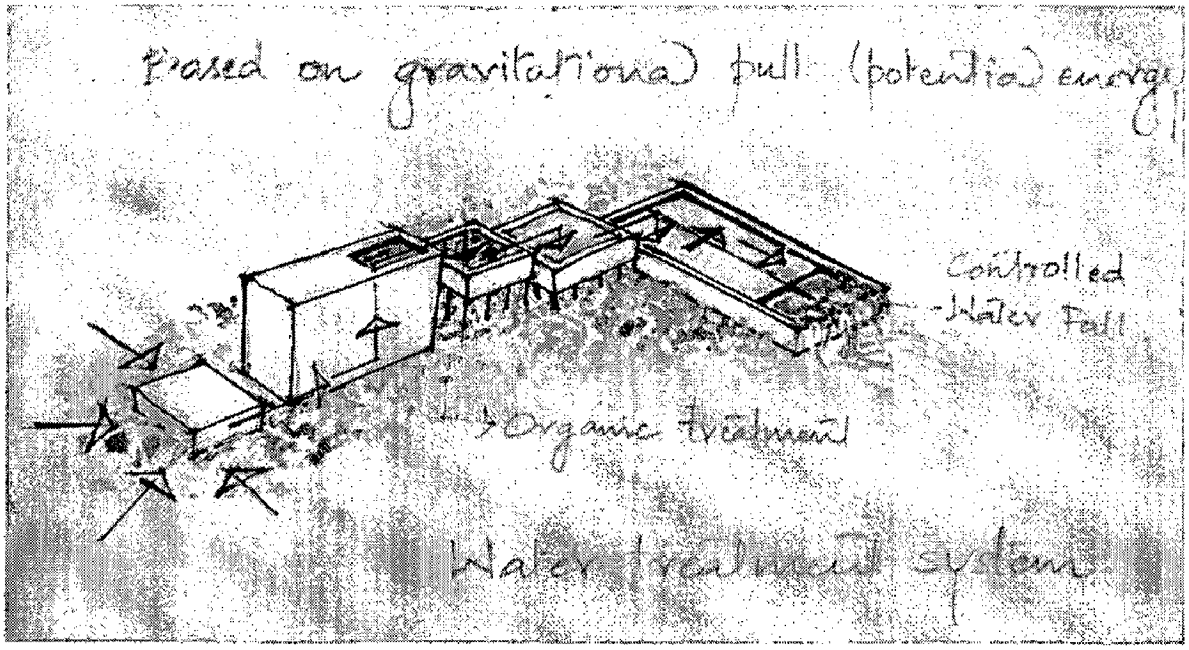


Figure 6-13: water treatment based on gravitational flow

Not only Nullah, but waste water treatment at community level will also be implemented so as to get clean water which will be added to the previously treated canal.

