ENVIRONMENTALLY-EFFICIENT DEVELOPMENT MANAGEMENT SYSTEM FOR GREATER KOCHI IN KERALA STATE

Thesis submitted to

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DOCTOR OF PHILOSOPHY

Under the faculty of Social Sciences

By

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KOCHI - 682022, KERALA

August 2009

Certificate

Certified that the thesis ***"Environmentally-Efficient Development Management System for Greater Kochi in Kerala State"*** *is the record of bona fide research carried out by* ***MAY MATHEW*** *under my supervision. The thesis is worth submitting for the degree of Doctor of Philosophy under the Faculty of Social Sciences.*

J Payyappilly

Prof. (Dr.) Jose T. Payyappilly
(Research Guide)
Former Director
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Kochi
31.8.2009

DECLARATION

I hereby declare that the thesis entitled **"Environmentally-Efficient Development Management System for Greater Kochi in Kerala State"** is a record of the bona fide research done by me under the supervision of Prof. (Dr.) Jose T. Payyappilly, Former Director, The School of Management Studies, CUSAT. I further declare that this thesis has not been previously formed the basis for the award of any degree, diploma or any other similar title of recognition.

Kochi -22
31.8.2009

MAY MATHEW

Acknowledgement

Subsequent to my post graduation thesis in the School of Planning and Architecture, New Delhi 'Environmental Imperatives for the development of Ernakulam in the Greater Cochin Area' in the year 1988, it was a haunting question to myself on how to take developmental-decisions in the most optimum path on total environment point of view by taking care of society, environment (physical) and economy. I started thinking aloud on how to develop a decision-making system on the above aspect. My job as engineer in the Military Engineer Services in Kochi (10 years) and town planner in the Greater Cochin Development Authority (10 years) greatly contributed my thought process on this topic.

The research proposal was given to the Council of Scientific and Industrial Research, New Delhi in the year 1998. CSIR was kind enough to award me a Senior Research Fellowship to do research on this topic with which I could do my Ph. D. registration in the School of Management Studies, Cochin University of Science and Technology. I express my sincere gratitude to Prof. (Dr.) Jose T. Payyappilly who agreed to guide me on this multidisciplinary and challenging topic. The valuable guidance, the moral boost and confidence given to me at various stages of my research by my guide as well as by my doctoral committee member Prof. (Dr.) George Varghese, I record with deep gratitude and reverence.

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Now, I present this doctoral thesis for the glory of God and the service of humanity.

May Mathew

Contents

LIST OF MAPS / FIGURES

LIST OF CHARTS

LIST OF TABLES

LIST OF ANNEXURES

ABBREVIATIONS AND SYMBOLS

ARGW	-	Artificial Recharge of Ground Water
BAU	-	Business as usual
B_C	-	Biocapacity
CBD	-	Central Business District
CCI	-	Carrying Capacity Index
CFC	-	Chloro- Flouro Carbons
CRZ	-	Coastal Regulation Zone
CSD	-	Commission on Sustainable Development
CSDMS	-	Centre for Space, Development and Media Studies
CT	-	Census Town
DPI	-	Dubai Port International
DRC	-	Development Rights Certificate
DTPS	-	Detailed Town Planning Scheme
EFp	-	Ecological Footprint
EFpI	-	Ecological Footprint Index
ESRI	-	Environmental Systems Research Institute
FAR	-	Floor Area Ratio
GCDA	-	Greater Cochin Development Authority
GDP	-	Gross Domestic Product
GIDA	-	Goshree Island Development Authority
GIS	-	Geographic Information System
GKMA	-	Greater Kochi Metropolitan Area
GKRR	-	Greater Kochi Resource Region
GNP	-	Gross National Product
GPS	-	Global Positioning System

GTS	-	Great Trigonometric Survey
GSDP	-	Gross State Domestic Product
GUO	-	Global Urban Observatory
HDI	-	Human Development Index
HDR	-	Human Development Report
ICTT	-	International Container Transshipment Terminal
IDDP	-	Integrated District Development Plan
IGBC	-	Indian Green Building Council
IIRS	-	Indian Institute of Remote Sensing
IRS	-	Indian Remote Sensing Satellite
ISRO	-	Indian Space Research Organisation
IPCC	-	Inter-governmental Panel on Climate Change
ISO	-	International Standards Organisation
IT	-	Information Technology
ITES	-	Information Technology Enabled Services
IUCN	-	International Union for Conservation of Nature
JNNURM	-	Jawaharlal Nehru National Urban Renewal Mission
Kochi UA	-	Kochi Urban Agglomeration
KLT	-	Kerala Law Times
LDP	-	Local Development Plan
LEED	-	Leadership in Energy and Environment Design
LNG	-	Liquefied Natural Gas
LPI	-	Living Planet Index
LPR	-	Living Planet Report
LUO	-	Local Urban Observatory
MA	-	Millennium Ecosystem Assessment

MSA	-	Micro Study Area
NASA	-	National Aeronautics and Space Administration
NH	-	National Highway
NRI	-	Non-Resident Indian
NRK	-	Non-Resident Keralite
NRSA	-	National Remote Sensing Agency
OECD	-	Organisation for Economic Co-operation and Development
OG	-	Out Growth
PPP	-	Purchasing Power Parity
PQLI	-	Physical Quality of Life Index
RWH	-	Rainwater Harvesting
SOI	-	Survey of India
SWOT	-	Strengths, Weaknesses, Opportunities and Threats
TDR	-	Transferable Development Right
UNCHS	-	United Nations Centre for Human Settlements
UNDP	-	United Nations Development Program
UNEP	-	United Nations Environment Program
UNFCCC	-	United Nations Framework Convention on Climate Change
USAID	-	United States Agency for International Development
WCED	-	World Commission of Environment and Development
WWF	-	World Wide Fund for Nature
$\mathbf{I_e}$	-	Environmental Efficiency Index
$\boldsymbol{\mu}$	-	Land Utility Index
$\boldsymbol{\alpha}$	-	Accessibility Index
$\boldsymbol{\beta}$	-	Per capita Built-up
$\boldsymbol{\delta}$	-	Disturbance factor

Chapter·1

INTRODUCTION

Contents

1.1 CONCEPT AND DEFINITION OF SUSTAINABLE DEVELOPMENT

Sustainable Development is the most popular term of the era and has taken the centre stage of multidisciplinary thoughts. The term sustainable means the ability to sustain or continue forever. It is a condition of continuous and everlasting existence.

The concept of sustainable development attained worldwide attention after the publication of the Report of the World Commission on Environment and Development (WCED 1987) 'Our Common Future'. It spelt out the need for sustainable development that would meet the needs of the present generation without compromising the needs of the future generation. Adoption of the ethics of care, respect and responsibility towards nature is a pre-condition for the successful implementation of the policy of sustainable development (Telang 1997).

There are umpteen numbers of definitions of sustainable development. Monto et al. (2005) in their book on the Sustainability and Human Settlements, compiled the various definitions of sustainable development. Some of the definitions are as follows:

As early as 1915 Canadian Conservation Commission has opined that each generation is entitled to the interest of the natural capital, but principal should be handed over unimpaired. According to IUCN, WWF and UNEP (IUCN et al. 1980) Sustainable Development is earmarked by the maintenance of essential ecological processes, life support systems, preservation of genetic diversity and sustainable utilisation of species and ecosystems, while Allen (1980) underlines the importance of achieving satisfaction of human needs and improvement of the quality of human life. But major challenge of the coming decades is to learn how long term large scale interaction between environment and development can be better managed to increase the prospects for ecologically sustainable improvements in human well being (Clark and Munn 1986). This necessitates an approach that will permit continuing

improvements in the quality of life with a lower intensity of resource use, thereby leaving behind for future generations an undiminished or even enhanced stock of natural resources and other assets (Munasinghe and Lutz 1991). The concept of sustainable development combines two basic notions, economic development and ecological stability. Ecologically sustainable economic development can be thought of as the process of related changes of structure, organisation and activity of the economic-ecological system, directed towards maximum welfare which can be sustained by the resources to which that system has access (Braat 1991). Schultink (1992) put forth the definition of Sustainable Development as the development and management of natural resources to ensure or enhance the long-term productive capacity of the resource base and improve the long-term wealth and well-being derived from the alternative resource use systems with acceptable environmental impacts.

However, the attainment of the efficiency of the total environment around man greatly contributes to sustainable development. The total environment comprises of mostly the physical environment, social environment and economic environment. Physical environment is usually referred to as the 'environment' in the Economy-Environment-Society tripod. The efficiency can be determined by the total output with respect to the total input.

1.2 CONCEPT OF ENVIRONMENTAL EFFICIENCY

Environmental efficiency is the term introduced in this thesis in which environment means the 'total environment' and the various dimensions of it being the physical environment, social environment and economic environment. Environmental efficiency of development management system aims to reduce the spare capacity and losses, so that output is attained with minimal wastage. This spare capacity is causing diseconomy and wastage is causing environmental hazards.

Major portion of sustainable development can be achieved through the practice of environmental efficiency and it does not advocate to compromise human comfort or convenience. In fact it aims at improving the quality of life, while reducing the consumption in terms of land and energy.

Attainment of Environmental efficiency aims to make everybody in the system happy, so that public acceptance and practicability are more and has a promising future. The basic purpose of development is to enlarge people's freedom and choices by creating an enabling environment for people to enjoy long, healthy and creative lives. Philosophers like Aristotle (384-322 B.C.), Emmanuel Kant (1724-1804) and Adam Smith (1723-1790) have shaped the idea that human beings are the ultimate end of development and not convenient fodder of the materialistic machine (Haq 1996).

1.3 RELEVANCE OF ENVIRONMENTAL EFFICIENCY IN HUMAN SETTLEMENTS

Nearly every other person on earth already lives in cities. By 2030, 60 % of the world population is expected to live in cities, as per the estimates of UN Population Division which is reported in the State of World Cities report (UN-Habitat, 2004). 'Cities are engines of economic growth', say economists. Lion's share of the GDP of the world is produced in cities. This is due to the high population density in the cities which enables better functioning of labour markets, lower transportation costs, faster diffusion of knowledge, larger economies of scale in production and due to a critical mass of adjacent consumers. Cities are centers of good as well as bad. World cities are major contributors of global warming, Chloro-Fluro Carbons (CFCs) causing ozone layer depletion and acid rains. Also cities are the major consumption centers of natural resources and energy.

There comes the importance of environmentally-efficient development management system at the human settlements to make it more livable for all the sections of society and for the future citizens as well, while maintaining a sustainable globe where land, water and ecosystems are protected.

1.4 INTRODUCTION OF THE STUDY AREA

The study area is the Greater Kochi Metropolitan Area lying inside the Greater Kochi Resource Region in the State of Kerala. Hence it is necessary to introduce the State of Kerala, Greater Kochi Resource Region and the Greater Kochi Metropolitan Area—Kochi Urban Agglomeration.

The State of Kerala

Geography

Kerala State, wedged between the Laccadive Sea and the Western Ghats, is lying between north latitudes 8°15'54" and 12°45'30" and east longitudes 74°53'37"and 77°3'34". Humid equatorial tropical climate is prevalent in Kerala. Kerala's coastal line extends to 580 km and the width varies from 35 km to 120 km. Kerala can be divided into three topographically distinct regions: the eastern highlands, the central midlands and the western lowlands. Eastern Kerala consists of high mountains and valleys immediately west of the Western Ghats' rain shadow. Out of the 44 rivers flowing through the region, 41of them are west flowing and others are east flowing. Kerala's western coastal belt is relatively flat, with a network of canals, lakes, estuaries and rivers.

Climate

With 120–140 rainy days per year, Kerala has a wet and maritime tropical hot humid climate influenced by the seasonal heavy rains of the southwest and northeast monsoons. Kerala's rainfall averages 3,107 mm annually, while the mountains of eastern Idukki district receive more than 5,000 mm of orographic precipitation, the

highest in the state. The mean daily temperature of the state ranges from 19.8 °C to 36.7 °C (Wikipedia).

Biodiversity

The State of Kerala is synonymous for its rich biodiversity. Agasthyamalai Biosphere Reserve, Periyar Tiger Reserve and Silent Valley are only some among them in the eastern hills. Almost a fourth of India's 10,000 plant species are found in the state. Its 9,400 sq. km of forests include tropical wet evergreen and semi-evergreen forests, tropical moist and dry deciduous forests and montane subtropical and temperate (*shola*) forests. Altogether, 24% of Kerala is forested (Sreedharan 2004). Two of the world's Ramsar Convention listed wetlands—Lake Sasthamkotta and the Vembanad-Kol wetlands—are in Kerala (Ramsar Convention Bureau 2001). Kerala's fauna are notable for their diversity with 102 species of mammals, 476 species of birds, 202 species of freshwater fishes, 169 species of reptiles and 89 species of amphibians (Economic Review 2004). These are threatened by extensive habitat destruction, including soil erosion, landslides, salinity intrusion and resource extraction (Wikipedia).

There are 14 revenue districts which are lying in the three historical regions of Thiruvithamkoor, Kochi and Malabar. Kerala's 14 revenue districts are subdivided into 63 taluks, 1453 revenue villages and 999 panchayats.

Transport

Kerala has 145,704 kilometers of roads (4.2% of India's total). This translates to about 4.62 kilometers of road per thousand population, compared to an all India average of 2.59 kilometers. Virtually all of Kerala's villages are connected by road. Traffic in Kerala has been growing at a rate of 10–11% every year, resulting in high traffic and pressure on the roads. Kerala's road density is nearly four times the national average and Kerala's annual total of road accidents the nation's highest (Kumar, 2003).

Demography

Kerala is home to 3.44% of India's people at 819 persons per sq. km. and its land is nearly three times as densely settled as the rest of India, which is at a population density of 325 persons per sq. km. Kerala's rate of population growth is India's lowest, and Kerala's decadal growth (9.42% in 2001) is less than half the all-India average of 21.34%. Kerala's population more than doubled between 1951 and 1991 by adding 15.6 million people to reach 29.1 million residents in 1991. The population stood at less than 32 million by 2001 (Census Report 2001). Kerala's coastal regions are the most densely settled leaving the eastern hills and mountains comparatively sparsely populated.

Tourism

Kerala is one of the most popular tourist destinations in India and popularly known for its eco-tourism initiatives and named as 'God's own country', one of the 'ten paradises of the world' and '50 places of a lifetime'.

The Greater Kochi Resource Region

The Ministry of Environment and Forests, Government of India has identified certain regions for which carrying capacity based development planning studies were conducted/initiated. Carrying capacity study for the national capital region of Delhi and carrying capacity study for the Greater Kochi Region are two among them.

The core team entrusted with the carrying capacity study of Greater Kochi Region delineated 13182 sq. km. area including Greater Kochi Metropolitan area as the potential region which is the watershed of Vembanadu estuary system through which seven major rivers of Kerala viz. Chalakudy, Periyar, Moovattupuzha, Manimala, Pampa and Achenkovil are flowing towards west and fall in the backwaters (Greater Kochi Carrying Capacity Study Report 2002).

District- wise break-up of Greater Kochi Region identified is as follows:

Ernakulam	2407 sq. km.
Kottayam	2204 sq. km.
Idukki	5019 sq. km.
Thrissur(part)	64.19 sq. km.
Pathanamthitta(part)	2452.67sq. km.
Alapuzha(part)	1036.09sq. km.

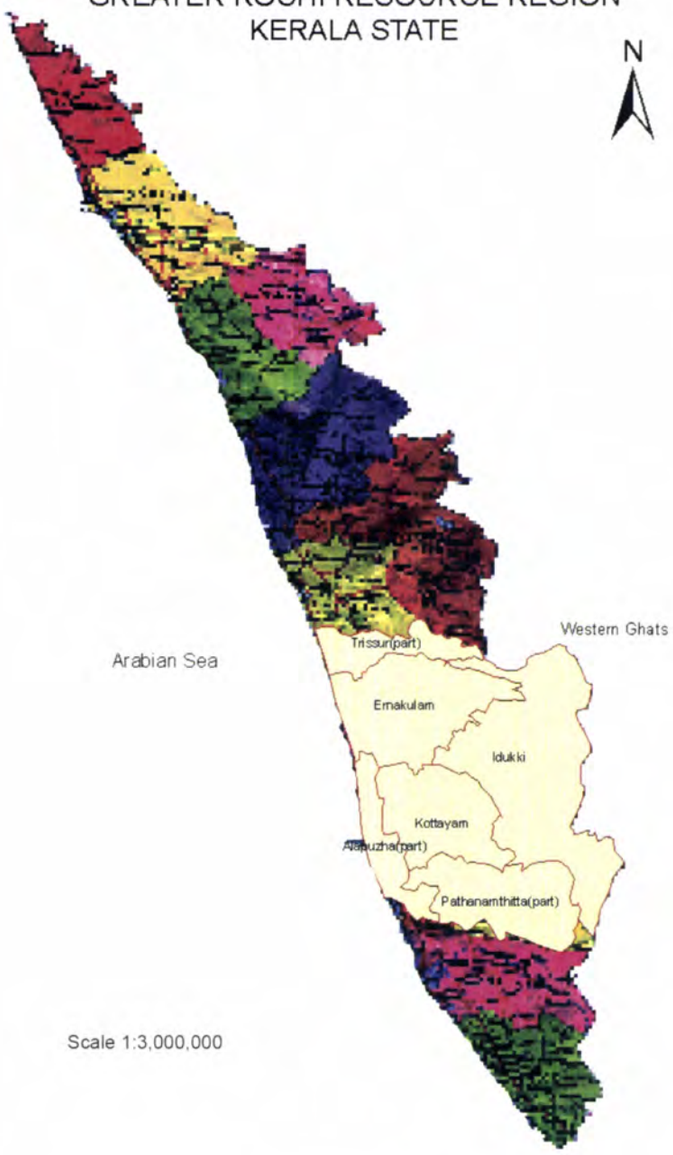
The delineated area accounts for 34% of the geographical area of Kerala. Boundaries are

North	Chalakudy river
West	Arabian Sea
East	Western Ghats
South	Achenkovil river

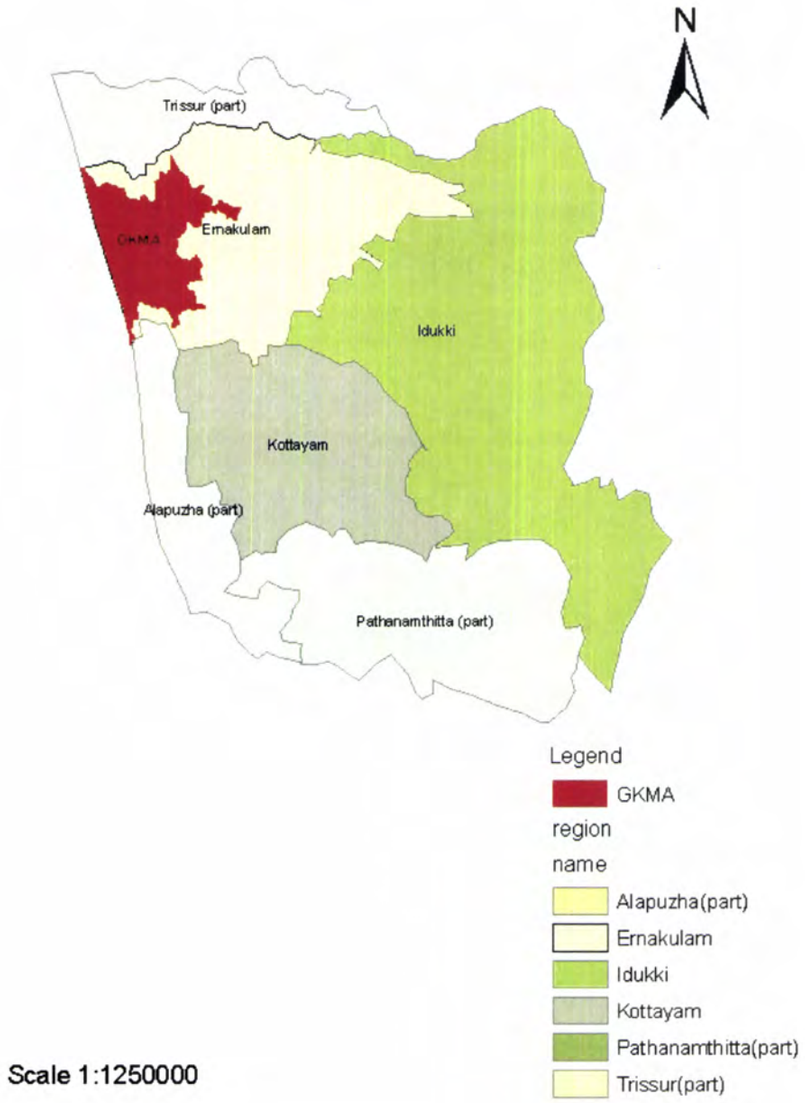
Area of the Greater Kochi Resource Region is only 39% of the area of National Capital Region. Most urbanised national capital territory of Delhi inside national capital region is 1483 sq. km., while the Greater Kochi Metropolitan Area inside Greater Kochi Resource Region is only 732 sq. km (Map 1.1 and Map 1.2) .

Map 1.1

GREATER KOCHI RESOURCE REGION
KERALA STATE



Map 1.2
REGION, DISTRICT, METROPOLITAN AREA



The Greater Kochi Metropolitan Area—Kochi Urban Agglomeration

The Greater Cochin Development Authority (GCDA) having a jurisdictional area of 732 sq. km was constituted in the year 1976 and it consists of Cochin Corporation, six adjoining municipalities and 33 panchayats.