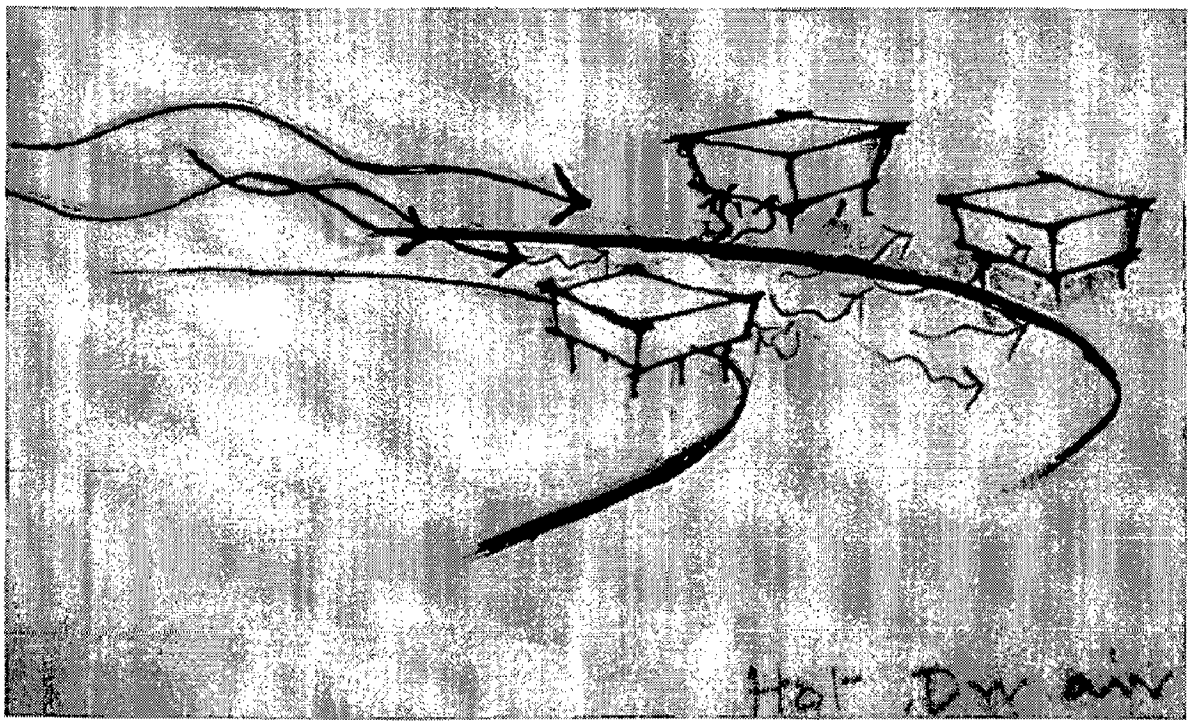


Figure 6-14: cool breeze for land mass, after wind gains moisture from clean drain

This step will set an example for how simple efforts can bring change in society, how nicely we can achieve positives from negatives.

This drain will be treated at the place between railway line and high way; here a huge pond already exists. After treatment this drain will become clean, it will no more be harmful to touch. It will not spread foul smell and thus will act as clean canal. This clean canal will be protected by green belt which will contain passive recreational activities. This will create a healthy environment and will give chance to feel as if sitting on nature's lap. Waste water after treatment at community level will join this canal only. As waste water generated by the block will be treated within their courtyard (underground water treatment plant). Area required for this treatment is 1900 sq mtr. (for waste water generated by 1500 of population). Area provided is 1900 (at least) for 1400 population (maximum). The mentioned canal would be catchment for rain water harvesting system also. And thus a moment towards understanding natural resources and respecting them will aware people and will come up with new and meaningful approach to achieve sustainability.

7 CONCLUSION

Sustainability being major issue to ensure our existence on earth, the major challenge for human beings is to survive in changing environmental context. This study focuses on a biomimicry concept to seek solutions for sustainability.
Biomimicry teaches; to live in nature, to live with nature, we should live like nature. Or in other words biomimicry means to mimic nature which is the only best way to merge with nature and to create sustainable conditions for us, as well as for coming generations. This process involves certain steps such as observing nature, finding out sustainable solutions from it and incorporating them in our designs. Basic principles which biomimicry teaches to urban developments may be:

- **It generates its own food**
- **Circulates through whole body and gains energy out of it, and**
- **Produces waste which becomes other's food.**

In terms of urban development these parameters can be

- **Allocating and generating resources and energy out of it**
- **Provision of services and transportation to whole system, and**
- **Waste management.**

By putting initial efforts, sustainable measures can be achieved. The essential change which is required is to develop an understanding towards nature and responds to it. This can be done by incorporating following sustainable paradigms in our planning process:

- Conservation of resources by introducing methods like ecological taxation.
- Provision of energy generation within the site which is to be planned.
- Nature oriented development which has high density, compact and public transport oriented.
- And finally waste management, settlement should treat its own waste (solid, liquid or gaseous) or treat waste as resource.

As this thesis proposes for the site in "L" zone Delhi, briefly discussed below:

Nature also teaches optimum utilization of resources. Resource allocation in nature gives result to efficient and suitable functionality to whole system. This property is applied to generate land use plan which comprises of respective activities in any settlement. On given proposal landuse are allocated in such a manner that the inter-dependent resources or inter-related activities are located according to preference. Industrial zone for example is connected with highway and lower income group (L.I.G. and abadi area) for good accessibility and to provide employment respectively.

In nature energy generation is done from renewable resources, for example producers by the process of photosynthesis convert renewable energy from sun to other usable form of energy. This prime source of renewable energy from sun is considered for generating energy for energy requirement in the proposed settlement. Surfaces where direct sunlight is not required (parking, roads, roofs, etc.) can be utilized to generate electricity by the help of solar panels. Here, land use allotted to energy 42 hectare (for sub-station and administration) can produces 769 MW of energy/ annum.

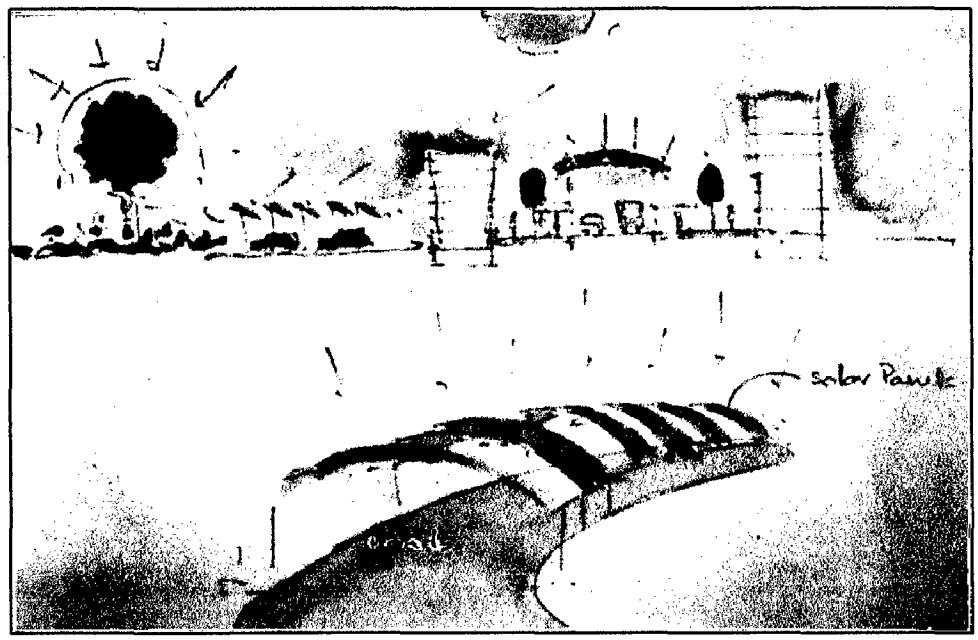


Figure 7-1: energy generation in nature & in an urban development

Diversity in nature also teaches how nicely it distributes its resources. This teaches us the pattern in which facilities should be decentralized to provide opportunity and reduce pressure to each facility. In terms of urban development this can be pronounced as mixed land use, this has added advantage to provide choice as well. Thus the proposal has building module with commercial (ground floor) and residential (on floors above). Site also has CORE (Commercial, Offices, Residential, and Energy generation in same building) along periphery, to provide mixed land use at higher hierarchy.

As nature is combination of all, our activities are also interconnected and interrelated to each other. An activity leads to another and thus resultant is the integration of whole built system. Now this integration