The concept of urban agglomeration (UA) was introduced in the Census of India in 1981 onwards. An urban agglomeration is a continuous urban-spread, constituting a town and its adjoining urban out growths or two or more physically contiguous towns together and any adjoining urban out growths of such towns. In 2001 Census (Census Report 2001) two more conditions were added to the concept of urban agglomeration.

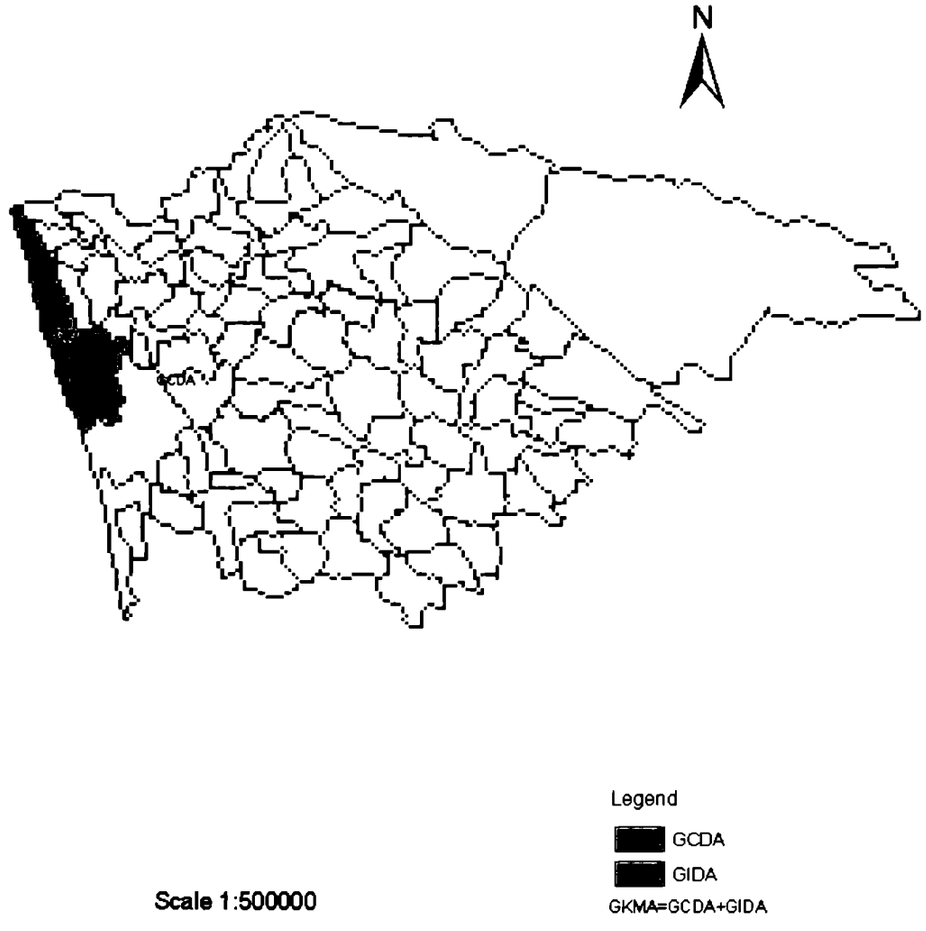
1. The core town or at least one of the constituent towns should necessarily be a statutory town.
2. The total population of the constituent units ie towns and out growths of an urban agglomeration should not be less than 20000 as per the 1991 Census population figures.

Population of Kochi Urban Agglomeration (included mostly in GCDA) area as per the Census of India 1991 is 1140605 spread in an area of 373.27 sq. km. (Census Report, 1991). Kochi was thus included in the list of 23 million plus cities of India in 1991. In 1994, for giving special attention to island panchayats Goshree Island Development Authority (GIDA) was formed by taking out eight island panchayats from Greater Cochin Development Authority jurisdictional area. In 1995, Government of Kerala declared the Greater Kochi Metropolitan Area (Map 1.2) extending to 732 sq. km. and consisting of Cochin Corporation, six adjoining municipalities and 33 panchayats and which contain the Kochi Urban Agglomeration 1991. This is the original jurisdictional area of the Greater Cochin Development Authority. Thus, Greater Kochi Metropolitan Area consists of two development authorities namely Greater Cochin Development Authority (632 sq. km.) and Goshree Island Development Authority (100 sq. km.) (Map 1.3).

As per the 2001 Census Kochi Urban Agglomeration area has increased to 452.64 sq. km. with a population of 1355972 which is mostly inside the metropolitan area.

Map 1.3

GREATER KOCHI METROPOLITAN AREA
IN ERNAKULAM DISTRICT



1.5 GREATER KOCHI IN THE GROWTH TRAJECTORY

Greater Kochi attains the status of an international city once the International Container Transshipment Terminal (ICTT) starts functioning here in full swing. Cochin Port has entered into an agreement with M/s Dubai Port International (DPI) to set up a Container Transshipment Terminal at Greater Kochi on Build-Operate-Transfer basis and the construction work is going on. Also many unique economic ventures are coming up in port-based special economic zones in Greater Kochi to contribute to the ICTT function. Some of the above ventures are as follows:

1) LNG degasification plant
2) Ship repairing yard
3) Bunkering yard
4) Cruise terminal
5) Marina

Greater Kochi can no longer remain in low profile due to the above economic functions allocated to it. The surging metropolis is to be steered with sound development management techniques to contain the developmental momentum for a sustainable Greater Kochi.

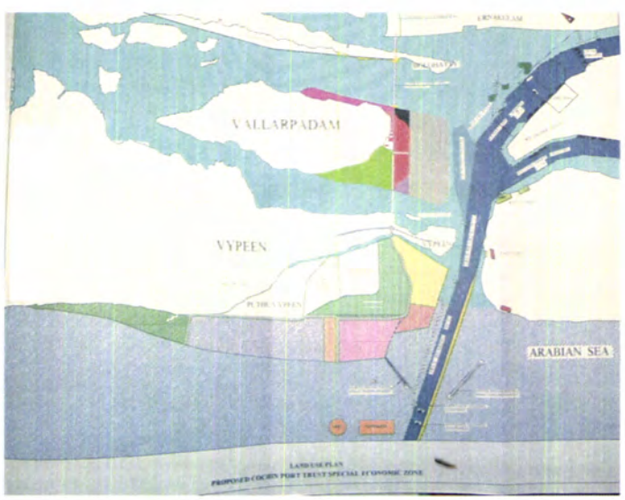


Fig.1.4 Port Based Special Economic Zones, Source: Cochin Port Trust

1.6 SWOT OF GREATER KOCHI

To take stock of the Strengths, Weaknesses, Opportunities and Threats of Greater Kochi is very much adequate for this study of environmentally-efficient development management system. SWOT of Greater Kochi which is gathered through discussions and seeking experts' and stakeholders' opinion. The pro forma circulated for SWOT stocktaking is as per Annexure 1. SWOT gathered are listed below under five different heads:

1. Nature and Resources
2. Infrastructure and service demand
3. People and competencies
4. Political and social
5. Economic and financial

STRENGTHS

S-Nature and Resources

- Geographically central location of the state
- Proximity to international shipping lane
- Potential agricultural area in the region
- Scenic beauty of the backwaters and rivers
- Plenty of rain, sun and moderate climate
- varied ecosystems in the region
- Network of canals suitable for city and cargo transport
- A place of rich heritage
- Attractive tourist spot in the region

S-Infrastructure and Service Demand

- Good accessibility by road, rail, air and sea to the rest of the world
- Good regional connectivity inside the state

- All weather port and coming up container terminal
- Landing point for submarine cables
- Presence of wholesale markets for agricultural produce
- Major distribution centre for commodities
- Nodal point for collection and distribution of manpower and cargo
- Coming up LNG terminal, cheaper fuel for industries
- High supply of serviced urban vacant land
- Low rental value compared to other cities of the world

S-People and Competencies

- Good communication skills of the residents
- Low cost of living compared to other international cities
- High literacy level and educated youth throughout the state
- Enterprising nature of the people
- Low attrition rates in employment

S-Political and Social

- Cosmopolitan character of the crowd
- Good Schools/Universities
- Wide-spread banking facilities
- Communal harmony
- Low crime rate
- Cheap and good medical facilities

S-Economic and Financial

- Most tax-generating place in the state
- Higher per capita income in comparison to other cities in the state
- High spending capacity and spending habit of the residents
- NRI mooring point for shopping, investment and stay

WEAKNESSES

W-Nature and Resources

- Unplanned and unregulated development resulting in urban sprawl
- Unviable population concentration for higher order infrastructure
- Non-judicious industrial location
- Non-uniform distribution of stadiums, parks, and open spaces
- Fast run-off due to steep terrain condition of the hinterland
- Deterioration of West Kochi area
- Degradation of river Periyar and the various canals in the city
- Sea erosion, flooding and mosquito menace
- Less productivity of the resource base of the region
- Land acquisition for developmental work highly expensive
- Diminishing Government land

W-Infrastructure and Service Demand

- Disposal of untreated industrial waste into water bodies
- Lack of adequate solid waste management facilities
- Lack of proper storm water drainage in low-lying areas
- Absence of efficient sewage disposal system
- Disposal of sewerage to surface drainage in many areas
- Pressure on road network due to increase in personalised vehicles
- Lack of adequate parking space
- Lack of suitable mode of mass transport and inter-modal facilities
- Deteriorated infrastructure in West Kochi
- Deteriorated bridges across water bodies
- Lack of head room of canals to enable inland navigation
- Silting up of canals

- Lack of high capacity infrastructure to accommodate high residential densities
- Non-judicious location of high-rise buildings
- Plenty of non-performing serviced vacant land and vacant buildings
- Lack of efficient disaster management system

W-People and Competencies

- Lack of adequate bureaucratic support not being the capital city
- Lack of mechanism to create housing for the poor
- Lack of coordination between various government bodies
- Lack of effective role given to development authorities
- Lack of effective legislation for innovative development management
- Obsolete Town Planning Act

W-Political and Social

- Rising Corporation tax rates with diminishing services offered by Corporation
- Unscientific taxation formulae
- Loss of productive hours due to political unrest for trivial issues and trade unionism
- Uncontrolled migrant labour resulting in unauthorised colonies
- Low bargaining power of the elected representatives due to lack of population concentration

W-Economic and Financial

- High morbidity rate of population, prevalence of life style diseases
- Distribution of tax collected from the area to the rest of the state and country
- Incompetency in utilising the available government funds

OPPORTUNITIES

O-Nature and Resources

- Cheaper cost of fuel from LNG plant can revitalise the industrial economy
- Harnessing the minus energy of LNG for generation of drinking water
- Conservation of ecosystems and agricultural areas in the hinterland
- Improve mass transit to reduce traffic congestion
- Construction of small dams in the region to reduce fast runoff and salinity intrusion
- Development of middle class tourism to attract domestic tourists to enjoy the nature
- Encouragement of IT and ITES industries
- Encouragement of energy-efficient city planning and energy-efficient building practices

O-Infrastructure and Service Demand

- Enlisted as a beneficiary of Jawaharlal Nehru National Urban Renewal Mission
- Suburban rail for mass transport
- Inland navigation for transport of cargo, city transport and tourism
- Continuing investment in port and container terminal facilities
- Continuing investment in the development of the International Airport
- Development of interstate bus terminal with multimodal interchange facility
- Establishment of higher order infrastructure
- To develop as a world class service centre
- Planned compact high density development

O-People and Competencies

- High literacy rates and availability of skilled labour
- Return of NRIs with financial capital, experience, new ideas and know-how

- Keralites scattered throughout the world for building up business opportunities in their homeland

O-Political and Social

- State-wide commitment to develop Greater Kochi as a top class global city
- Formulation of the mandatory Metropolitan Planning Board/Committee
- Re-delineation of effective metropolitan area and region for planned development

O-Economic and Financial

- Can attract tourists for rest and relaxation
- Provision of infrastructure on private-public participation
- Can emerge as an international conference centre
- Can be a centre for international and national trade fairs
- Can be developed as centre for hosting events in sports

THREATS

T-Nature and Resources

- Degradation of rivers and the canals causing unpleasant atmosphere and epidemics
- Sea level rise can affect the high density population near water bodies
- Sea erosion of West Kochi area and land subsidence of the filled-up areas
- Establishment of Vizhinjam container terminal, within-state competition
- Degradation of heritage buildings
- Earthquake zone reclassified as zone III
- Loss of productivity of the ecosystems in the hinterland

T-Infrastructure and Service Demand

- High susceptibility to fire hazard due to lack of scientific disaster management facilities
- Unscientific land filling and cutting can cause land slide and land subsidence
- Unscientific rainwater harvesting can cause land slides
- Lack of flyovers and bridges causing loss of man hours and fuel repel economic opportunities
- Air pollution causes severe respiratory diseases

T-People and Competencies

- Aging of the resident population as educated youth are working outside the country
- Sedentary habits causing high occurrence of life style diseases

T-Political and Social

- Corruption and high labour militancy
- Increase in crime rate and road accidents
- Lack of parental care for the young generation as one of the parents may be working abroad

T-Economic and Financial

- Decline and degradation of the city resulting in loss of total economy

Going through the SWOT one can see that the strengths and opportunities are immense and they overweigh the weaknesses and threats which can easily be overcome by prudent and effective development management measures.

1.7 BASE CONCEPT, OBJECTIVES AND METHODOLOGY

The base concept from which the entire research problem emerged is as follows:

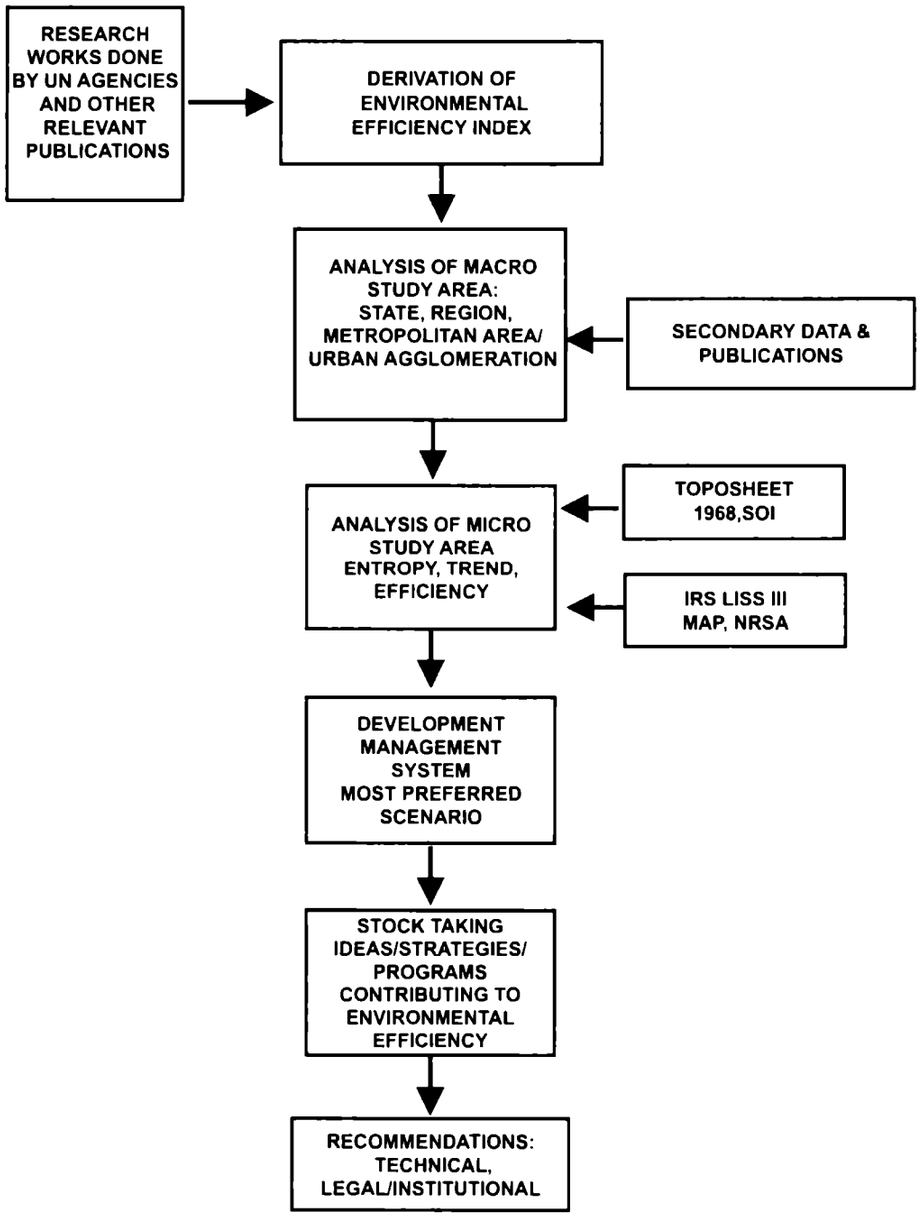
Lack of spatial planning and effective development management system lead to urban sprawl with non-optimal density of population to support urban infrastructure on the one side causing a lesser quality of life in urban areas. On the other side it causes loss of productivity of natural ecosystems and agricultural areas due to disturbance to the ecosystems. Planned compact high density development with compatible mixed land use can go a long way in achieving environmental efficiency of development management system.

OBJECTIVES

1. To take stock of the research works across the world in the field of sustainable development and to derive the most suitable and pragmatic efficiency index for the evaluation of environmental efficiency of the development management system.
2. To detect the infirmity of the development paradigm of the Macro Study Areas, State of Kerala, the Greater Kochi Resource Region and the Greater Kochi Metropolitan area by a critical analysis of the socio-economic characteristics vis-à-vis urbanisation pattern.
3. Physically examine Greater Kochi Micro Study Area through remote sensing and GIS capabilities, the population increase vis-à-vis built-up area increase across space and time.
4. To examine the modeling and simulation possibilities for the Greater Kochi Micro Study Area to identify the growth trend and possible intervention.
5. To prepare the efficiency map of the Micro Study Area, to evaluate and monitor the environmental efficiency of development management system of the Micro Study Area.

6. To take stock of the ideas, strategies and programs which contribute to environmental efficiency
7. To recommend technical, legal/institutional mechanism to monitor the environmental efficiency of the development management system.

METHODOLOGY



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Chapter-2

THEORY AND EVALUATION OF ENVIRONMENTAL EFFICIENCY

Contents

2.1 INTEGRATION OF ENVIRONMENT AND DEVELOPMENT —MAJOR MILESTONES

The *Global Environmental Outlook* published by United Nations Environment Programme (UNEP 2003) gives a comprehensive and chronological report on the efforts made at international level on this topic. The requirements of balance between environment and development assumed international attention during 1960s. Books such as Rachel Carson's '(Carson 1962) '*Silent Spring*' and article such as Garrett Hardin's (Hardin 1968) '*The Tragedy of Commons*' alongwith a series of catastrophes prompted the international community into action. At the end of the sixties environmental concern was gaining attention in the west, while the developing countries considered it as a mere luxury. In the west there were two principal schools of thought about the causes of environmental degradation: one school blamed at greedy and ruthless consumption habits and the other blamed population growth. Stanley Foundation (1971) put it 'unabated pollution and unstabilised population are the real threats to our way of life and life itself'. In the year 1972 the book 'Limits to Growth' was published by Club of Rome (Meadows et al. 1972) based on a computer model of the global future which caught international attention. The model analysed five variables namely technology, population, nutrition, natural resources and environment and underlined the importance of environmental consciousness in the decision-making to avoid overshoot and collapse of the global system.

The Stockholm Conference 1972

The UN Conference on Human Environment (1972) paved the foundation for the modern environmentalism. The Conference was hosted by Sweden at Stockholm following severe damage of thousands of lakes in Sweden from acid rain as a result of air pollution. The outcome of the Conference was a declaration of 26 principles

and a number of action plans of recommendations. Though the attention was mainly on the management of biophysical environment such as wild life management, soil conservation, water pollution and desertification, there was a clear-cut consensus that development is needed to improve the environment and environmental policy must not hamper development (Principles 8 and 11). Principle 13 underlined the importance of integrated development planning. The drafting committee noted in its report in April 1972 that environmental protection must not be an excuse for slowing down the economic progress of the emerging countries. The Stockholm Conference articulated the right of people to live in an environment of a quality that permits a life of dignity and well-being. A series of legislations on environment were passed in Sweden and in other countries.

The Birth of UNEP

After the Stockholm Conference a small Secretariat was formed by the United Nations for environmental action and coordination within the UN System. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing and enabling nations and peoples to improve their quality of life without compromising that of future generations. UNEP is known as the '*environmental conscience*' of the UN System (UNEP, Geo 3,page 4).

World Conservation Strategy (WCS 1980)

Launched in 1980 by IUCN the strategy recognised that addressing environmental problems and the integration of environment and development calls for long-term effort. Many countries formulated their own strategies for addressing sectoral objectives.

World Commission on Environment and Development (WCED)

Also known as Brundtland Commission, WCED was formed in the year 1983 to hold hearing across the globe and produce a formal report of its findings. The

report was issued after three years of hearings with government leaders and public all over the world on the integration of environment and development issues. 'Our Common Future', the commission's final report (WCED 1987), concluded that the existing decision-making structures and institutional arrangements, both national and international, simply could not cope up with the demands of sustainable development. Integration of environment and development was reiterated in the report and thus the concept of sustainable development caught worldwide attention. By the end of the decade the concept of eco-efficiency was introduced into industry as a means of simultaneously reducing the environmental impacts, while increasing profitability. Academic interest in the subject grew and environment and development became legitimate subjects of study of social, economic and natural disciplines. In 1987, Organisation for Economic Co-operation and Development (OECD) countries established a development advisory committee and formulated guidelines for the integration of environment and development on decision-making for development assistance. In 1989 Inter-governmental Panel on Climate Change (IPCC) was established by United Nations Environment Program (UNEP) to scientifically assess the climate change and its socio-economic and scientific impacts.

The Earth Summit 1991

The United Nations Conference on Environment and Development, popularly known as Earth Summit 1991, produced a handful of major achievements. Rio-declaration on environment and development containing 27 principles, Agenda 21 and Commission on Sustainable Development (CSD) are very prominent among them. '*Think Global and Act Local'* is the famous phrase put forward at the summit. CSD convened its first meeting in 1993 and decided to work on the inter-governmental decision-making capacity by setting up Sustainability Indicators. Commission on Sustainable Development, at its third session in 1995, published the outcome of a work program on the indicators of sustainable development.

CSD Indicators of Sustainable Development

Indicators are manageable units of information formulated with sound scientific backing and can identify the trend and enables comparison and possible intervention at the policy level. Chapter 40 of agenda 21 calls on countries at the national and international—both at governmental and non-governmental—organisations to develop and identify indicators of sustainable development for rational decisions and interventions. There was consensus that indicators should be concise, focused, pragmatic and flexible. CSD work program formulated indicators in four dimensions of sustainability namely social, economic, environmental and institutional.

In the year 1996 the UN Conference on Human Settlements (Habitat II) was held in Istanbul and ISO 14001 standards for corporate environmental management system were formulated.

Kyoto Protocol (1997)

This was signed by delegates of third Conference of Parties to the UN Framework Convention on Climate Change (UNFCCC). Thirtyeight developed countries agreed to reduce emission of six green house gases. Collective agreement was made to reduce emissions at least 5% below 1990 levels by 2012. Voluntary reduction targets were expected from the developing countries.

World Summit on Sustainable Development 2002

This summit was held in Johannesburg and focused on elimination of poverty, the prime requisite for environmental protection.

2.2 THEORY OF ENVIRONMENTAL EFFICIENCY—INPUT AND OUTPUT INDICATORS

Theory of environmental efficiency starts from the very fact that it is the efficiency of the total environment which is considered. The bio-psychic conditions of human beings determine the total quality of life. The bio-psychic conditions are determined by the natural and built environment around man. In other words, quality of life is a determinant of the total environment around man, the various dimensions of it being physical, social and economical. Environment (Physical), Economy and Society are considered as three pillars of total environment and the concept can very well be fitted in the Place-Work-Folk theory of Sir Patric Geddes (Geddes 1968).

Derivation of Environmental Efficiency

The ratio of the output to the input of any human settlement system is considered as environmental efficiency and it determines the total quality of the system.

Efficiency of the total environment of a human settlement system

I_e=Output/Input

Now it is of paramount importance to correctly identify the input and output of a human settlement system.

Human Settlement Input and Output Indicators, Research works by the UN Agencies

Living Planet Report-WWF

Living Planet Report is published by WWF from the year 1998 onwards. Three indicators of consumption and their consequent effect on the physical environment is reflected in the report. They are as follows:

1. Living Planet Index

2. Ecological Footprint
3. Biocapacity

Living Planet Index is an indicator designed to monitor the state of world's bio-diversity which tracks trends in nearly 5000 populations of 1686 species of mammal, bird, reptile, amphibian and fish from around the globe. The changes in the population of each species are then averaged and shown relative to the year 1970, which is given a value of 1.0. Global Living Planet Index shows an overall decline of 30% from 1970 to 2005 (LPR 2008 page 6).

Ecological Footprint measures the humanity's demand on the bio-sphere in terms of the area of biologically productive land and sea required to provide the resources we use and absorb our waste. In 2005 global ecological footprint was 2.7 global hectares per person. A global hectare is a hectare with world average ability to produce resources and absorb waste.

Biocapacity of bio-sphere is the carrying capacity of the bio-sphere in terms of productivity and waste-absorbing capability to produce what is required for consumption and to absorb the waste generated by human activities. As per the Living Planet Report 2008 biocapacity of the earth is estimated as 2.1 global hectares per person.

Ecosystem Services rendered by the Bio-sphere

Biological diversity plays a critical role in underpinning ecosystem services. Governments supported the establishment of the Millennium Ecosystem Assessment (MA 2005) through decisions taken by the Convention on Biological Diversityand other international conventions. The MA was initiated in 2001 under the auspices of the United Nations and governed by a multi-stakeholder board that included representatives of international institutions, governments, indigenous peoples, NGOs, and business. The secretariat was coordinated by the United Nations Environment Program. More than 1,360 scientists from 95 countries contributed to the assessment.

Millennium Ecosystem Assessment mentions four categories of ecosystem serves rendered by the planet as reported in LPR 2008. They are as follows:

1. Supporting services such as nutrient cycling, soil formation and primary production
2. Providing services such as production of food, fresh water, material or fuel
3. Regulatory services such as climate and flood regulation
4. Cultural services including aesthetics, spiritual, educational and recreational.

Human beings' livelihood and life depend on the services provided by the earth's natural systems. The latest Living Planet Report 2008 tells that human beings are consuming the resources at a rate faster than it can be replenished, which can endanger our prosperity. Over the past 35 years earth's wild life population has declined by a third. We are living on overshoot as ecological footprint exceeds biocapacity by 30%. If this consumption trend is continued unabated, by the year 2030 we need at least two earths to support our lifestyle and consumption. More than 75% of the population is ecological debtors as their national consumption is outstripping their national biocapacity. Sound environmental management strategies supplemented with sustainable technologies alongwith lifestyle modifications are the need of the hour to combat the situation.

As per the Living Planet Report 2008 the direct anthropogenic threats to biodiversity are grouped under five headings:

1. Habitat loss, fragmentation or change especially due to agriculture
2. Over- exploitation of species, especially due to fishing and hunting
3. Pollution
4. Spread of invasive species or genes
5. Climate change.

All these five threats stem ultimately from human demands on the bio-sphere. While humanity is racing towards luxury and high standards of living, deviating from the human development-oriented activities with low efficiency, the planet is losing its ecosystem-integrity which may result in the reduction of biocapacity.

Decline of bio-diversity and reduction of a number of critical species at a local level will have an adverse impact on the ecosystem services, even if those species are not threatened globally. Millennium Assessment reports that biodiversity loss contributes to food and energy insecurity, increased vulnerability to natural disasters such as flood or tropical storms, poorer health, reduced availability of quality fresh water and erosion of cultural heritage.

Various consumption sectors incorporated in the ecological footprint calculations in Living Planet Report 2008 are:

1. Timber, paper, fuel wood and fiber
2. Food crops, oil crops, fiber crops, meat, dairy, egg , skins, farmed fish and sea food
3. Construction cement, mining, metals
4. Wild meat, fish
5. Domestic water, industrial processing
6. Transport, trade, tourism
7. Energy use, fossil fuel and consumption.

Ecological Footprint, the Comprehensive Input Indicator

Ecological Footprint calculations were invented in 1992 by Dr William Rees and Maths Wackernagel at the University of British Columbia, which was later adopted by WWF. Ecological Footprint calculations provide compelling evidence of impacts of consumption. Ecological Footprint compares the natural resources and energy consumption with the nature's biologically productive and assimilative capacity.

Going through the available literature and research works across the world no other indicator is so comprehensive and highly exhaustive to accommodate the total input of a human settlement system. Various inputs of a human settlement system are built-up land, energy, fishing ground, forest, grazing and cropland, assimilation required for CO_2 from fossil fuels etc. All kinds of consumption are brought to a common platform in units of global hectares. However, consumption of non-renewable materials not causing pollution is not taken in the ecological footprint calculations.

Human Development Report of UNDP

Human Development Report is published by United Nations Development Program (UNDP) giving the world's state of development and is published yearly basis from the year 1975 onwards. Human Development Indices of nations across the world are calculated on a five yearly basis from the year 1975 to 2005. Human Development Report (HDR 1990) defines Human Development as the process of enlarging peoples' choices. Later publications of Human Development Report (HDR 2008) bring forth 'Human Development Approach' for a sustainable globe.

Indices incorporated in the Human Development Report

Human Development Index

Human Development Index (HDI) is a composite index that measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. These basic dimensions are measured by life expectancy at birth, adult literacy alongwith combined gross enrolment in primary, secondary and tertiary level education and gross domestic product per capita in purchasing power parity in US Dollars (PPP US$) respectively. The index is constructed from indicators that are available globally using a methodology that is simple and transparent.

Other Indices

Other major indices published by Human Development Report are:

1) Gender Development Index (GDI)
2) Human Poverty Index 1 for developing countries (HPI 1)
3) Human Poverty Index for OECD countries (HPI 2)
4) Inequality indicator-Gini coefficient
5) GDP per unit of energy consumed
6) Carbon intensity of energy-CO_2 emissions per unit of energy used.

2.3 GLOBAL URBAN OBSERVATORY PROGRAM OF UN HABITAT

Global Urban Observatory was established in the year 1997 after HABITAT II in response to a decision of the United Nations Commission on Human Settlements, which called for a set of mechanisms to monitor global progress in implementing HABITAT agenda and to monitor and evaluate global conditions and trends.

Goals of Global Urban Observatory are as follows:

1. To help all partners monitor and evaluate urban conditions and trends as measures of progress in implementing HABITAT Agenda and Agenda 21
2. To help all partners use urban data in participatory decision-making processes at all levels

Key Activities of Global Urban Observatory includes:

1. Global monitoring and reporting of Global Urban Indicators data base, monitoring 'Urban Indicators Program' and publishing the State of World Cities Report
2. Local Capacity Building which includes setting up of Local Urban Observatories, which enable formulation of local policies and setting up of

Urban Information Management System by integrating Urban Indicators with Geographic Information System (GIS).

Urban Observatory Network is functioning at four levels:

- Global Urban Observatory (GUO)
- Regional Urban Observatory (RUO)
- National Urban Observatory (NUO)
- Local Urban Observatory (city/metropolitan area level) (LUO)

Urban Indicators tool kit, published by UN Habitat, contains 23 quantitative indicators and nine qualitative indicators to be formed at the city level. Methodologies are also explained in the tool kit.

2.4 REDEFINING EFFICIENCY—GDP /ENERGY TO HD/EFp

Umpteen number of research works exist on the energy intensity of Gross Domestic Product (GDP) of countries. Also considering GDP as output and energy as input it is established that a strong correlation exists between energy consumption and GDP of countries. But GDP per energy consumption may not indicate a consistent scenario of the performance of the countries. Hence it is more justified and rational if HD/EFp achievements of different countries are taken where HD is the human development and EFp, the ecological footprint. In HD/EFp calculations the socio-economic aspects are taken care of by the numerator, while the physical environmental aspects are taken care of by the denominator.

HD/EFp the most comprehensive Efficiency Index

The concept of HD/EFp is introduced in the year 2005 (May 2005) and the relevance of more livable cities where human development is to be seen in comparison to the ecological footprint (EFp) of the city is highlighted. Living Planet Report in 2006 (LPR 2006)made a comparison of the Human Development

achievements and ecological footprint of nations for the first time. The sustainability index HD/EFp is suggested for evaluating Kerala situation (May 2007).

HD/EFp is a comprehensive indicator of environmental efficiency as it incorporates the following aspects:

1. Health achievements in terms of life expectancy at birth
2. Educational achievements in terms of adult literacy rate and combined gross enrolment ratio of primary, secondary and tertiary education
3. Standard of living achievements in terms of PPP adjusted per capita income
4. Energy consumption
5. Built-up area consumption
6. Food consumption
7. Fossil fuel consumption etc.

HD/EFp index is not totally exhaustive, as it does not take into account the consumption of non-polluting, non-renewable materials.

2.5 HDI, EFp AND EFFICIENCY OF WORLD COUNTRIES

HDI and EFp achievements of world countries are downloaded from UN agencies websites of WWF and UNDP and country-wise analysis are attempted and are as below:

The countries which have both HDI data and EFp data for the year 2005 are taken.135 countries are listed. Scatter Diagram of HDI and EFpI* are as per Chart 2.1.

* *EFpI is calculated by dividing EFp of a particular country by maximum EFp of all the countries.*

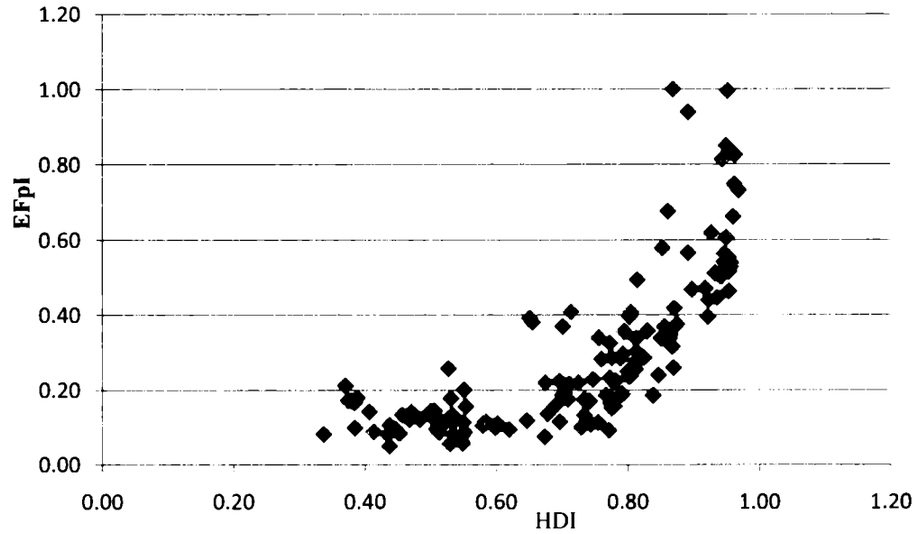


Chart 2.1 Scatter Diagram HDI and EFpI

Going through the scatter diagram it is found that for less developed countries (HDI less than 0.5) EFpI increase is very meagre compared to HDI achievements. However, for medium developed countries (HDI value between 0.5 and 0.7) HDI achievements and EFpI are getting correlated. For highly developed countries (HDI value is greater than 0.7) EFpI increase is far greater than HPI increase.

This may be attributed to the following reasons:

- Inadequacy of human development quantification in the case of developed countries as it is felt that basic human development only is evaluated in UNDP's HDI calculations. Educational achievement index is to be modified to suit the overall human skills achievement. Also health index is to be modified to accommodate the wellness of the people.
- Human development deviated and wasteful consumption patterns of developed countries.

Chart 2.1 can be split into three categories for low HDl, medium HDI and high HDl countries which are as per Chart 2.1.1, 2.1.2 and 2.1.3.

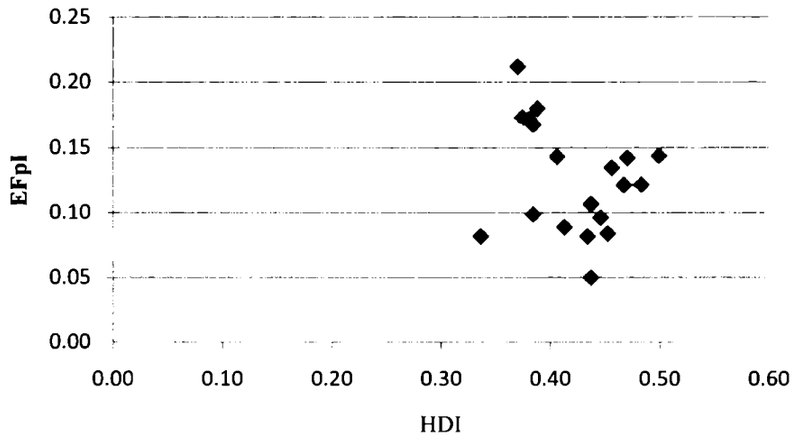


Chart 2.1.1 Scatter Diagram HDI and EFpl of low HDI countries

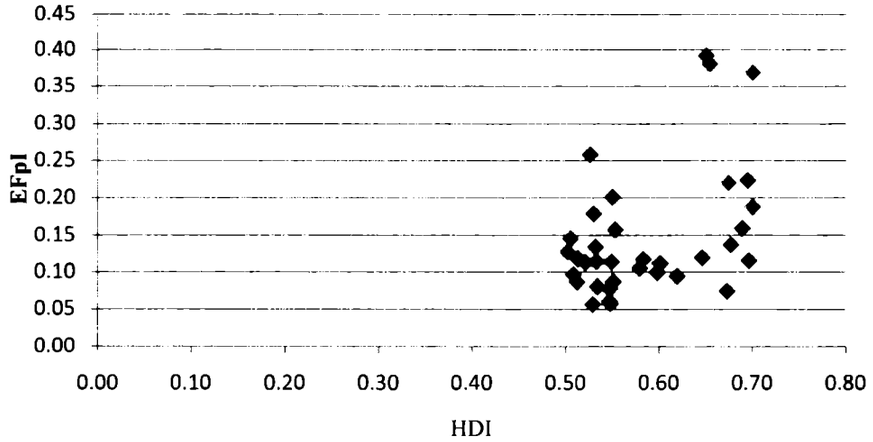


Chart 2.1.2 Scatter Diagram HDI and EFpl of medium HDI countries

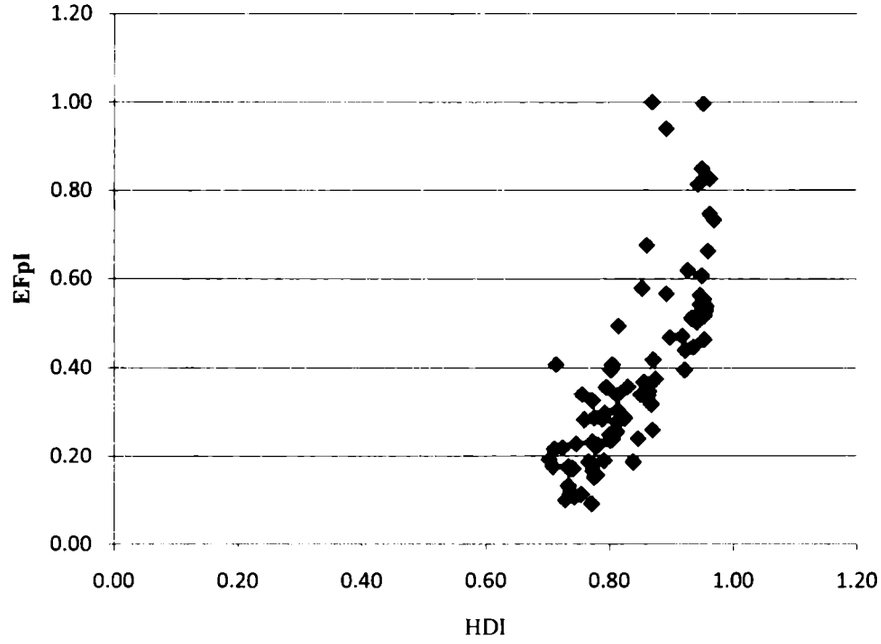


Chart 2.1.3 Scatter Diagram HDI and EFpI of high HDI countries

Linear Regression Analysis, low, medium and high HDI countries and EFpI.

For low HDI countries EFpI shows a very weak correlation. For medium HDI countries the correlation between HDI and EFpI improved and for high HDI countries correlation further improved. The correlation values are as per Table 2.1:

Table 2.1

HDI and EFpI, R^2Value

EFpI	R^2Value
Low HDI countries (HDI<0.5)	0.073
Medium HDI countries (0.5< HDI<0.7)	0.199
High HDI countries (HDI>0.7)	0.606

Also detailed research work is to be carried on the effect of climate of different nations as a good share of energy is expended for heating and cooling requirements for life and livelihood.

HD and Efficiency—World Countries' Analysis

XY scatter of HDI and HDI/EFpI also gives some meaningful results as per Chart 2.2. During the early stages of development the HDI/EFpI is found to be low. As the human development level increases, the efficiency level also increases and reaches a peak value and then decreases. World countries' HDI, EFpI and efficiency maps are prepared as per Maps 2.1.1, 2.1.2 and 2.1.3.