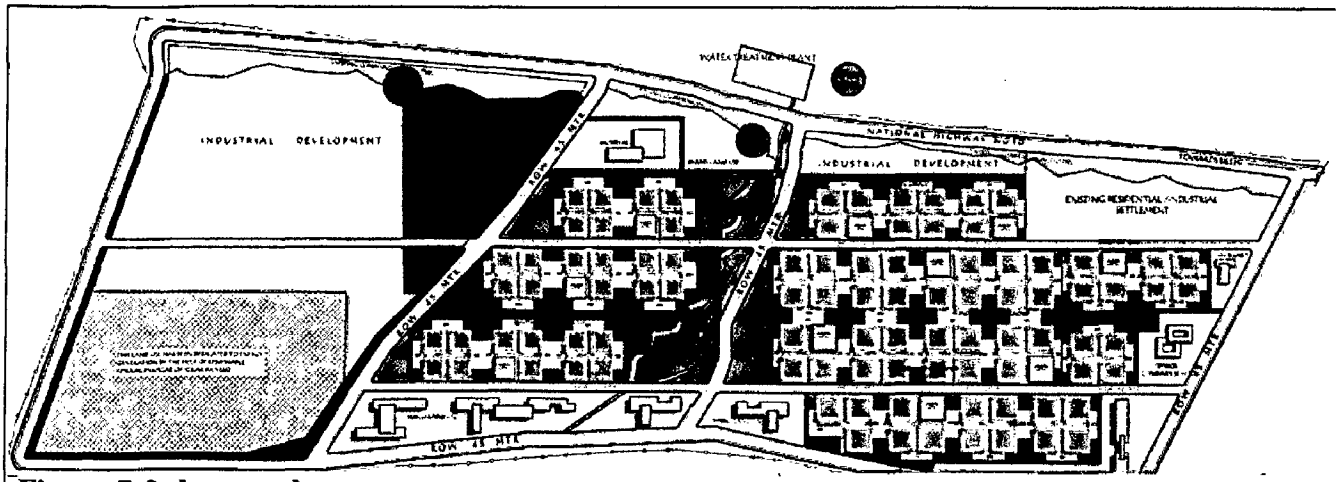


Figure 7-2: layout plan

demands exchange of things within the sub-systems of any development, to provide sustainable co-existence of systems within an urban development. By observing borders in nature, lesson which we get is that nature too has borders and they have maximum scope of exchange of nutrients and thus possess variety (due to climatic and other contextual reasons) ex. Mycelium and climate responsive growth. Similarly in given context planning is done in such a manner that borders or merging of different disciplines has been given opportunity for exchange to take place. Instead of any strict zone, a buffer, open space or recreational spaces which can accommodate informal demands and has scope of flexibility in future have been provided.

The transportation in nature is carried out in a very interesting manner. It always one-way directed (flow of rivers, blood in nerves), hierarchical in nature to extend its foliage (trees, tributaries and distributaries). Flow follows path of least resistance. Similarly, our transportation and services distribution should be designed in a settlement. In given proposal, roads are laid as veins in leaves. Cul-de-sec or dead ends have been provided to define the flow and to restrict the unwanted disturbance to move throughout the development. Whole of the development is accessible by

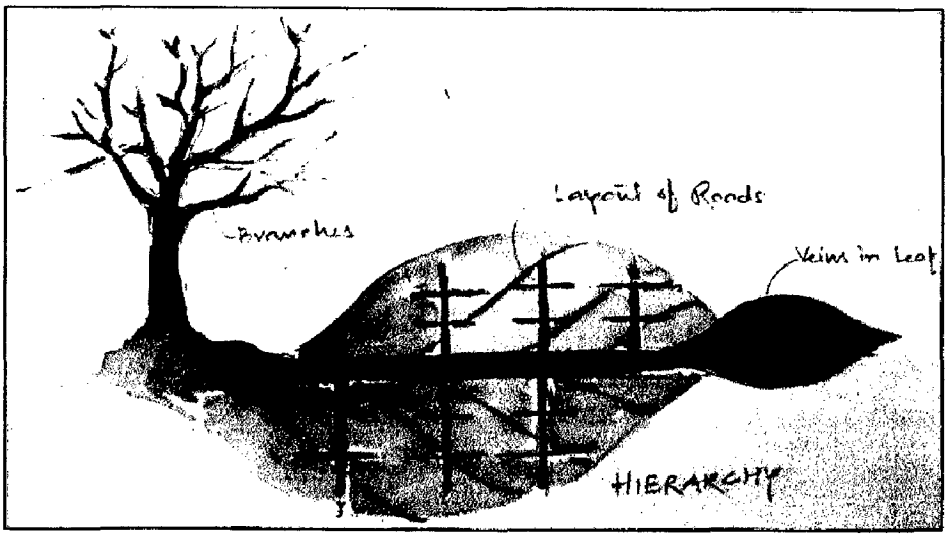


Figure 7-3: hierarchy & distribution of nutrition in nature evolves road network

is

pedestrian, or facilities are provided within walkable distances. Public transport is at approachable distance (maximum of 150 mtr) to pedestrian, this can only ensure efficiency in transportation. Efficiency in transportation can only overcome biological line "stagnation leads to contamination"; defined one way movement will lead to least resistant path to achieve smooth flow in transportation and services.

Nature as is full of openness provides full exposure to sun, wind and water. On similar lines, proposal for the development has approximately 50% of open area, even after achieving density of 305 persons /hectare. Abundance of natural spaces, recreational spaces, parks and tot-lots are provided as lungs within the settlement. This connection with natural environment makes it preferred livable urban development.

As a matter of fact that high density settlement perform better than any other (reduced consumption of resources and energy, reduced generation of CO2 or waste)and thus prove to be environmentally sustainable developments. But in such cases the answer to functionality becomes mixed land use and pedestrian friendly, approachable planning.

Last but not least comes waste, no doubt by high density and compact planning by providing mixed land use and pedestrian friendly environment reduces CO2 production considerably. Providing adequate amount of green spaces can reduce it even more. Regarding waste water treatment the membrane bioreactor (MBR) process shall be installed in every housing unit. Water after treatment from every unit shall act as tributaries to connect as clean water drain and further to the main drain which is already treated.