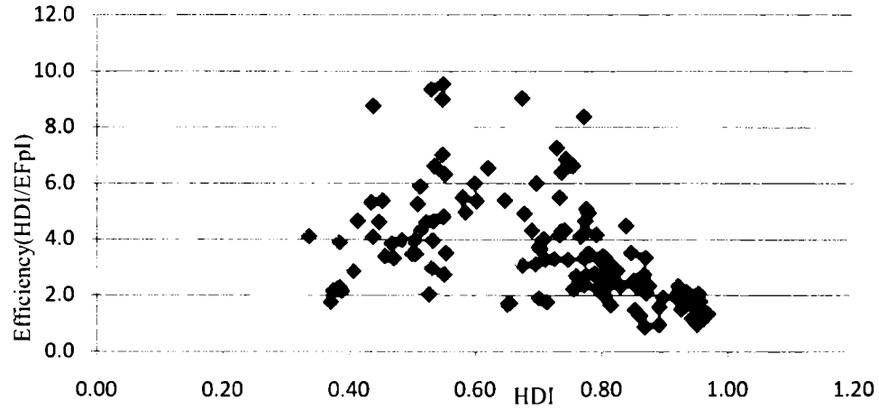
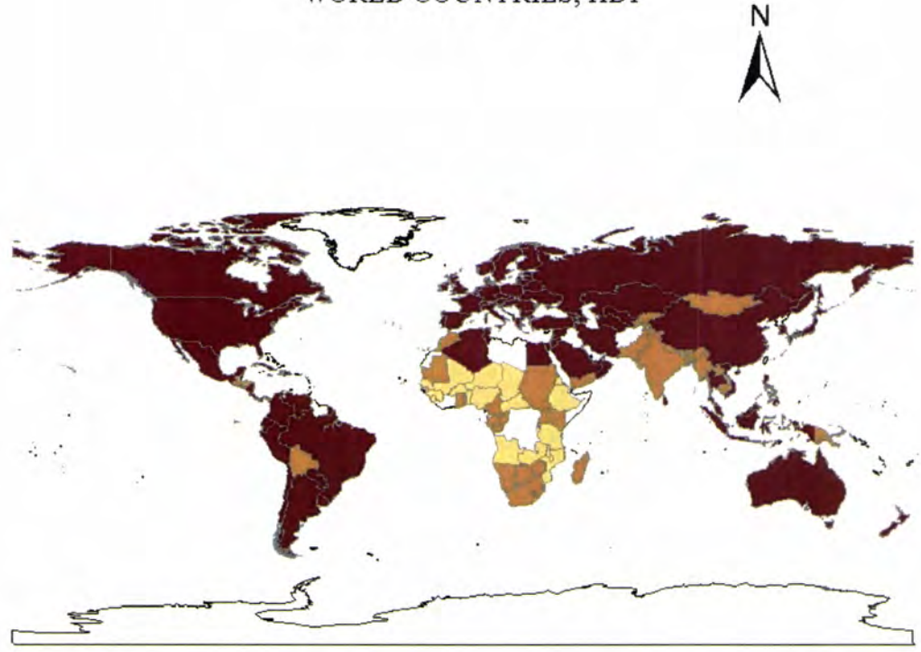


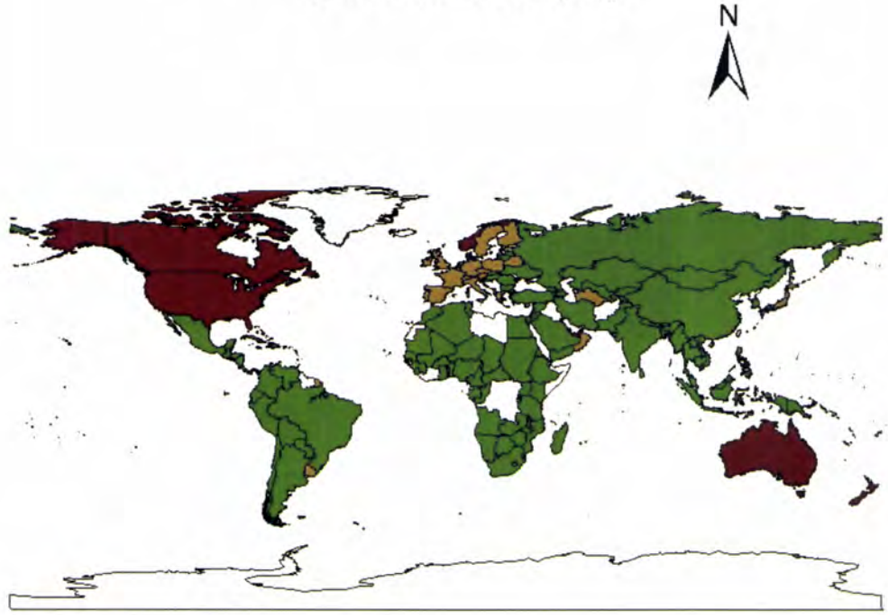
Chart 2.2 Scatter Diagram HDI and Efficiency of World Countries

Map 2.1.1
WORLD COUNTRIES, HDI



Map 2.1.2

WORLD COUNTRIES, EFpI



Legend

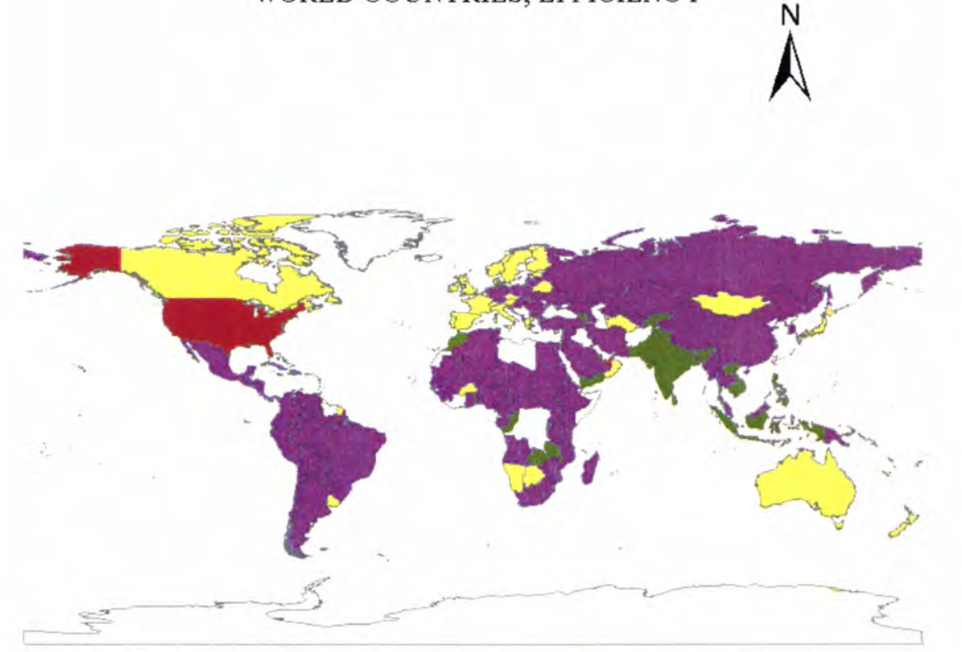
EFpI

- no data
- 0- 0.4 low
- 0.4 - 0.7 medium
- 0.7- 1.0 high

Scale 1:200,000,000

Map 2.1.3

WORLD COUNTRIES, EFFICIENCY



Types of Countries Based on HD and Efficiency

Based on HDI and HDI/EFpI values 10 types of countries are identified. They are as follows.

Table 2.2

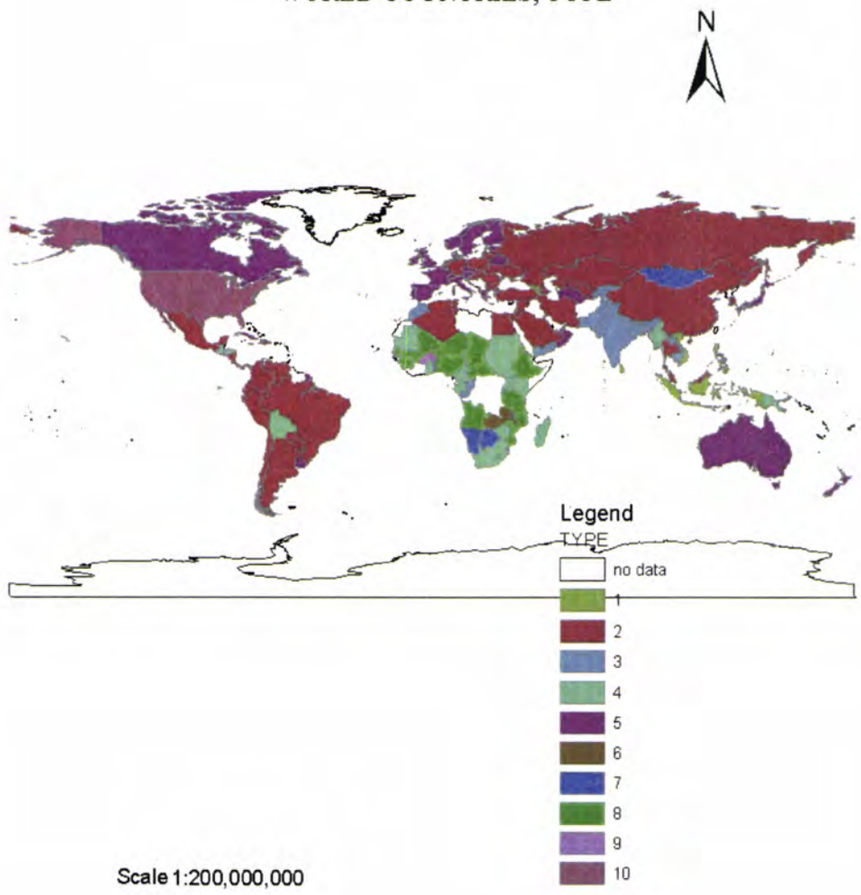
Types of countries based on HDI & Efficiency

Type	Description	HDI	HDI/EFpI
1	High HDI,High Efficiency	>0.7	>5
2	High HDI, Medium Efficiency	>0.7	2-5
3	Medium HDI, High Efficiency	0.5-0.7	>5
4	Medium HDI, Medium Efficiency	0.5-0.7	2-5
5	High HDI, Low Efficiency	>0.7	1-2
6	Low HDI, High Efficiency	<0.5	>5
7	Medium HDI, Low Efficiency	0.5-0.7	1-2
8	Low HDI, Medium Efficiency	<0.5	2-5
9	Low HDI, Low Efficiency	<0.5	1-2
10	High HDI, Very Low Efficiency	>0.7	<1

World Countries, Type map is also prepared as per Map 2.2.

Map 2.2

WORLD COUNTRIES, TYPE



2.6 CONTAINED EFFICIENCY OF NATIONS—CONCEPT OF CARRYING CAPACITY

National governments to contain their ecological footprint within their biocapacity are also very important for the sustainability of the nations. The concept of Carrying Capacity Index is introduced in this thesis by dividing the biocapacity of nations by its ecological footprint.

CCI=Bc/EFp

World countries' carrying capacity map is prepared as per Map 2.3. Based on carrying capacity index (CCI) nations are divided into CC type A and CC type B. If the CCI is greater than or equal to one it is categorised under A and if CCI is less than 1 it is categorised under B.

2.7 TYPES OF COUNTRIES BASED ON HUMAN DEVELOPMENT, EFFICIENCY AND CARRYING CAPACITY

All the type 1 to 10 nations can be subdivided into A and B category depending on the value of Carrying Capacity Index. Only 58 out of 135 countries under analysis are Carrying Capacity type A category. Only two countries are type1A category namely Georgia and Indonesia. These two countries are having high human development, high efficiency and high carrying capacity and thus they are top-performing countries. On the other hand, countries categorised under type 10 B namely Kuwait, UAE and the United States are having high human development with low efficiency and low carrying capacity. India is categorised under type 3B category (medium human development, high efficiency and less carrying capacity). List of countries based on human development, efficiency and carrying capacity are prepared as per Table 2.3.

Seventeen types of countries are identified based on human development, efficiency HDI/EFPI, and carrying capacity BC/EFP.

Map 2.3

WORLD COUNTRIES, CARRYING CAPACITY

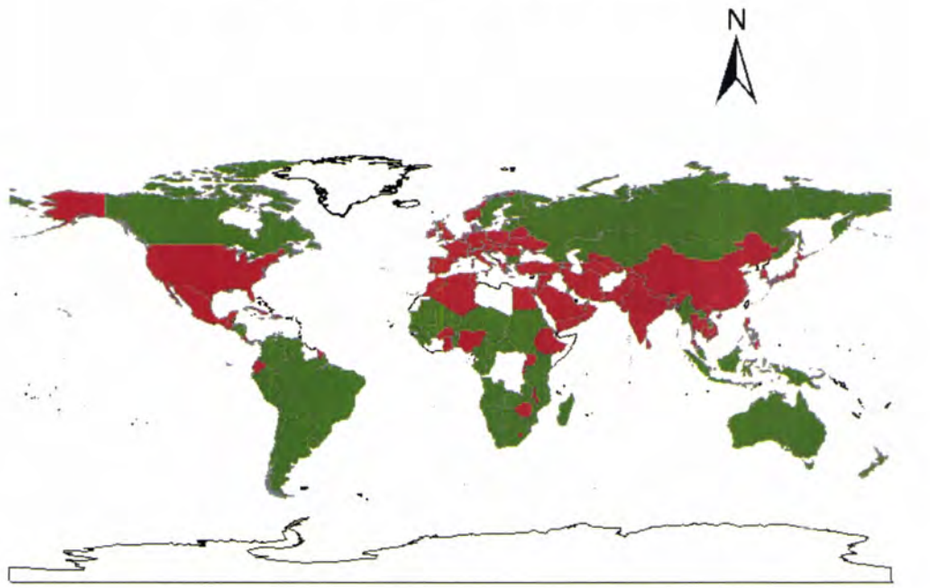


Table 2.3

Types of Countries based on HDI, Efficiency and Carrying Capacity

Name	HDI	Efficiency	CCI
Type 1A Countries			
Georgia	0.75	6.63	1.63
Indonesia	0.73	7.26	1.47
Type 1B Countries			
Armenia	0.77	5.09	0.57
Jamaica	0.74	6.40	0.58
Philippines	0.77	8.39	0.63
Sri Lanka	0.74	6.86	0.37
Viet Nam	0.73	5.50	0.64
Type 2A Countries			
Argentina	0.87	3.35	3.31
Brazil	0.80	3.21	3.08
Bulgaria	0.82	2.87	1.03
Chile	0.87	2.73	1.38
Columbia	0.79	4.18	2.18
Kazakhstan	0.79	2.23	1.27
Latvia	0.86	2.32	2.00
Lithuania	0.86	2.55	1.31
Malaysia	0.81	3.17	1.11
Maldives	0.74	4.33	1.59
Nicaragua	0.71	3.28	1.60
Panama	0.81	2.41	1.09
Paraguay	0.75	2.22	3.02
Peru	0.77	4.67	2.57
Russian Federation	0.80	2.03	2.17
Venezuela	0.79	2.67	1.12

Name	HDI	Efficiency	CCI
Type 2B Countries			
Albania	0.80	3.40	0.54
Algeria	0.73	4.17	0.56
Azerbaijan	0.75	3.27	0.47
China	0.78	3.49	0.41
Croatia	0.85	2.51	0.69
Cuba	0.84	4.50	0.60
Dominican Republic	0.78	4.95	0.54
Ecuador	0.77	3.32	0.97
Egypt	0.71	4.02	0.22
El Salvador	0.74	4.30	0.44
Germany	0.94	2.09	0.46
Hungary	0.87	2.33	0.80
Iran	0.76	2.68	0.53
Jordan	0.77	4.29	0.16
Korea, Republic of	0.92	2.33	0.19
Lebanon	0.77	2.37	0.14
Mauritius	0.80	3.37	0.32
Mexico	0.83	2.32	0.49
Netherlands	0.95	2.05	0.26
Poland	0.87	2.08	0.53
Romania	0.81	2.68	0.79
Saudi Arabia	0.81	2.93	0.48
Singapore	0.92	2.10	0.01
Slovakia	0.86	2.48	0.86
Syrian Arab Republic	0.72	3.30	0.41

Name	HDI	Efficiency	CCI
Thailand	0.78	3.47	0.46
Tunisia	0.77	4.11	0.65
Turkey	0.77	2.70	0.61
Ukraine	0.79	2.77	0.89
Uzbekistan	0.70	3.66	0.56
Type 3A Countries			
Bhutan	0.58	5.50	1.84
Congo	0.55	9.54	25.56
Kyrgyzstan	0.70	6.01	1.51
Laos, PDR	0.60	5.38	2.21
Swaziland	0.55	7.03	2.29
Togo	0.51	5.90	1.32
Type 3B Countries			
Bangladesh	0.55	9.00	0.44
Cambodia	0.60	6.00	0.99
Haiti	0.53	9.36	0.49
India	0.62	6.55	0.46
Morocco	0.65	5.41	0.61
Nepal	0.53	6.63	0.48
Pakistan	0.55	6.32	0.52
Tajikistan	0.67	9.04	0.79
Yemen	0.51	5.27	0.64
Type 4A Countries			
Bolivia	0.69	3.10	7.42
Cameroon	0.53	3.97	2.42
Gabon	0.68	4.94	19.25
Gambia	0.50	3.95	1.01

Name	HDI	Efficiency	CCI
Honduras	0.70	3.73	1.05
Kenya	0.52	4.62	1.12
Madagascar	0.53	4.66	3.46
Mauritania	0.55	2.74	3.35
Myanmar	0.58	4.98	1.35
Papua New Guinea	0.53	2.97	2.63
South Africa	0.67	3.06	1.06
Sudan	0.53	2.04	1.14
Type 4B Countries			
Ghana	0.55	3.52	0.78
Guatemala	0.69	4.33	0.85
Lesotho	0.55	4.83	0.98
Uganda	0.50	3.47	0.69
Zimbabwe	0.51	4.34	0.67
Type 5A Countries			
Australia	0.96	1.17	1.98
Canada	0.96	1.29	2.84
Estonia	0.86	1.27	1.42
Finland	0.95	1.72	2.24
New Zealand	0.94	1.16	1.83
Sweden	0.96	1.77	1.96
Uruguay	0.85	1.47	1.92
Type 5B Countries			
Austria	0.95	1.80	0.57
Belarus	0.80	1.97	0.89
Belgium	0.95	1.74	0.22

Name	HDI	Efficiency	CCI
Czech Republic	0.89	1.57	0.51
Denmark	0.95	1.12	0.71
France	0.95	1.83	0.62
Greece	0.93	1.49	0.29
Ireland	0.96	1.45	0.68
Israel	0.93	1.82	0.08
Italy	0.94	1.87	0.26
Japan	0.95	1.84	0.12
Norway	0.97	1.32	0.88
Oman	0.81	1.65	0.55
Portugal	0.90	1.91	0.28
Slovenia	0.92	1.94	0.49
Spain	0.95	1.56	0.23
Switzerland	0.95	1.81	0.25
Turkmenistan	0.71	1.75	0.95
United Kingdom	0.95	1.68	0.31
Type 6A Countries			
Zambia	0.43	5.33	3.72
Type 6B Countries			
Malawi	0.44	8.77	0.99
Rwanda	0.45	5.39	0.60
Type 7A Countries			
Botswana	0.65	1.72	2.34
Mongolia	0.70	1.89	4.19
Namibia	0.65	1.66	2.42

Name	HDI	Efficiency	CCI
Type 8A Countries			
Angola	0.45	4.65	3.57
Benin	0.44	4.10	1.46
Central African Republic	0.38	2.29	5.92
Chad	0.39	2.16	1.75
Eritrea	0.48	3.98	1.80
Mali	0.38	2.22	1.59
Mozambique	0.38	3.90	3.67
Niger	0.37	2.16	1.12
Senegal	0.50	3.48	1.12
Sierra Leone	0.34	4.12	1.31
Tanzania	0.47	3.86	1.04
Type 8B Countries			
Burundi	0.41	4.67	0.82
Ethiopia	0.41	2.84	0.74
Nigeria	0.47	3.31	0.72
Type 9B Countries			
Burkina Faso	0.37	1.75	0.80
Type 10B Countries			
Kuwait	0.89	0.95	0.06
United Arab Emirates	0.87	0.87	0.11
United States	0.95	0.95	0.53

2.8 URBAN AND REGIONAL EFFICIENCY EVALUATION OF HUMAN SETTLEMENTS

Urban Environmental Efficiency—HD/EFp

The methodology introduced by UNDP and WWF for human development index and ecological footprint can be applied at national, sub-national, district and human settlement level. UN-Habitat, in its Urban Indicators Tool Kit, explains the methodology of finding out the 'city product' (indicator 21) which would be useful for the calculation of Human Development Index at city level.

City Product as per indicator 21 of Urban Indicators Tool Kit is calculated using two methods. Method A consists in taking the national product in each industry sector and then multiplying it by differential wage rates at the city level, for each industry sector. This method is used when employment by industry sector is known. Method B consists in using the city household income figures and by multiplying by the ratio of GNP to total households' income at the national level. This method assumes that the ratio of the GNP to the household income is the same at the city and the national levels. So far, this method has been used in most of the cases.

Health achievements and educational achievements can be calculated at city level, if not in a modified way, by incorporating wellness of the society and overall human skills achievements. EFp calculations at city level are also possible. City of Santa Monica calculated its Ecological Footprint from 1990 to 2000 and reduced the footprint from 2914 sq. miles to 2747 sq. miles through policy initiatives, energy conservation and alternate energy measures.

HD/EFp is a reliable performance indicator of the city and it is easy to check on what aspect the urban system fails. Through suitable policy initiatives and corrective measures we can achieve a better HD/EFp index which enables comparison with other cities.

Regional Efficiency—(Bc/EFp), the carrying capacity

All metropolitan areas are supported by a region to provide natural resources and energy for city input. Regional Efficiency Bc/EFp is also very important for attaining environmental efficiency HD/EFp. The efficiency of the supporting region is the carrying capacity of the region, which can be expressed by the carrying capacity index.

CCI= Bc/EFp

Carrying capacity enhancement is possible through reduction of ecological footprint or by increasing the biocapacity. Biocapacity can be enhanced by increasing the agriculture and forest productivity, through ecosystem conservation measures and carbon capturing initiatives through bio-fuel plantations.

Bc/EFp Contributes to HD/EFp

Through Bc/EFp enhancement regional dependence on resources can be inculcated. This can reduce the fuel charges for transportation of resources required for the city. This leads to, less ecological footprint and thus better environmental efficiency HD/EFp.

2.9 COMPACT CITIES—TOWARDS ENVIRONMENTAL EFFICIENCY, LITERATURE BACKUP AND CASE STUDIES

Mike Jenks, then the director of Oxford Centre for Sustainable Development and Rod Burgess, the senior lecturer at the School of Planning Oxford Brookes University, compiled and edited (Jenks et al. 2000) a series of research papers published by various authors on this topic. Some of the relevant quotes/references and case studies are as per the following paragraphs:

It is cities that drive economies and it is within them that innovation occurs and an increasing part of global output is produced. Soon over half of the world population live in cities, the majority in the developing countries (Jenks page 2).

The life styles of those living in low-density suburban areas on the periphery will be responsible for the consumption of more resources than those with similar incomes living in cities (Miltlin and Satterthwaite 1996).

Compact cities will become more emphatic when it is seen that at the start of the 20th century only 13% of the world population was living in cities and at the end of it almost one-half of the world population was urbanised. In the fifty year period between 1975 and 2025 alone the global level of urbanisation will have increased from 37.7% to 61.1% and the total population living in cities will have risen from 1.58 billion to 5.06 billion (UNCHS 1996).

Cultural and climatic factors certainly influence the level of space consumption. In general, urban densities are the highest in Asia, high in Europe, North Africa and Middle East, low in Latin America and Sub-Saharan Africa and lowest in North America and Australia (Acioly and Davidson 1996).

A 'hand- off' approach to the process of informal densification can only lead to a worsening of the existing environmental, health and social conditions. Guided densification in a planning style based on community enablement, local authority involvement and democratic stakeholding arrangements would seem to offer the greatest opportunity for sustainability gains (Burgess page 18).

Megacities of the world are characterised by holistic urban form models. Many megacities are already exhausting their environment support capacity with water consumption exceeding the replacement capacity of primary sources, the destabilisation of ecosystems and air pollution levels that are highly injurious to human health and safety (Atkinson 1993).

The bigger the city, higher its levels of consumption, the greater would be its ecological footprint (Burgess page 20).

A number of spatial models and strategies have been developed to change the urban structure to achieve the desired sustainability benefits. They are as follows: (Burgess page 21):

1. High-rise, high-density redevelopment— widely used in South East Asia
2. Creation of concentrated decentralisation—Here there is an attempt to shift from a monocentric to a polycentric structure based on the densification and activity intensification of selected sub-centers connected by transport and development corridors.
3. Linear transit oriented development, e.g. the city of Curitiba, over a period of 35 years, has managed to convert a radio circular form to a linear form.
4. Traditional infill densification and intensification which is used for regeneration of core areas, historic centers etc.

It is true that present generation cities are having problems due to overcrowding, traffic blocks, air pollution etc. But strong association between densities and traffic congestion is less a verdict on the consequences of compactness than a byproduct of street design, the minimal land use allocation for roads before the automobile age and the resource constraints that inhibited investment in transportation infrastructure. Situation has been aggravated by the rapid motorisation of recent years in the developing countries (Richardson et al. 2000).

Compact cities of developing countries have not been planned and they are not the result of some prescient ground design. Rather their compactness has emerged spontaneously, if not chaotically (Richardson et al. 2000)

High population densities reduce unit cost of infrastructure and services with obvious environmental benefits, in terms of piped water, sanitation, garbage collection

and drainage. High production densities generate economies in waste handling and facilitate regulation enforcement (Hardoy and Satterthwaite 1992).

Present generation compact cities may have problems, but they are not necessarily a problem in themselves. It is the failure of effective governance in cities that explains the poor environmental performance of so many cities rather than an inherent characteristic of cities in general. Manipulation of urban forms and the provision of better forms of governance may go some way to overcome the city problems (Mitlin et al. 1996)

Downs. A introduced the world *urban containment*, to stop metropolitan sprawl by confining the development of contiguous areas, adjoining built-up spaces (Downs 1994).

Two propositions put forward by Clark and Tsai (2000) are:

- Preservation of open spaces increases agricultural productivity on the urban fringe when the urban edge is firm and rural values are protected. It appears that this effect is magnified further in those cities, situated where rivers meet oceans, soils are particularly rich and marginal rural to urban land conversions exact a heavy toll.
- Second proposition is that the net marginal social benefit of urban containment in these countries will be positive, because it enables cities to function more efficiently.

Growth managements, as practised, in the United States aims to contain the peripheral sprawl, preserve agricultural land and maintain interstitial spaces that separate free standing municipalities. It also aims to foster higher densities to ensure full utilisation of the existing infrastructure to prompt the use of urban mass transit and to secure lower public service costs (Clark and Tsai 2000).

The promotion of compact development could help to protect the loss of prime agricultural land, reduce the development costs, save energy and promote more sustainable urban development (Yeh and Li 2000).

Compact development with substantially reduced per capita land consumption can be found in many international cities. Six million people are living in a radius of 14 km around Paris giving a density of 30,612 persons per sq. km. In Seoul six million people stay within 10 km of the city centre giving a density of 60,000 persons per sq. km. Hongkong is an extreme case of compact development with the density of inner city as high as 116,531 persons per sq. km. (Yeh and Li 2000).

Urban growth is not only a result of development but is also a motor of development. Urban development that promotes improved environmental conditions and reduces energy demand will favour economic development and improve the quality of life (Silvia et al. 2000).

The idea of compact city goes very well with HD/EFp concept towards efficiency and sustainability. In compact cities human development probabilities are more due to proximity and accessibility, while less per capita built-up ensures less ecological footprint. Land Utility is also high in the case of compact cities as facilities are provided mostly under common ownership.

Case Studies, Guided Versus informal Densification

City of Curitiba and Sao-Paulo in Brazil (Claudio et al. 2000)

Curitiba is internationally acclaimed as an environment-friendly city. A master plan was drawn up in 1965, which encouraged the decongestion and revitalisation of inner city and the shift from a radial-concentric to a linear urban pattern. A north-south axis of traffic and transportation was created tangential to the inner city, the structural axis. Subsequently other structural axes were also created. This has allowed the local government to implement one of the continent's most

successful and efficient public transport system based on buses. The system transports 1.3 million passengers a day out of a population of 1.6 million people (in 2000) giving an energy-saving ratio of 30%, higher than any other large Brazilian cities. Prudent land use planning measures were adopted. Along the various structural axes higher population densities with mixed land use were allowed. This resulted in a viable public transport system and the new developments have come along the structural axis away from the inner city. Higher floor area ratio (FAR) was given to plots situated alongside the structural axis (FAR upto 6) resulting in gross population density of 600 inhabitants per hectare. FAR of land decreased as distance from the public transport network increased. Networks of urban parks were also provided with amenities and public services with the result that city contains one of the world's highest rates of green area (50 sq. m/inhabitant).

In order to preserve the buildings of architectural and historic value and to enable inner city revitalisation 'transferable development rights' were given which could be applied in area rich in infrastructure and amenities after careful study of the impacts of densification. An automated land information system was established in the early 1980s which provided the municipality with very precise information on the FARs of each and every plot. Transactions with development right generated huge amounts of money to municipal government which they diverted for social housing in the land surrendered in lieu of TDRs.

The municipality of Sao Paulo applied Transferable Development Right in 1962 when it needed land to restructure the city's most famous road—the Avenida Paulista. An integrated urban management system was introduced to allow the municipality to optimise the infrastructure and services through a guided densification process coupled with the occupation of available vacant land.

The most innovative aspect of the policy was the linkage between densification and social housing production and revenue generated from interlinked

operations. A large scale operation was initiated to create 1,50,000 sq. m of built area through TDR at the heart of the inner city causing inner-city revitalisation approved by the municipal law. All the above strategies have effected in positive changes towards compactness like checking of urban sprawl, urban vitality, more inner city housing and amenities, private sector participation and intra-urban economic development.

Unlike Sao Paulo, the city of Curitiba links public transport, land use and housing development in an intelligent densification strategy which helped the city to save energy, ease congestion, maximise population mobility and promote private sector participation in urban development. High performance standards of Curitiba public transportation system as well as its reliability and economic efficiency are due to the densification policy and urban intensification strategies undertaken by municipal government. The experiences in Curitiba and Sao Paulo demonstrate that an empowered local government is the key to sustainable urban development.

Inverted Compact City of Delhi, no Advantage of a Compact City (Ashok 2000)

Delhi urban agglomeration is characterised by the high residential densities at the peripheral areas, while low residential densities prevail in inner areas. Gross densities are at least four times higher than that in the inner city, it is reported.

In effect Delhi does not have any advantage of a compact city. The average trip length has increased from 5.4 km in 1970 to 8.5 km in 1993. The average trip length by public transport buses has more than doubled from 6.2 km in 71-72 to 14 km in 88-89 (Sahoo 1995). The average travel time in Delhi increased from 30 minutes in 1985 to almost three quarters of an hour in 1993. Power transmission losses in Delhi rose to an unprecedented 50.2% in January 1996 (Raj 1996)

In order to achieve the compact city benefits the policy of containment at the planning division level adopted by Delhi Development Authority should be pursued

in full spirit alongwith encouragement of high-rise, high-density development in planned areas. This alongwith the Delhi Metro Rail can drastically reduce trip time and trip length, it is expected.

City of Hong Kong, the extreme Case of Compactness

Urban Planners and policy makers increasingly believe that there is a link between prospects for sustainability and urban form.(Xing Quan Zhang 2000). European cities accepted the ideas of compact city in 1990s (Morrison1998) although the benefits of compact cities are not at all certain. The policy change in urban development from dispersal to compaction in Hong Kong began much earlier about 50 years ago at a time when western planners, engineers, architects and social scientists strongly opposed the idea of high-rise, high-density development. They stressed the ill-effects of high- rise, high-density development such as crime, vandalism, social dysfunction and high vacancy rates.

Hong Kong can be seen as a product of accidental circumstances as well as intentional interventions that have combined to produce economically and environmentally viable urban model (Zaman et al. 2000). Combination of rapid population growth and limited land resources made dispersed urban development unsustainable in Hong Kong and thus switched to high-rise, high-density development. Now, Hong Kong has the highest urban density in the world and it is a good example of compact city model. Due to limited land resources often interrupted by hilly terrain there was no scope for primary and secondary sectors of economy. Hong Kong has concentrated on tertiary sector and turned out to be a service-oriented economy which made compaction more feasible.

Land and property development turned out as the most profitable business in Hong Kong. Now Hong Kong is the most expensive city in the world. Hong Kong has been affected by high economic and real estate gains through limited land

availability. Lot of investment has started pouring into the area, which created more and more demand for space. The property developers raised densities and pushed the skyline of the urban centre.

Alongwith compaction public housing also expanded very rapidly and Hong Kong now has the world's second highest proportion of public housing in the market economies. There were both owner-occupied housing stocks as well as public rental housing which were of high-rise, high-density. Public housing accommodates a major share of total population in Hong Kong. The northern shore of Hong Kong Island with an area of 22.5 sq. km. with 17 km long and average 1.3 km wide houses approximately 1 million people and provides 7,00,000 jobs (Tong and Wong 1997) which includes CBD, shopping complexes, residential buildings, government institutions and community facilities.

Because of the degree of compaction of the city, open space and country are within walking distance. Hong Kong's 70% of territories have been left green. A rich array of urban amenities, recreational and natural environments are within easy reach and contribute greatly to the quality of life.

High-rise, high-density development provide the population thresholds for viable economic activities together with specialised services, facilities, amenities, recreational and cultural opportunities.

High-rise, high-density development in Hong Kong has its own disadvantages also. Hong Kong's sustainability research initiatives have revealed the astonishing deterioration of the environment which include poor air quality, water depletion, noise and excessive waste production. The environmental problems are serious enough for the government to put the improvement of the environment at the top of its agenda (Tung 1999)

Fig 2.4 Hong Kong in Google Map

Summary of Hong Kong experience is that compact cities can go a long way towards efficient and sustainable cities. Extensive research is needed on how to minimise the negative effects of compaction, while maximising the positive results to a better and happy living of the people of today and tomorrow.

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Chapter 3

MACRO LEVEL ANALYSIS

Contents

3.1 SOCIO-ECONOMIC CLIMATE

The State of Kerala

The tiny state in the south west corner of the Indian Peninsula, Kerala is having an area of 38863 sq. km. with a population of 31.8 million in the year 2001. The density of population in 1991 was 749 persons per sq. m., while in the year 2001 it has increased to 819 persons per sq. km. The two states having density higher than Kerala are Bihar and West Bengal (Census Report 2001).

The State of Kerala received world-wide acclamation due to its unique settlement pattern and the achievements in the socio-economic sectors without economic growth. For Richard Franke and Barbara Chasin (1990) Kerala's experience is an example for the 'development without growth'. Kerala State attained the highest physical quality of life, while enjoying the lowest per capita income among the states of India (Tewari et al. 1988). The physical quality of life index (PQLI) is a composite index formed by Overseas Development Council of United States in their report 'United States and World Development, Agenda for 1977', to measure the economic and social welfare of the people by taking three components namely life expectancy, infant mortality and literacy. Following this methodology Tewari and Joshi (1988) have worked out PQLI for Indian states and India. The PQLI of Kerala and India from 1961 onwards are as per the Chart below (Pillai 1994). The per capita income is not taken in the PQLI calculations.

Table 3.1

Physical Quality of Life-Kerala and India

Physical Quality of Life Index (PQLI)					
	1951	**1961**	**1971**	**1981**	**1991**
Kerala	29.64	50.47	68.14	79.2	90.52
India	NA	30	40	45	55.45

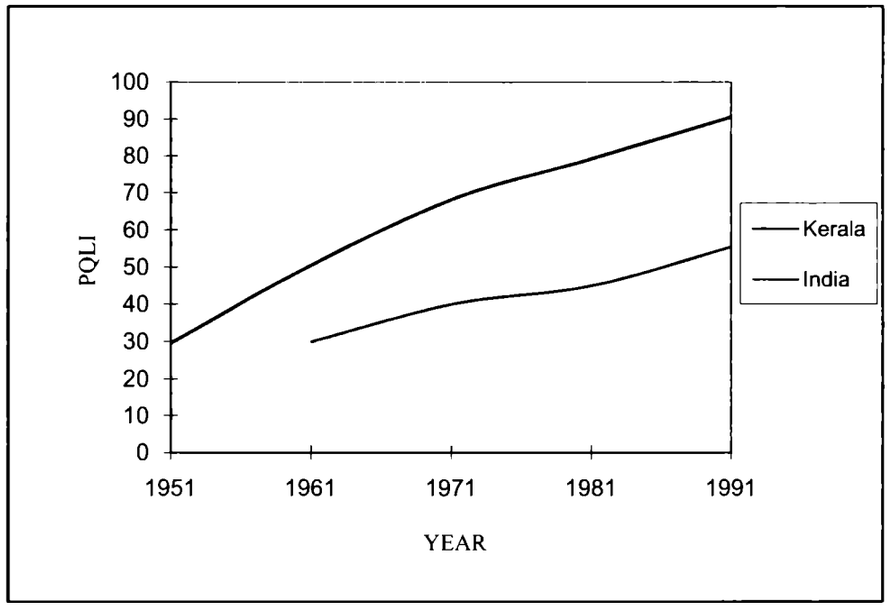

Chart 3.1 Physical Quality of Life Kerala and India

Later United Nations Development Program (UNDP) formulated the concept of Human Development Index (HDI) as a measure of socio-economic welfare of the people. In HDI calculations health and educational attainment alongwith per capita income is considered. Human Development Index of Kerala is found to be low compared to developed countries which enjoy the same physical quality of life. This is due to the low per capita income of Keralite. However, HDI is found to be greater than all India average due to the health and educational attainments by Kerala. HDI of India is estimated as 0.41 in 1990, while Kerala's HDI is estimated as 0.651 in 1987 (Sivakumar 1991). Without having per capita income, urbanisation and industrialisation the state has reached the third stage of demographic transition with good medical care and education (Jeromi 2002).

The highly impressive performance of Kerala among the states of India is due to the welfare-oriented strategy of developments adopted by the 'Native Kings' of Kerala and followed by the successive state governments. During the past five decades Kerala gave great emphasis to education, health and infrastructure coupled

with several radical redistributive policies like distribution of landholdings. Some critics have considered Kerala's development experience as 'naive romanticism' (Parayil 2000) and some others have underlined 'Limits to Kerala Model'(George 1999) They have argued that the deteriorating finance of the state government, due to stagnancy in economic growth, limit the government expenditure on social welfare measures and thus the sustenance of achievements already made (Pay Revision Report 2006).

Kerala has started tasting the bitterness of 'Kerala Model'. Now it has been facing a serious crisis due to low growth, high cost, low productivity, low investment and low employment in the state's economy (Jeromi 2002). Kerala stood to suffer in the growth and development of primary and secondary segments of the economy. Agriculture is badly affected due to the high cost of cultivation, poor productivity, unviable smaller holdings, and unremunerative price of products. Families depended on agricultural activities, borrowed funds to launch agriculture, fall victims to debt traps, leading to suicides. The state has invested lion's share of the economy for human resource development, not resulting in activities contributing to the state's primary and secondary sectors of the economy (Pay Revision Report 2006). The salaries and pensions in Kerala constitute a very high percentage of the state's revenue. A vicious circle of deficit, debt, debt service charges prevails in Kerala. As per the Economic Review 2008 the debt to Gross State Domestic Product (GSDP) ratio of Kerala is found to be the highest among the states of South India (42%), while our neighboring state of Tamil Nadu is having only 27%. Per capita debt is also the highest among the states of South India (Rs 12,681.-), while Tamil Nadu and Karnataka are having only Rs 7782.- and Rs 7446.- respectively.

The high standard of living enjoyed by Keralite is often supported by external remittances from Non-Resident Keralites (NRKs) who work outside Kerala and outside India. The result is the ageing of the resident population of Kerala as

educated and energetic working class work outside Kerala, leaving alone their old parents in palatial bungalows constructed with their remittances. The extreme consumerism converted Kerala a destination for marketing consumer goods and luxury items (Pay Revision Report 2006).

The development trajectory of Kerala has come to a halt as the state is not finding enough means to maintain the educational and health achievements it has acquired. High consumption standards of people without considering the long-term consequences make the situation further worse. To tide over the crisis of Kerala model, prudent diagnosis coupled with strategic intervention and awareness campaign is required. In this situation it is very much apt to examine whether the scattered settlement habit prevalent in Kerala has any cause-effect relationship to the socio-economic scenario of the state. In this back-ground it is appropriate to have an overview of the urbanisation characteristics of Kerala State.

3.2 URBANISATION CHARACTERISTICS

The State of Kerala

Urbanisation of a state is expressed by the percentage of people living in an urban area. Apart from all the urban designated areas Census of India has formulated three-fold criteria to declare an area as 'urban'. They are the following:

1. Population concentration criterion (not less than a population of 5000)
2. Density criterion (not less than 400 persons per sq. km.)
3. Productivity criterion (the percentage of male working population engaged non-agricultural activities is more than 75).

Accordingly the percentages of urban population and percentage of urban land from 1961-2001 is as per Table 3.2 and depicted as per Chart 3.2:

Table 3.2

Urbanisation Trend of Kerala

	1961	1971	1981	1991	2001
Urban Land %	2.88	3.46	4.6	8.65	8.37
Urban Population %	15.11	16.24	18.74	26.39	25.97

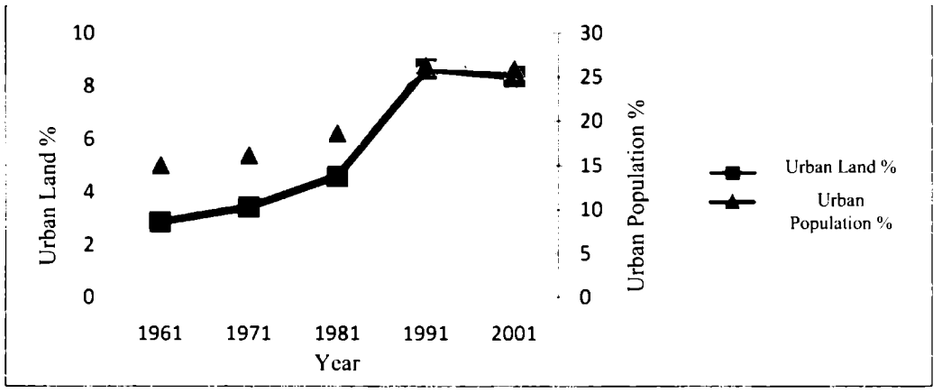

Chart 3.2 Urbanisation Trend of Kerala, Urban Land and Urban Population

It is seen that during the period 1961-1981 the urban land and urban population are almost going parallel. During 1981-1991 urban land has increased disproportionate to the urban population which indicates the existence of urban sprawl. Urban sprawl is unplanned urban spread with non-optimal density of population to support urban infrastructure. The after-effect of urban sprawl is experienced in the next decade (1991-2001) with a substantial decrease of urban population. Many of the areas declared as Census Towns (CTs) in 1991 are declassified as rural areas and Urban Out Growths (OGs). As per the Census of India definition, OGs are urban spreads which do not fulfill the three-fold urban criteria to be treated as independent CTs, but at the same, have all the other urban characteristics and infrastructural facilities.