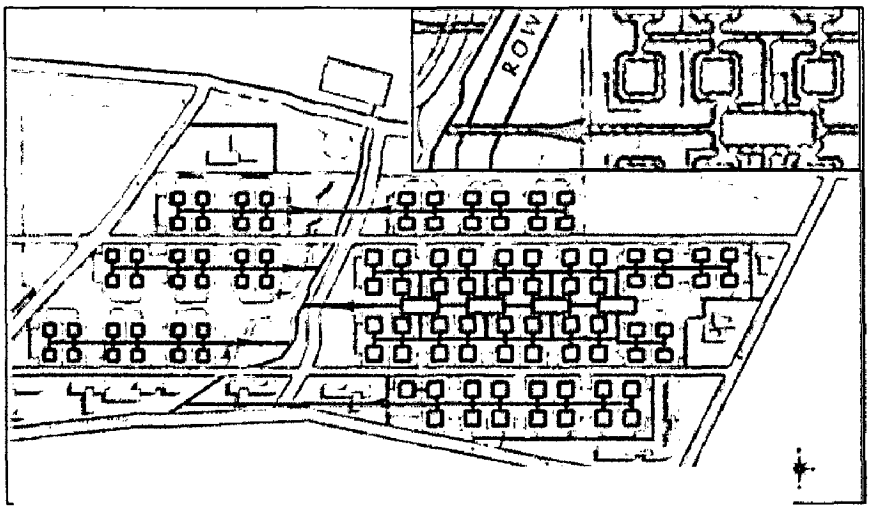


Figure 7-4: water after treatment within each module joins the already clean drain

8 ANNEXURE

THE UDPFI GUIDELINES based on which development is planned are as follows:

Table 3: UDPFI Guidelines

NORMS ACCORDING TO UDPFI GUIDELINES		
Settlement type	Persons / hectare	
Small town	75 - 125	
Medium town	100 - 150	
Proposed land use structures		
Landuse category	Small	Medium
Residential	45 - 50	40 - 45
Commercial	2 to 3	3 to 4
Industrial	8 to 10	8 to 10
Public & semi - public	6 to 8	10 to 12
Recreational	12 to 14	18 - 20
Transport & communication	10 to 12	12 to 14
Agriculture & water bodies	Balance	Balance
Total developed area	100	100

Table 4: UDPFI Guidelines for educational facilities

EDUCATIONAL FACILITIES		
a	Pre - primary nursery school 1 for 2500 population	
	Area for school	0.08 hectare
	Preprimary / nursery school to be located near a park	
b	Primary school (class I to V)	
	Strength of the school	500 students
	Area / school	0.4 hectare
	School building area	0.2 hectare
	Play field area with a min. of 18m x 36m to be ensured for effective play	0.2 hectare
c	Senior Secondary school (class V to XII)	
	Strength of the school	1000 students
	Area per school	1.6 hectares
	School building area	0.6 hectares
	Play field area with a min. of 68m X 126m to be ensured for effective play	1.6 hectares

Table 5: UDPFI Guidelines

HEALTH CARE FACILITIES			
a	Dispensary		
	1 for 0.15 lakh population		
	Area	0.08 to 0.12 hectare	
SOCIO - CULTURAL FACILITIES			
a	Community room		
	1 for 5000 population		
	Area	660 sq.m.	
DISTRIBUTION SERVICES			
a	Milk distribution		
	1 milk booth for 5000 population.		
COMMERCIAL CENTRES			
		Area / 1000 person sq.m.	No. of shops
a	Cluster centre	220	1 for 110 persons

Social facilities have been provided according to UDPFI guidelines.