As per the 2001 Census 17 numbers of Kerala Urban Agglomerations (UAs) have 33 numbers of urban Out Growths (OGs) which are lying at the periphery. Urban OGs are not 'true urban' as per the three-fold criteria of Census of India. Kerala is the state having the highest number of UAs even though it lacks a million plus city. As per the 2001 Census (Census Report 2001) 17 numbers of UAs in the state spread in an area of 57 % of the urban Kerala, carrying 72 % of the urban population. Comparing the Kerala UA with Delhi UA, Kerala UA carries only 46% of the population of Delhi UA as per the 2001 Census while its area is 2.2 times area of Delhi UA. In effect Delhi UA carries a residential density of 3.2 times of Kerala UA's residential density. 20% of Kerala UA area comprises OGs and 14% of the Kerala UA population is from OGs.

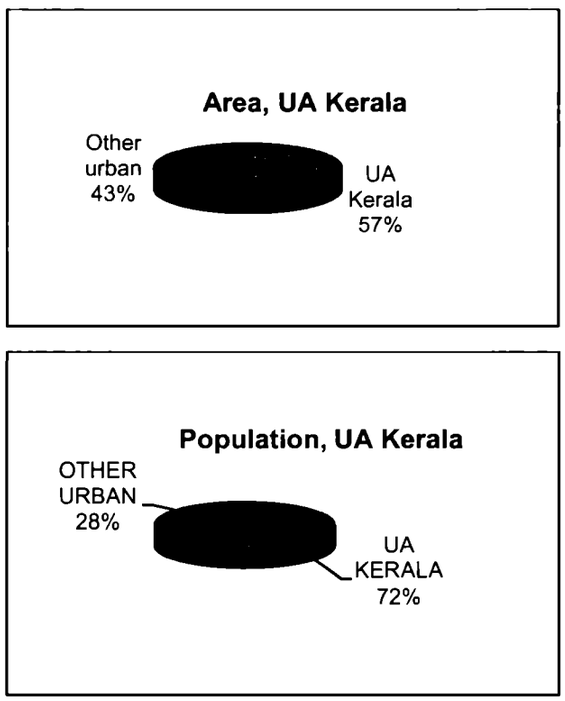

Chart 3.3.1 Area and Population —UA Kerala

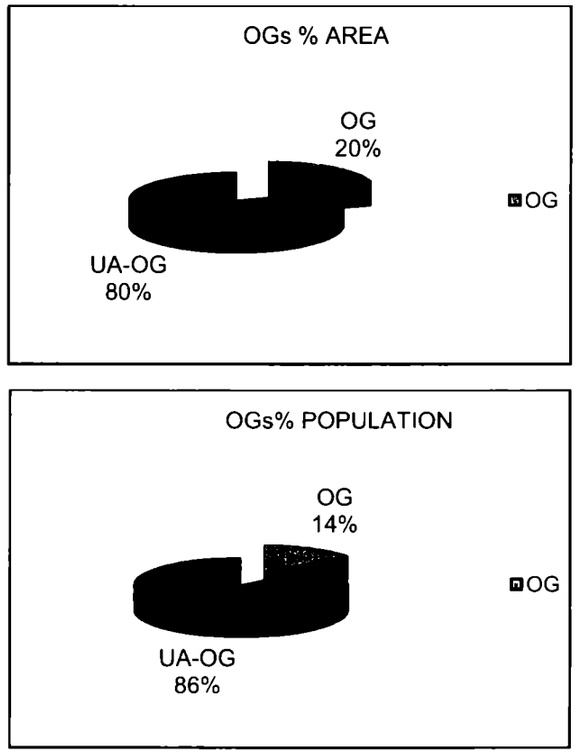

Chart 3.3.2 Area and Population —OG Kerala

If microscopically examined the Urban OGs of Kerala, one can see that all the criteria of Census of India, other than the productivity criterion, are satisfied. At the same time these areas are having urban infrastructure. This phenomenon is prevalent throughout the State of Kerala, even though no such classification has been made by the Census of India in areas other than UA. Kerala's rural resident has access to road, electricity, cooking gas, telephone and internet alongwith educational and health facilities. Only thing they lack is higher order shopping facilities. This may be the reason behind the high revenue expenditure with less revenue receipts prevalent in Kerala.

Government, in the name of welfare policies, continues investing in infrastructure for inadequate population concentration. When serviced land with ample spare capacity is idling in the city, people go further from the rural area invading agricultural/forestlands and pester government for infrastructure. This

causes loss of productivity of the agricultural and forestlands due to non-conforming and fragmented land utilisation pattern. The settlement pattern gets further scattered leading to more fossil fuel consumption to reach the human development-prone centers. This again contributes negatively towards the economy of the state.

In the tri-academy project (2001) report 'Growing Population, Changing Landscapes' it is reported (page 25) that South Florida and Kerala urbanisation characteristics are two extreme cases. In South Florida 96% of the people are urban and it is densely settled along the coast. Much of the inland areas are reserved for national parks and conservation areas. In the case of Kerala with its scattered settlement pattern throughout the state, the urban population remains as low as 26%.

Metropolitan Areas in Kerala

Until 1991 Census there was no area in Kerala having a million plus population. As per 1991 Census of India, Kochi is included as a 'million plus' city considering the population of Kochi Urban Agglomeration which spreads over an area of 373.30 sq. kms. Subsequent to this, the Government of Kerala declared Thiruvananthapuram, Kochi and Kozhikode as metropolitan areas in 1995, even though Kochi only is having a million plus population, and that too for the Urban Agglomeration. While the other million plus UAs of the nation are having a substantial core population, Kochi UA graph has a small hump at the core area and is flat towards the periphery.

Kochi Urban Agglomeration

In the case of Kochi the original jurisdictional area of Greater Cochin Development Authority (732 sq. km.) is included in the metropolitan area. Decade after decade urban agglomeration area of Kochi is expanding and it has spilled over the metropolitan declared area with a reduction in residential density. This is due to the lack of effective policies, to contain the population, to reduce transportation cost

and to save farmland which, in turn, saves forestland and limit the infrastructure cost. Kochi UA is the bread winner of the state as major share of the states' revenue is collected from Kochi UA.

Table 3.3 Area, Population and Density of Kochi UA

	1981	1991	2001
Area (sq. km.)	182.24	373.27	452.64
Population	686,000	1140605	1355972
Density (pp sq. km.)	3764	3056	2996

Table 3.4 Area, Population and Density of GKMA

	1981	1991	2001
Area (sq. km.)	731.31	731.31	731.31
Population	1481494	1660273	1819335
Density (per per sq. km.)	2026	2268	2483

If the productivity criterion of the Census of India is set apart, it is estimated that the major portion of Kerala is urban. This depicts the unsustainable development paradigm of Kerala which lacks efficiency. Effective policies and legislative tools are the need of the hour.

3.3 HD-EFp-Bc SCENARIO

The present HD-EFp-Bc scenario of Kerala State, which contains the Greater Kochi Metropolitan Area, can be characterised by the following:

a. Halting human development
b. Spiraling ecological footprint
c. Diminishing biocapacity
d. Diminishing HD/EFp and Bc/EFp

Halting Human Development

The State of Kerala attained laudable achievements in the case of health and education (basic level). Due to the lack of economic development the state is unable to go further to maintain the health and educational achievements in the business as usual scenario.

Although Kerala State as a whole is having substantial gross residential density (3rd among the states of India) the state lacks population concentration in cities where the quality of life enhancement can be made with higher order infrastructure. The viability of higher order infrastructure and facilities depends on the number of users in the case of private investment and the amount of tax collected in the case of government. The revenue expenditure of the state government is very high compared to the revenue receipts. State government is borrowing money from the external sources and major share of the state income is being expended for debt service charges. Hence the state is unable to provide the world class standards, which contribute to the desired human development. Further, it is stated that many of the human development-prone facilities provided are under-utilised due to insufficient accessibility. The major share of time is spent on travelling due to the inefficient transport system.

Spiraling Ecological Footprint

The ecological footprint of an average Keralite is very high due to the following reasons:

1. The food he consumes is manufactured or cultivated outside Kerala and fossil fuel is burnt to transport the same. More forestland is required to sequestrate the carbon dioxide discharged during burning. Thus carbon footprint of food consumption is more.
2. As the settlement pattern is scattered huge energy is wasted on transportation to reach the human development-prone centers, again leading to more fossil

fuel consumption, which is either shouldered by individual or by government. 'Kerala State Road Transport Corporation' is not profitable in Kerala and the reason may be the inadequate number of passengers from intake points due to the lack of population concentration phenomenon.

3. Due to the scattered settlement pattern 'built-up area / land' footprint is very high as scattering of built-up area reduces the productivity of the intermittent land (which remains underperforming or non-performing). High electrical distribution losses prevail in Kerala as distribution lines are covered in non-performing areas also.

4. The economic base of Kerala is the remittances of Non-Resident Keralites (NRKs). The energy footprint of a non-resident Keralite is high, as he often depends on air travel to reach the homeland burning huge amount of fossil fuel.

From all the above, the EFp of a Keralite is very high which can be a comparable figure to the EFp of developed countries, while enjoying less comfort than the people in developed countries. This illustrates the importance of finding the human development achievements with respect to the ecological footprint leading to HD/EFp Index.

Diminishing Biocapacity

As per the procedure adopted by the WWF in the Living Planet Report, biocapacity of Kerala can also be calculated which will be a diminishing figure as the productivity of agriculture, forest, marine and wet land ecosystems are less compared to the world average productivity. Integrity of ecosystems is lost due to the disturbance to the ecosystem due to human activities.

Diminishing HD/EFp and Bc/EFp

The efficiency indicator HD/EFp in the urban context and Bc/EFp in the regional context, both are having a diminishing trend in the case of the State of Kerala.

From all the above it is clear that any sincere effort to improve the crisis of Kerala model is to concentrate on the efficiency indicators HD/EFp and Bc/EFp and formulate policies, programs and legal tools to improve the same. Also it is true that there is no magic wand to improve the Kerala situation other than long-term measures. Through reforms in urban planning and applying energy-efficient technologies HD/EFp of Kerala can be improved in a phased manner. Encouraging planned, compact, high density development with compatible mixed land use around human development-prone centers alongwith the energy conservation technologies can go a long way to improve HD/EFp of Kerala. This, in turn, improves the Bc/EFp also as Bc improves when the ecosystems are undisturbed. Bc/EFp can further be improved through regional planning measures and inculcating functional dependencies in the region which, in turn, can reduce the fossil fuel consumption for the transportation of resources.

3.4 HISTORY AND PLANNING BACKGROUND

Development of Kochi as a primate city of Kerala is closely linked with the political and administrative history of Malabar Coast. Kerala was the important maritime nation in the dawn of the Christian Era. Early rulers had their capital at Thiruvanchikulam, located around 18 kms north of Kochi. Ancient port of Musiris served as the international centre of trade and commerce. Cochin port was formed in the year 1341 when the heavy floods of that year silted up the mouths of the Musiris Harbour and the surging water drained to the sea through Kochi Channel. Traders

subsequently shifted their activity to Kochi. Fort Kochi became the colonial settlement, Mattancherry the market town and Ernakulam mainland became the administrative centre with public buildings and educational centers. The existence of sand bar at the sea mouth prevented large ships to enter the port. It was in 1920 under the direction of Sir Robert Bristow the sand bar at the sea mouth was cut open and Cochin became an all weather port (GCDA 1991).

Development of the port has coincided with the commissioning of the Pallivasal Hydro electric project supplying ample power heralding a new era of industrial growth in the region. Fort Kochi, Mattanchery and Ernakulam were three separate municipalities and evolved schemes and projects in their respective areas of jurisdiction. In 1966 joint town planning committee was constituted by the government to co-ordinate the planning efforts of these municipalities. In 1967 the three municipalities, along with the adjoining areas, were merged to form the Corporation of Cochin.

A comprehensive approach to the planning of urban areas of Kochi and its environs was initiated after the formation of Kerala State in 1956 and the Department of Town Planning was constituted in the year 1959. Sanction for the preparation of development plan for Cochin Region was given by the Government of Kerala in 1961. Interim development plan for Cochin Region was prepared by the Department of Town Planning. Cochin town planning trust was constituted in the year 1968 to implement the proposals of interim development plan. Development Plan for Cochin Region was formulated in the year 1976 as a comprehensive policy document to stimulate balanced growth of the region. For effective implementation of the proposals in development plan Greater Cochin Development Authority was constituted in the year 1976, jurisdictional area being the present Greater Kochi Metropolitan Area.

3.5 DEVELOPMENT MANAGEMENT SCENARIO OF GREATER KOCHI

Presently the development management system of Greater Kochi is governed by:

1. Kerala Municipalities Building Rules of 1999 (KMBR 1999) formed as per the provisions in the Kerala Municipalities Act of 1994
2. Coastal Regulation Zone rules formed as per the provisions in the Environmental Protection Act of 1986
3. Airport Vicinity Control exercised by the Airport Authority of India.
4. Land Utilisation Order of 1967 which is notified as per the provisions in the Essential Commodities Act of 1955
5.. Master plan prepared for the central city area (1/3rd core area) namely the Structure Plan for the Central City and 24 detailed town planning schemes (prepared as per provisions of Town Planning Act). The list of 24 detailed town planning schemes which are under the various stages of implementation by the Greater Cochin Development Authority is as per Annexure 2.

Subsequent to the enactment of the 73rd and 74th Constitutional Amendment Act of 1992, the Government of Kerala enacted the Municipalities Act in 1994 to cater to the provisions of 74th Constitutional Amendment Act. Till 1999 development permits were given by the Greater Cochin Development Authority, while building permits were given by the respective local bodies. Government issued G.O.(MS) No.5122/E3/99/LSAD dated 5-12-1999 delinking the development authority from the development management scenario by giving the sole authority to the local governments including panchayats which is under the supervision of the Town Planning Department of the Government of Kerala. In this case it is noted that the 11th schedule of the 73rd Constitutional Amendment Act and Panchayat Raj Act does not envisage the spatial planning function to be given to local governments.

After the enactment of the Municipalities Act of 1994 the Greater Cochin Development Authority was unable to take up new town planning schemes. Local governments also could not take up new town planning schemes. Effectively development management scenario has come to a halt in Greater Kochi Metropolitan area. Apart from Municipalities and Corporation, Building Rules were applicable only in very few panchayats in the Greater Kochi Metropolitan Area till Government of Kerala issued orders to implement building rules in all panchayats in Kerala in 2007.

Meanwhile the Government of India accorded sanction to form an International Container Transshipment Terminal at Kochi and many national and international real estate development agencies moved their activities to Greater Kochi. As there was no building rule in panchayat areas real estate market has started booming up in panchayat areas. Witnessing the haphazard development scenario and umpteen number of court cases the Government of Kerala extended the KMBR regulation to all the panchayats in 2007 instead of making a separate panchayat building rules.

Twenty three out of 24 DTP schemes were silent on Floor Area Ratio stipulations, while structure plan for central city had a FAR limit of 1.5. Subsequently vide G.O. (MS) No 143/07/LSGD dated 31st May 2007 government issued variation to the structure plan giving an FAR upto 2.5 depending on the access road width.

Effective development management scenario in Greater Kochi Metropolitan Area is that in core area, where structure plan exists, maximum FAR permissible is only 2.5, while at peripheral areas, where there is no planned development, an FAR upto 4 is permissible.

On the other hand, Coastal Regulation Zone (CRZ) rules applicable to coastal panchayats and municipalities categorise the coastal zone of Greater Kochi to category I, II and III. Ecologically fragile ecosystems are categorised as Zone I, where no building activity is permitted. As per the coastal zone management plan of Kerala, coastal area of panchayats are categorised as Zone III, while coastal area of municipalities and corporation is categorised as Zone II. CRZ rules are more relaxed for Zone II which is already developed.

However it is ironical to note that the Land Utilisation Order of 1967 imposes restrictions on the reclamation of paddy fields, irrespective of whether it is in a developed area/ area proposed for non-agricultural development in the sanctioned town planning schemes. However this inconsistency has been overcome by a judgement from the Hon.High Court of Kerala. The judgement of the case Reliance Industries versus Commissioner of Land Revenue reported in 2007(2) KLT page 850 that no permission under Kerala Land Utilisation Order is necessary for any activity of construction or use of any land in residential use zone or any other zone in the town planning scheme area other than green strip area.

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Chapter- 4

URBAN SPRAWL ANALYSIS AT MICRO LEVEL

Contents

4.1 DELINEATION-DATA CAPTURE-FORMATION OF GRID DATA IN GIS

The geographical area included in the toposheet No 58/B8 of Survey of India between the latitudes of 10^0 and 10^015" North and 76^015" and 76^030" East which includes the major portion of Greater Kochi Metropolitan Area (GKMA) has been selected for detailed micro level analysis (Map 4.1.1).

This area includes Cochin Corporation (Part) and four out of six municipalities of Greater Kochi Metropolitan Area. The municipalities included in the Micro Study Area (MSA) are Kalamassery, Aluva, Angamaly and Perumbavoor. Two major highways are passing through this area namely National Highway No.47 (NH 47) and Main Central Road (M.C. Road) which connects Angamaly and Perumbavoor in the Micro Study Area. The local bodies included in the Micro Study Area is as per Annexure 3.

3km buffer zone

Using buffer function of ArcGIS Geographical Analysis tool a 3km buffer zone on either side of the highway is created (Map 4.1.2).

Built-up area 1968

The built-up area 1968 is retrieved from the toposheet 58 B/8 of Survey of India in ArcGIS platform. The built-up area retrieved is clipped with the buffer polygon to obtain the built-up area 1968 of the Micro Study Area (Map 4.2.1).

Built-up area 2002

For the creation of 2002 built-up data IRS 1C, LISS III image of the National Remote Sensing Agency, row and path 100 and 67 respectively, has been used. LISS III Image for the area was classified using the software ERDAS IMAGINE. Based on site verification, signature polygons were given to classify the LISS III image. Using the raster to feature conversion capability of ArcGIS Spatial Analysis extension the classified built-up (raster) was converted to polygon feature class

(vector), which is again clipped with the 3 km buffer polygon created on either side of the highway, to obtain the built-up area for the year 2002 (Map 4.2.2).

Local body-wise built-up 1968 and 2002

The built-up area feature classes for the year 1968 and 2002 are intersected with the local body boundaries to obtain the local body-wise built-up area for the year 1968 and 2002 (Map 4.1.3, Map4.2.3 and Map 4.2.4).

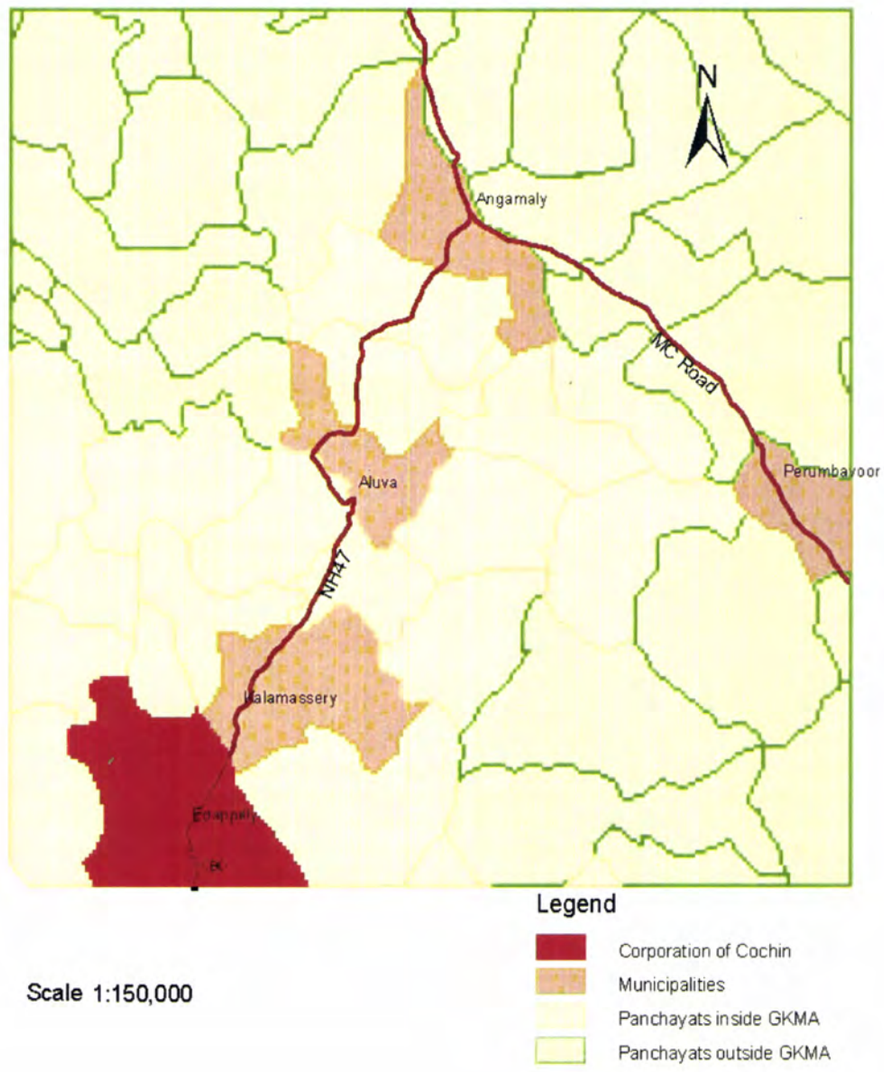
Local body-wise population density 1968 and 2002

Local body-wise population details are collected from 1971 and 2001 publications of Census of India. Population density of each local body was assigned by dividing total population by total area of the local body. Thus local body-wise population density maps are prepared (Map 4.3.1 and Map 4.3.2).

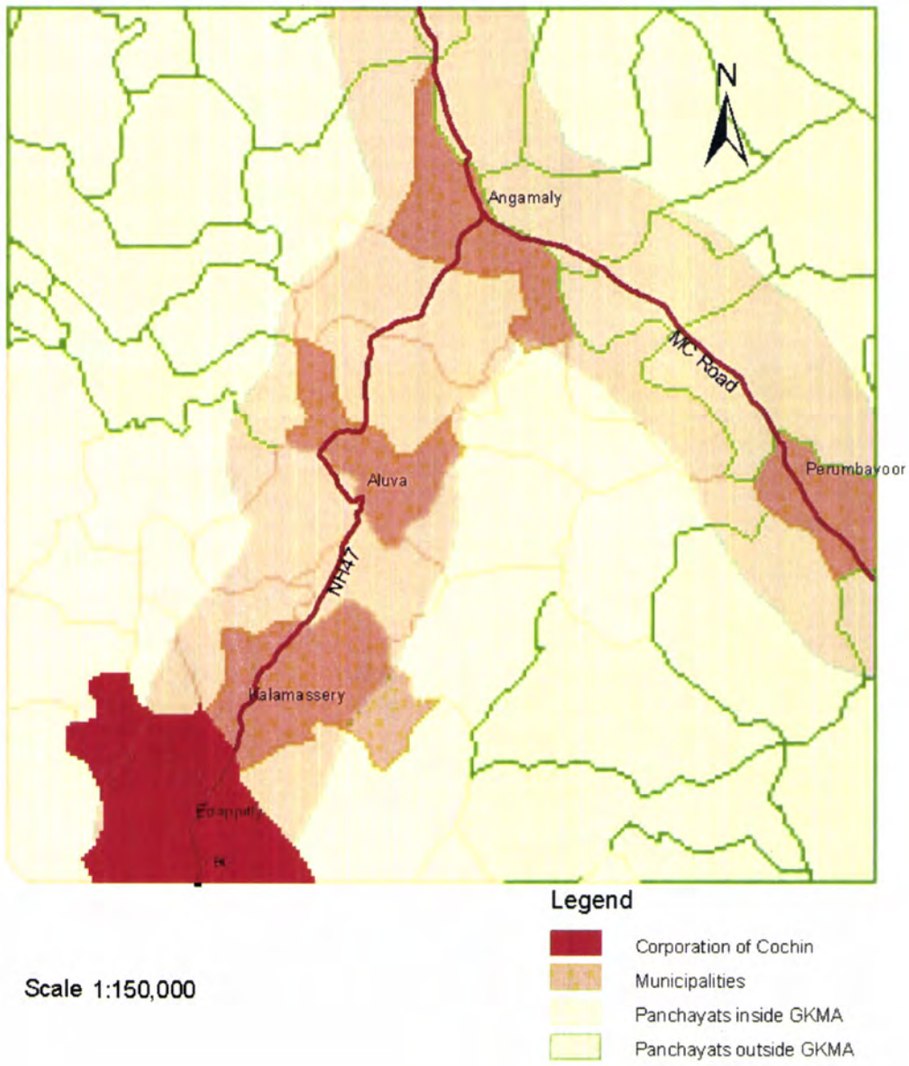
Formation of Grid Data

1km* 1km vector grid is created for the Micro Study Area (Map 4.4.1) to intersect the same with the built-up area 1968 feature class (Map 4.2.3) and built-up area 2002 feature class (Map 4.2.4). Thus grid data for the MSA is obtained with attribute information of built-up area and population density (Map 4.4.2 and Map 4.4.3). Three distance rasters are created, using ArcGIS spatial analysis extension, for the area namely distance from CBD, distance from points (municipalities) and distance from highways (Map 4.5.1, Map 4.5.2 and Map 4.5.3). The distance values are also added as attribute information in the grid data. Thus grid data pertaining to distance alongwith built-up area and population for the years 1968 and 2002 are kept ready for analysis.

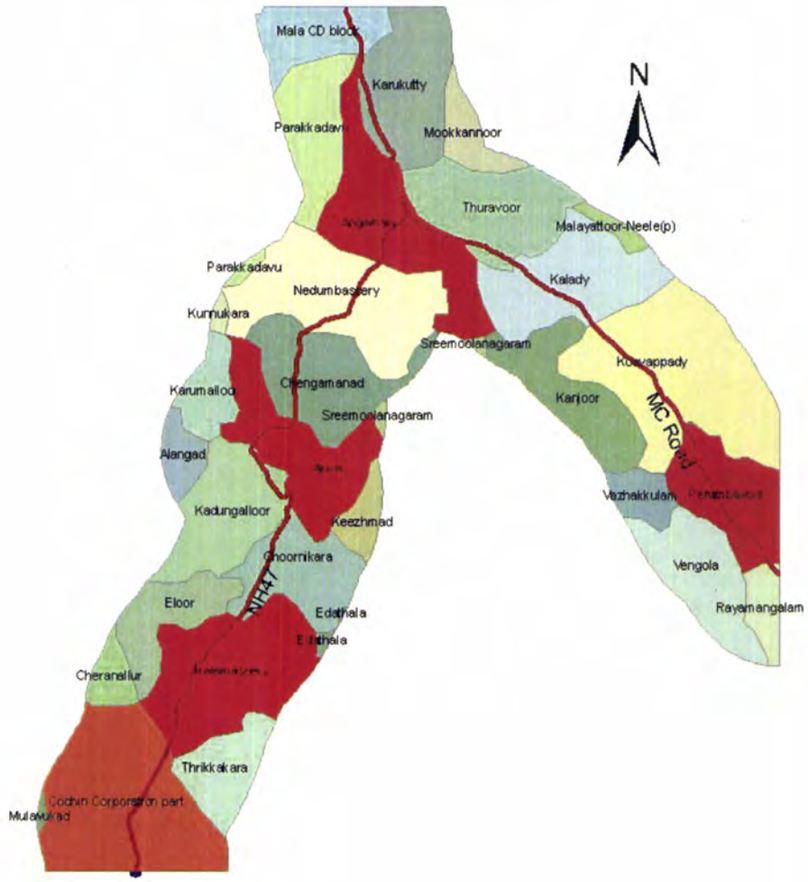
Map 4.1.1
INCLUDED LOCAL BODIES



Map 4.1.2
MICRO STUDY AREA

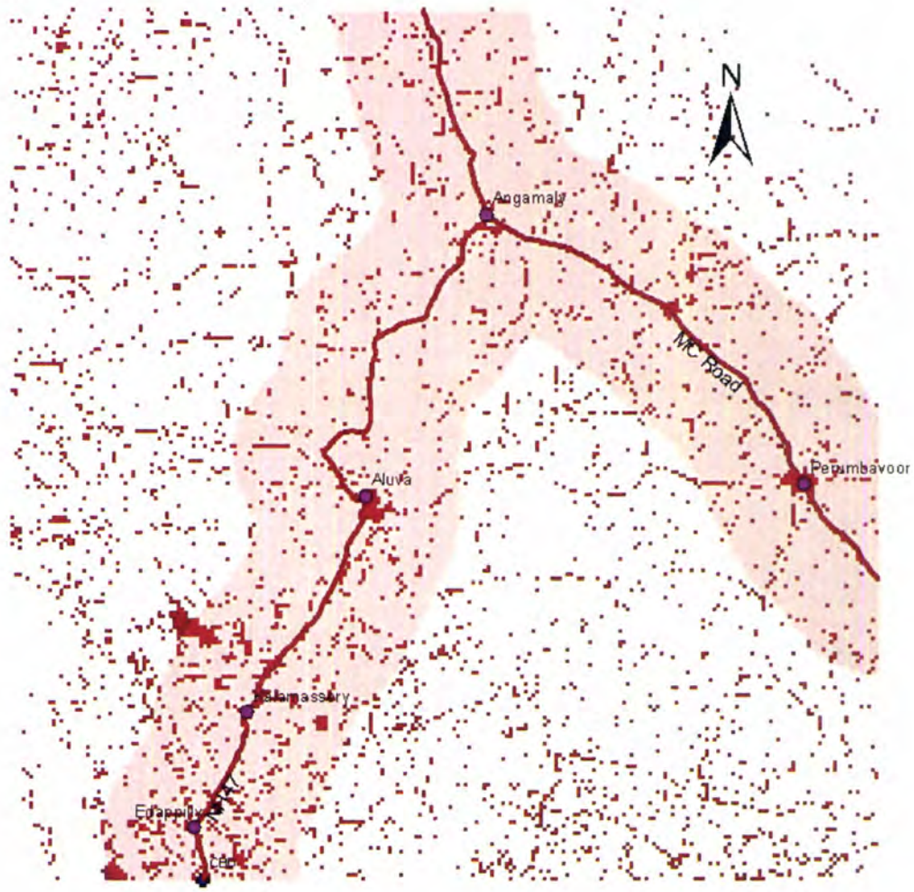


Map 4.1.3
LOCAL BODIES IN MICRO STUDY AREA



Scale 1:150,000

Map 4.2.1
MICRO STUDY AREA - BUILT- UP 1968



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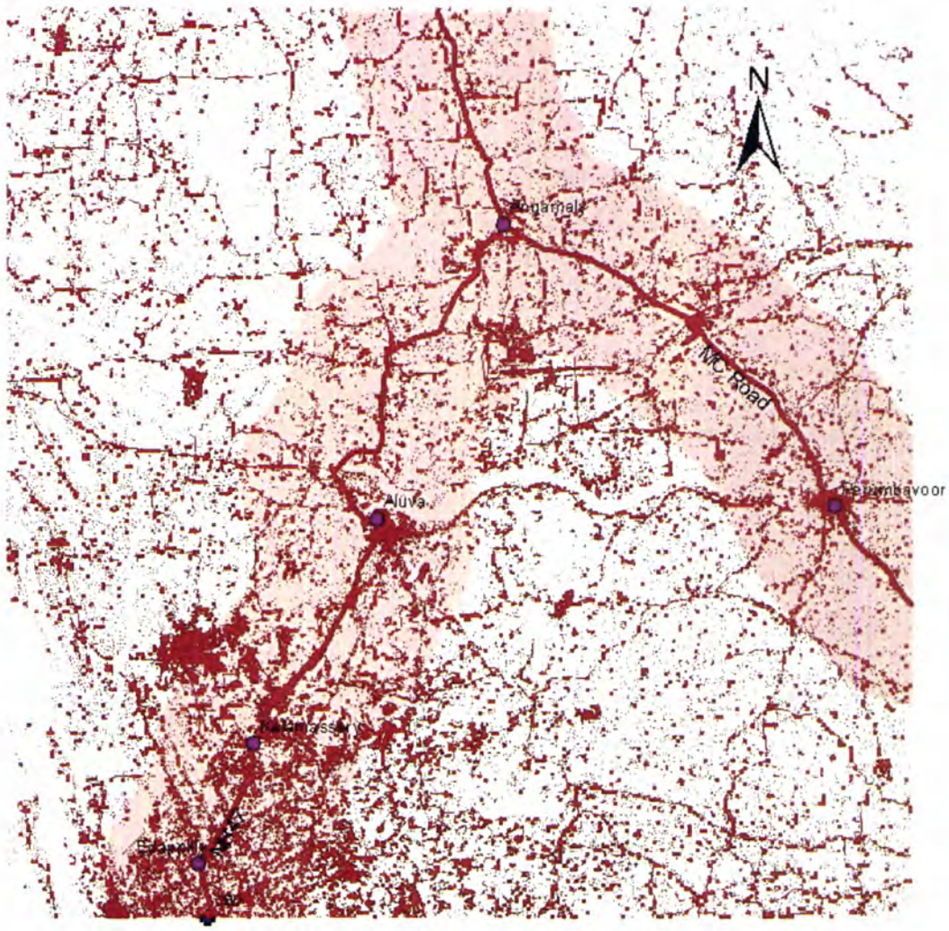
Map 4.2.2
MICRO STUDY AREA - BUILT- UP 2002



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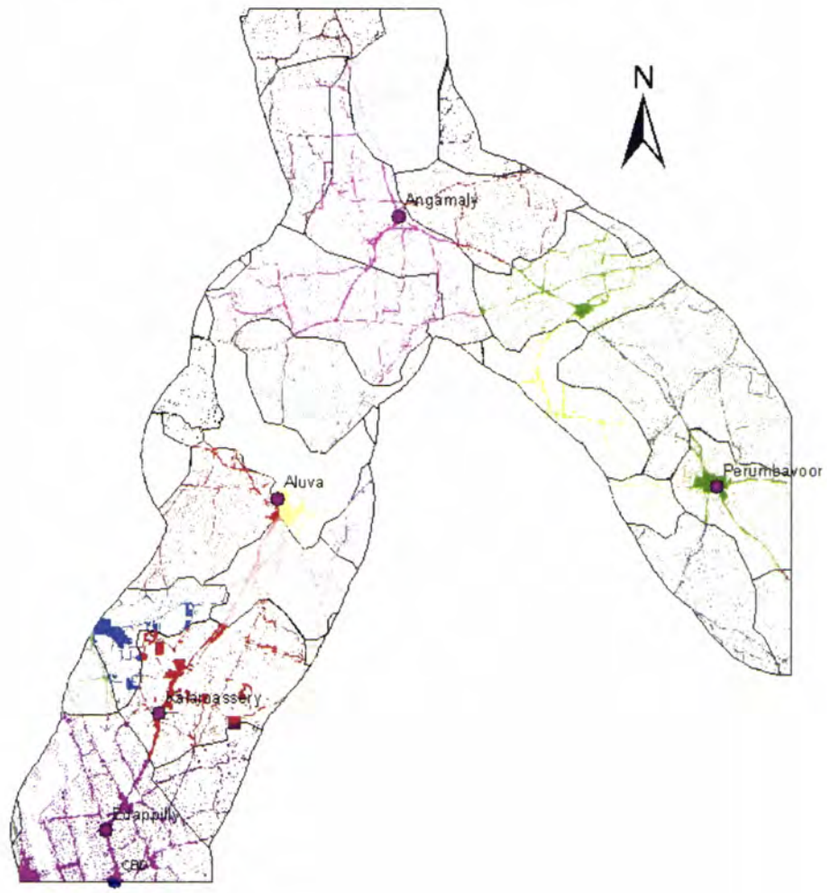
Map 4.2.3
LOCAL BODY-WISE BUILT- UP 1968



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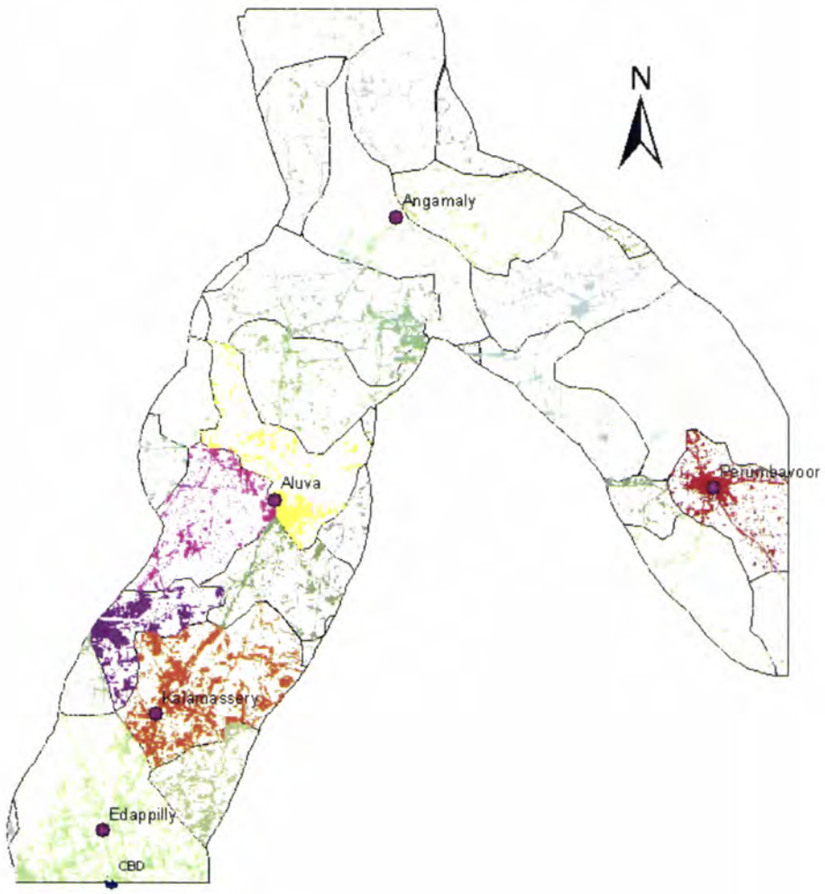
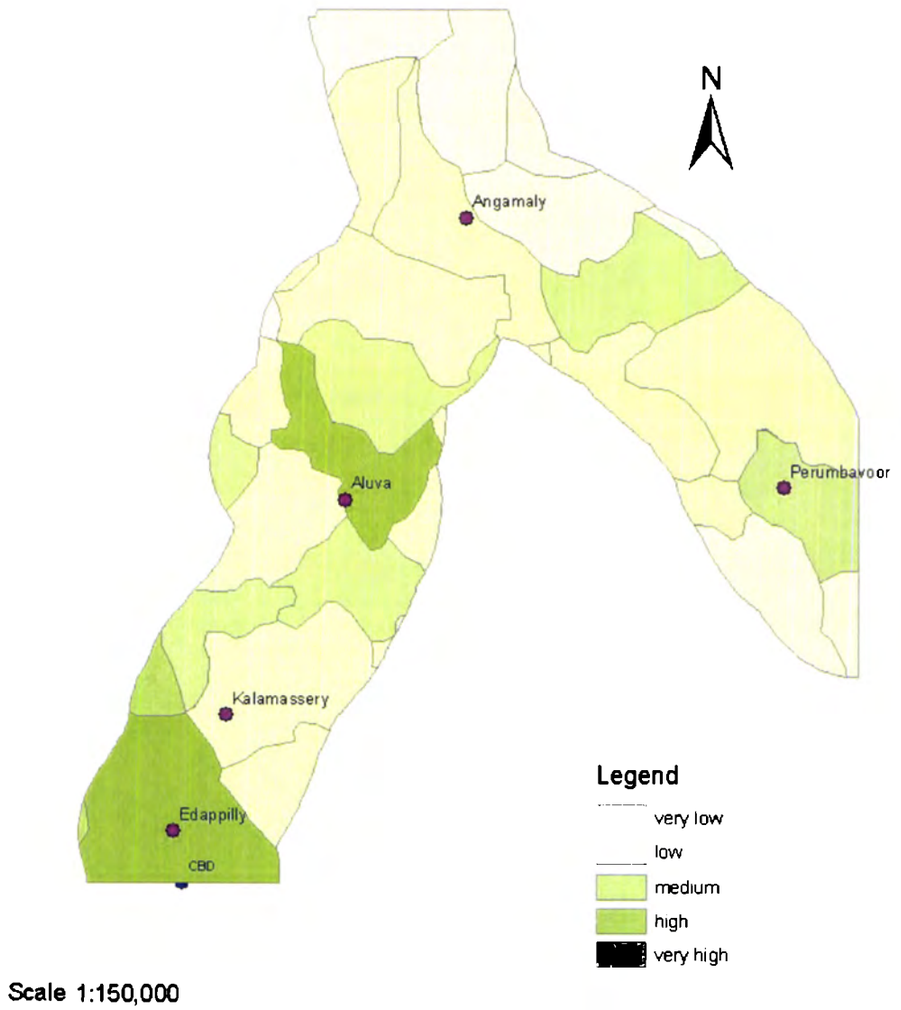
Map 4.2.4
LOCAL BODY-WISE BUILT- UP 2002