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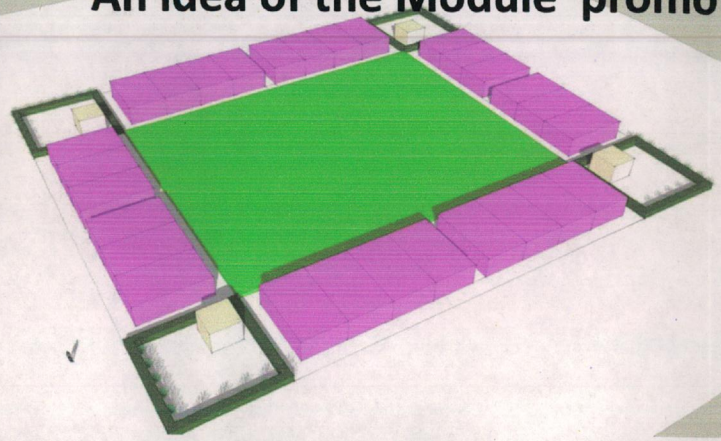
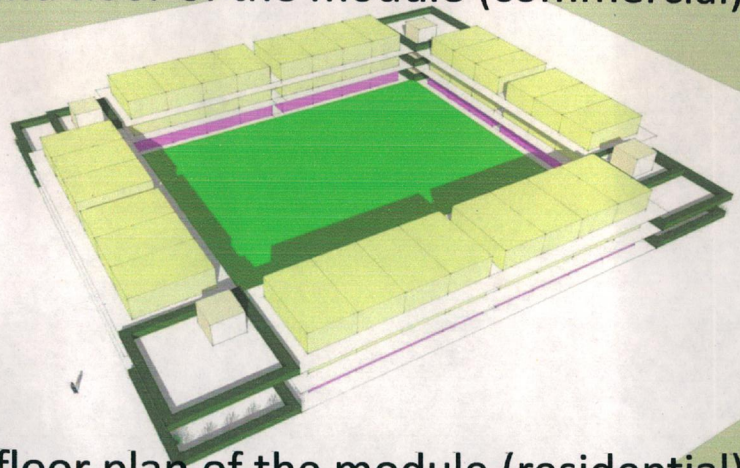
Underground planning and optimization of the underground ressources'combination looking for sustainable development in urban areas
-PierrickMaire, Pascal Blunier, AurèleParriaux, Laurent Tacher

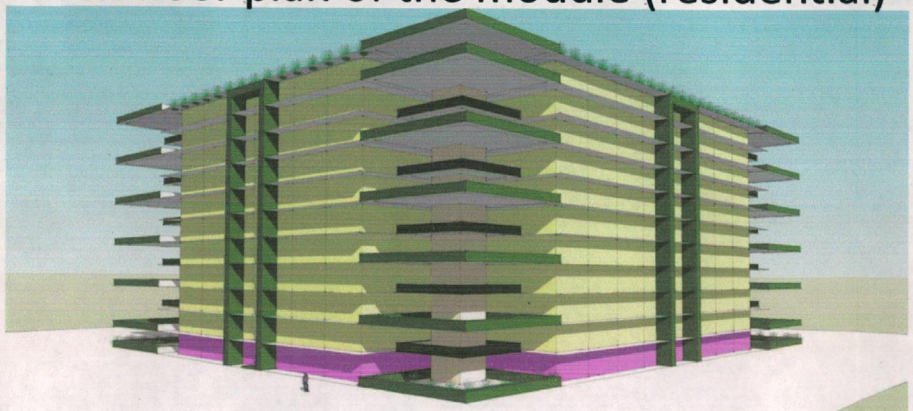
An idea of the Module promoting mixed land use within the development



Ground floor of the module (commercial)

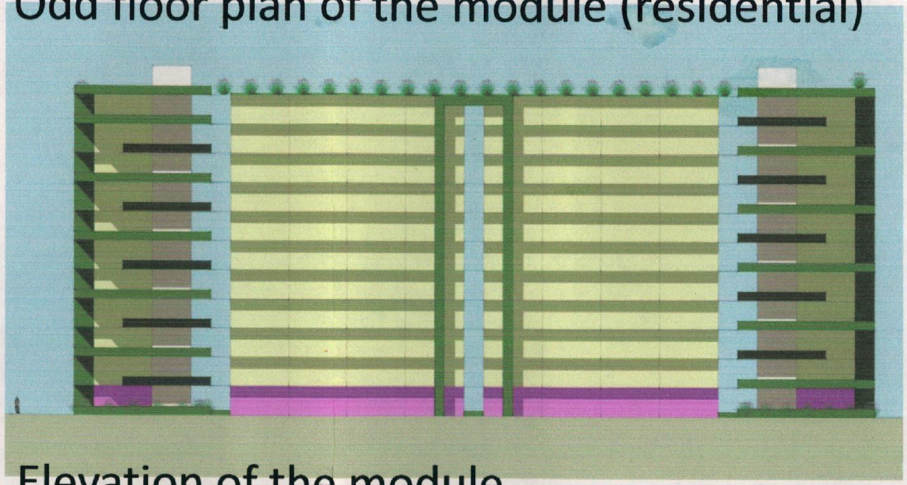


Even floor plan of the module (residential)

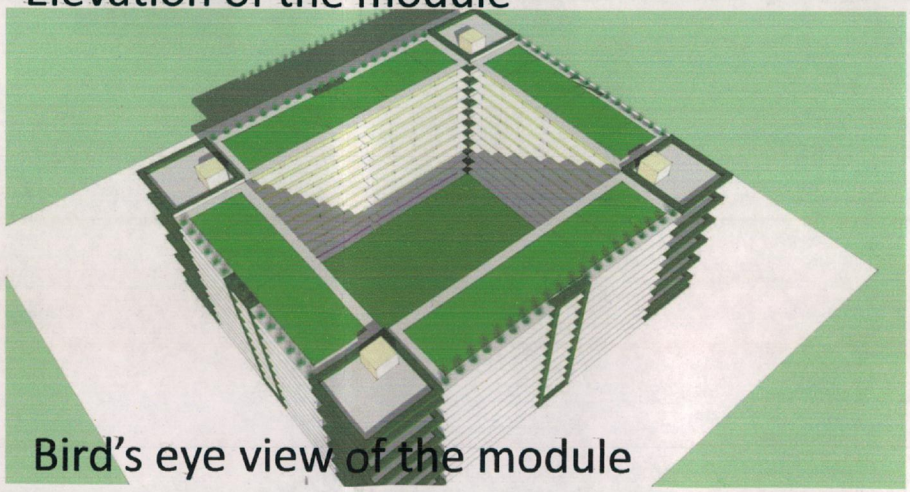


view of the module

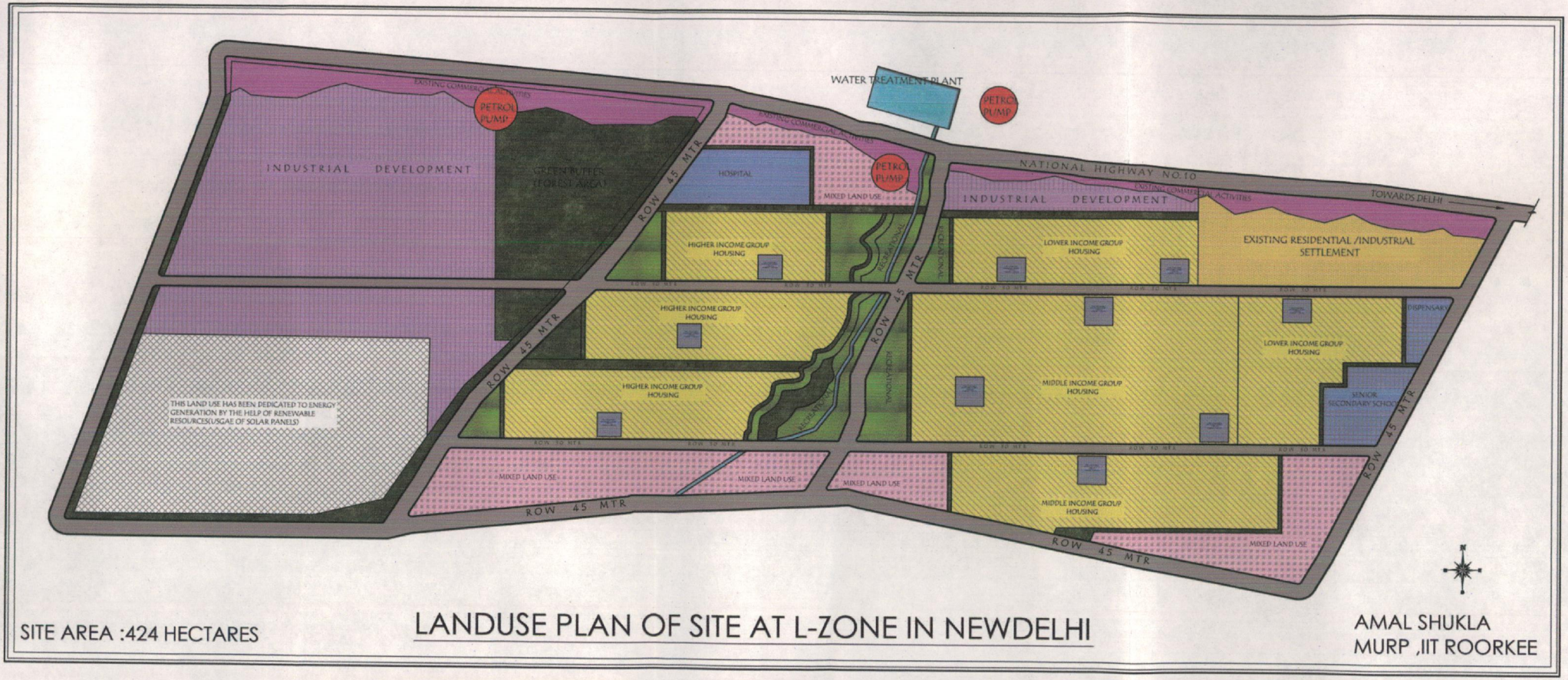
Odd floor plan of the module (residential)



Elevation of the module



Bird's eye view of the module



SITE AREA :424 HECTARES

LANDUSE PLAN OF SITE AT L-ZONE IN NEWDELHI

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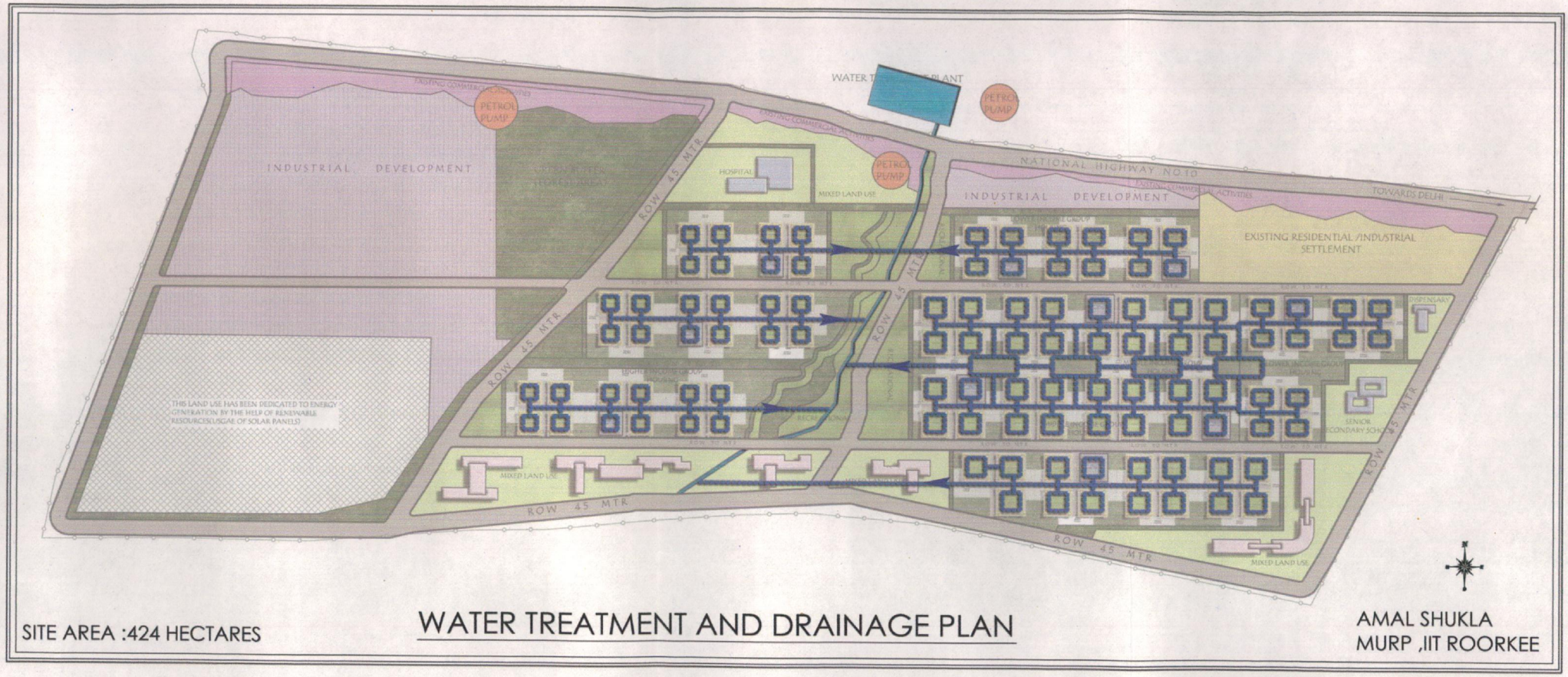
Legend:

- Industrial
- Residential
- Forest or green belt/areas
- Energy generation
- CORE (mix use building)
- Roads
- Public/ semi-public
- Recreational

SITE AREA :424 HECTARES

LAYOUT PLAN OF SITE AT L-ZONE IN NEWDELHI

AMAL SHUKLA
MURP ,IIT ROORKEE



SITE AREA :424 HECTARES

WATER TREATMENT AND DRAINAGE PLAN

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