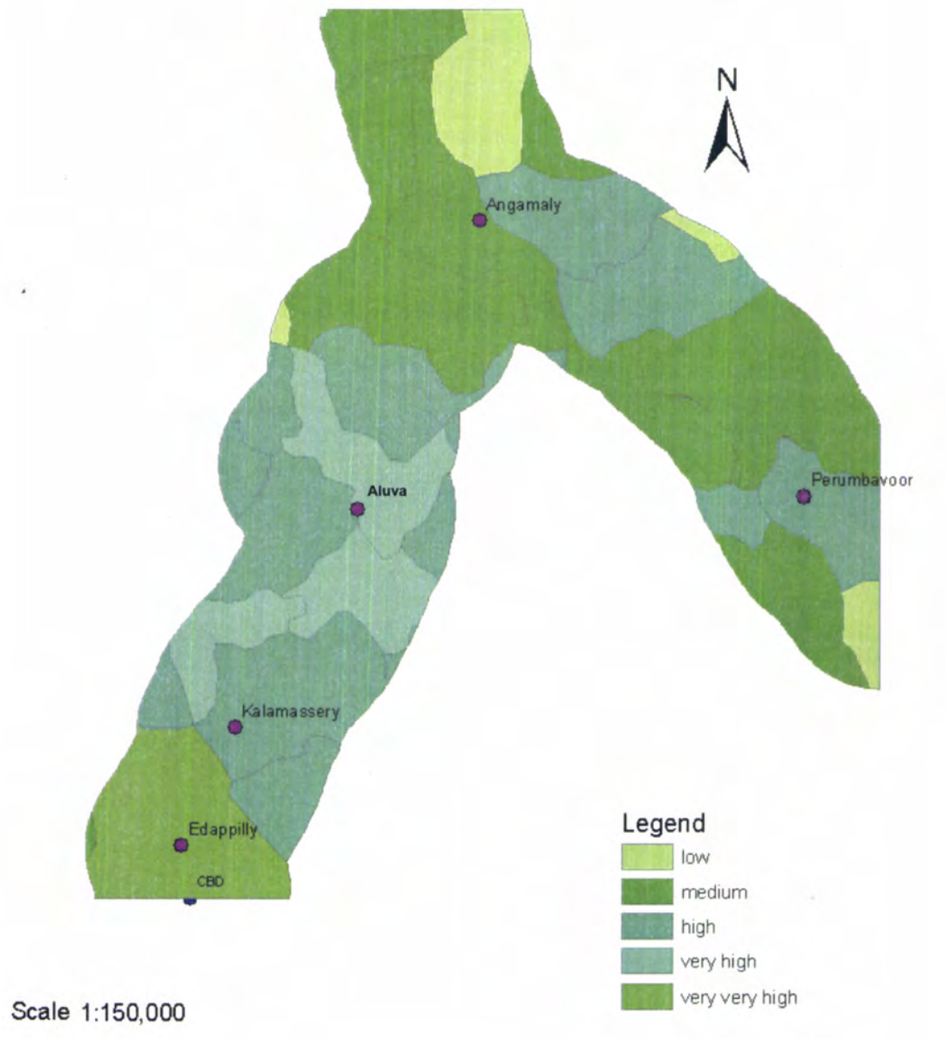
Scale 1:150,000

Map 4.3.1
LOCAL BODY-WISE POPULATON DENSITY 1968

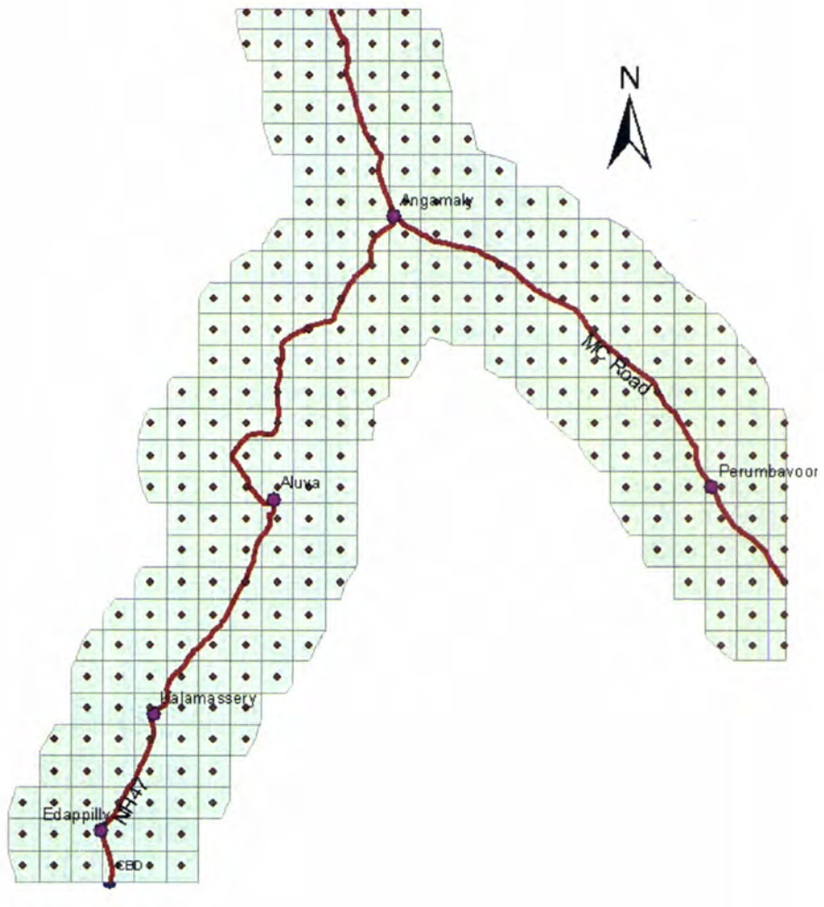


Scale 1:150,000

Map 4.3.2
LOCAL BODY-WISE POPULATON DENSITY 2002

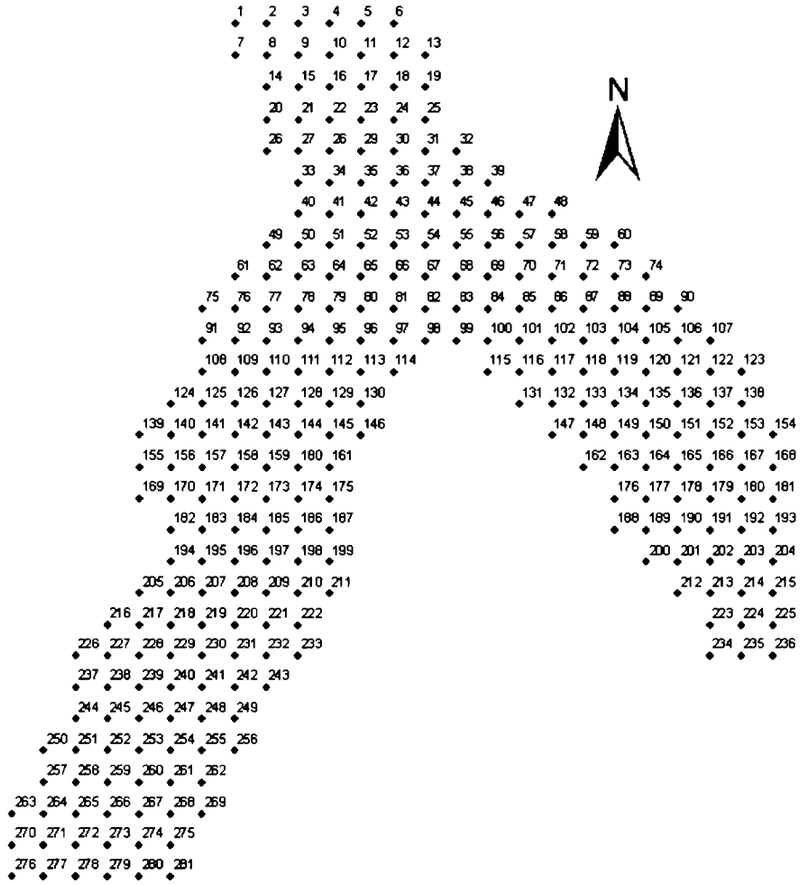


Map 4.4.1
VECTOR GRID



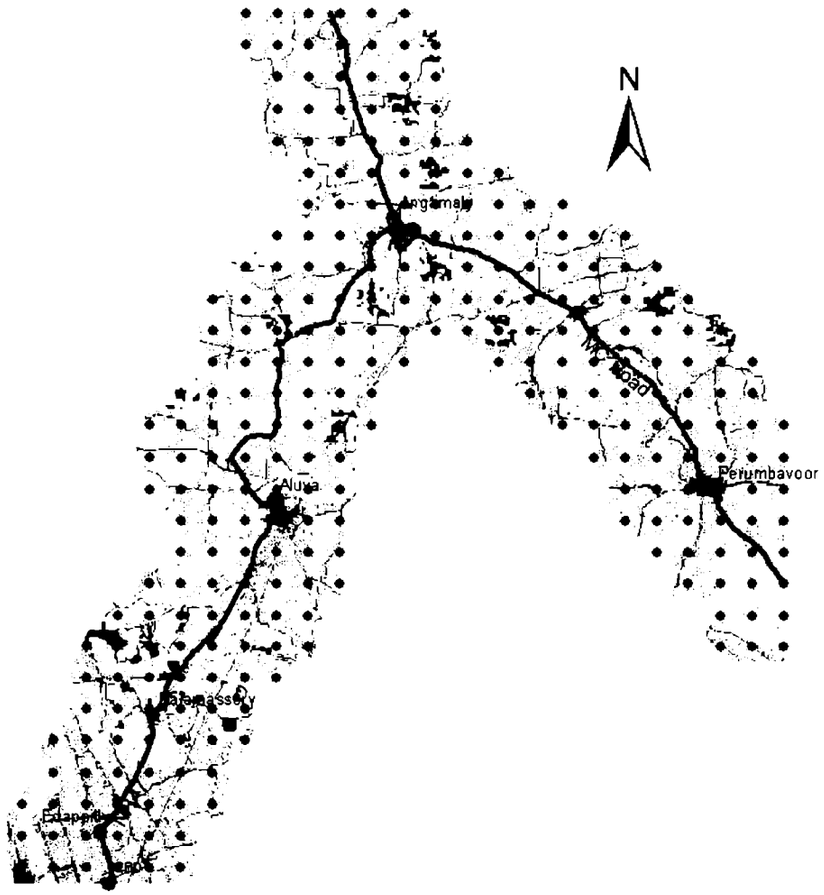
Scale 1:150,000

Map 4.4.2
CENTROID OF GRID POLYGONS



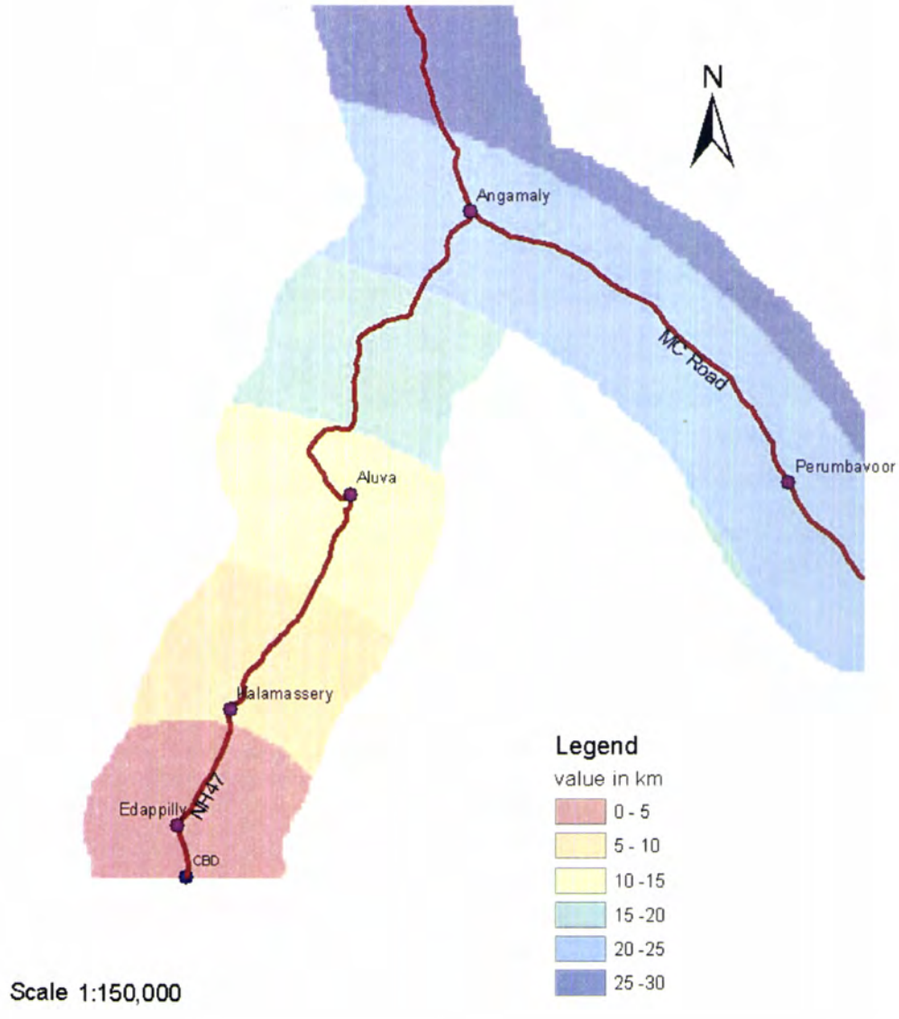
Scale 1:150,000

Map 4.4.3
GRID DATA BUILT-UP 68 SELECTED

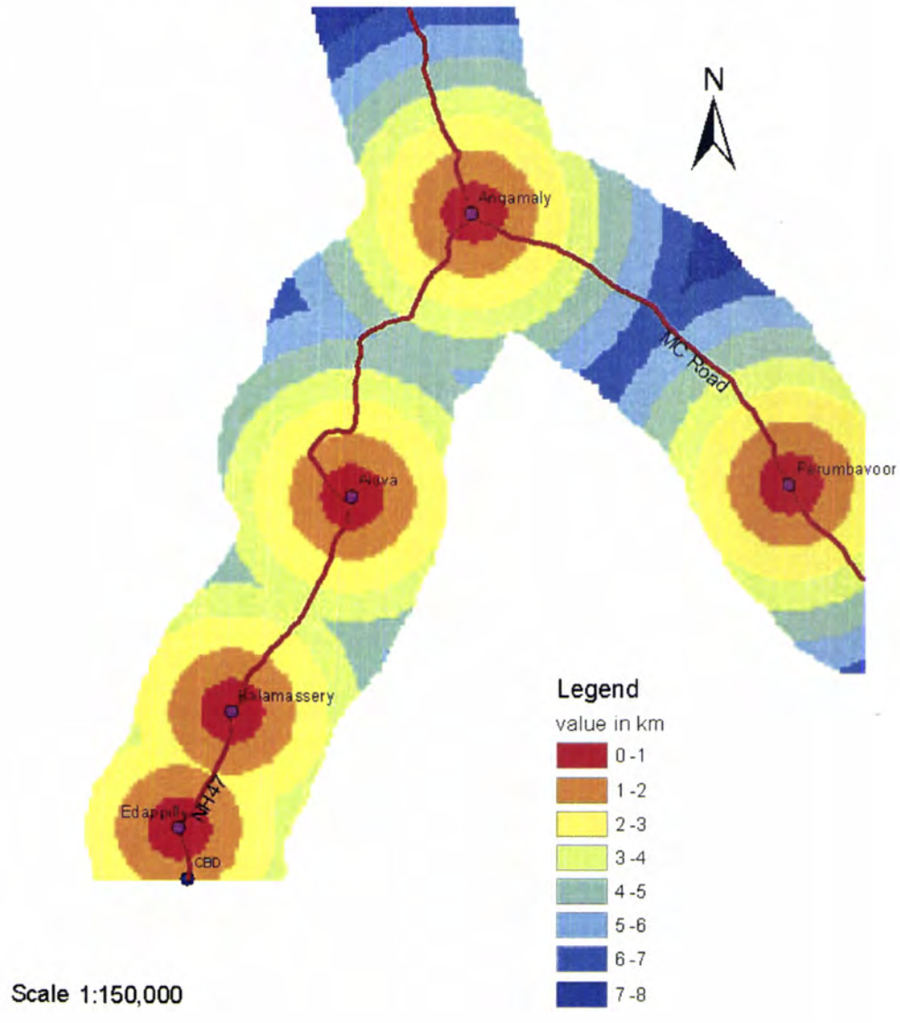


Scale 1:150,000

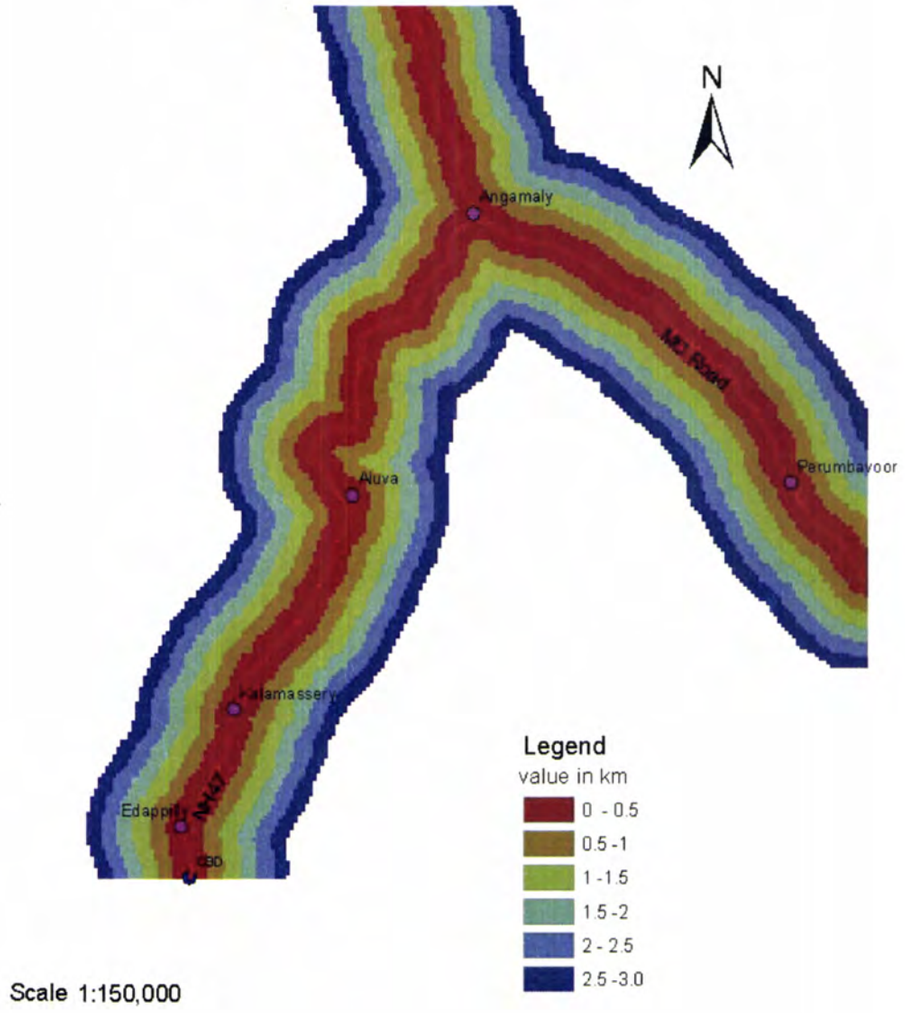
Map 4.5.1
DISTANCE RASTER FROM CBD



Map 4.5.2
DISTANCE RASTER FROM MUNICIPALITIES



Map 4.5.3
DISTANCE RASTER FROM ROAD



4.2 MAP DENSITY ANALYSIS

Map density is considered as the percentage of built-up area in each grid compared to the total area of the grid. Built-up area is expressed in sq. m. and hence the total area of the grid is 10^6 sq. m. Value of the map density of each grid is converted to raster data and thus the map density map for the years 1968 and 2002 are prepared (Map 4.6.1 and Map 4.6.2).Percentage change of map density is also prepared (Map 4.6.3). By referring the Map 4.6.3 and Chart 4.1.1 it is seen that 237 out of 281 grids are having percentage change less than 200%. This means built-up change is almost uniformly taking place in the majority of the grids. Change of map density results are tabulated as below:

value (%)	count
< 200	237
200-400	28
400-600	9
600-800	3
800-1000	2
1000-1200	1
1200-1400	0
1400-1620	1

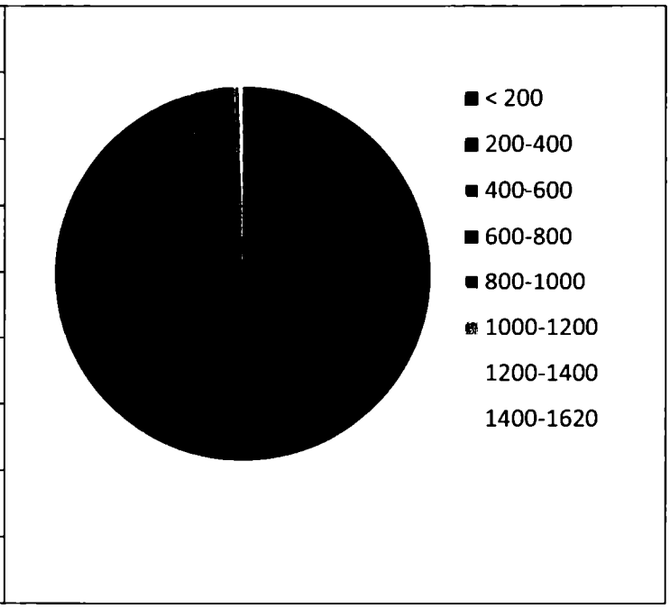


Chart 4.1.1 Change of Map Density Distribution

4.3 POPULATION DENSITY ANALYSIS

If the population is expressed in persons per sq. km. the density of population is the total number of people in each 1 km*1km grid. Population density map for the years 1968 and 2002 (Maps 4.7.1 and Maps 4.7.2) are prepared. Change of population density map is also prepared (Map 4.7.3).

value (%)	count
< 0	35
0-300	231
300-600	12
600-900	1
900-1200	1
1200-1307	1

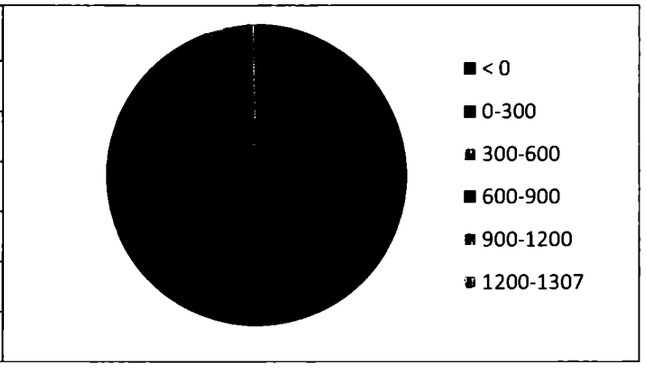


Chart 4.1.2 Change of Population Density Distribution

From the change in population density map (Map 4.7.3) and Chart 4.1.2 it is seen that 35 out of 281 grids are having negative population growth. 231 grids are having population density change upto 300%.

4.4 PER CAPITA BUILT-UP AREA ANALYSIS

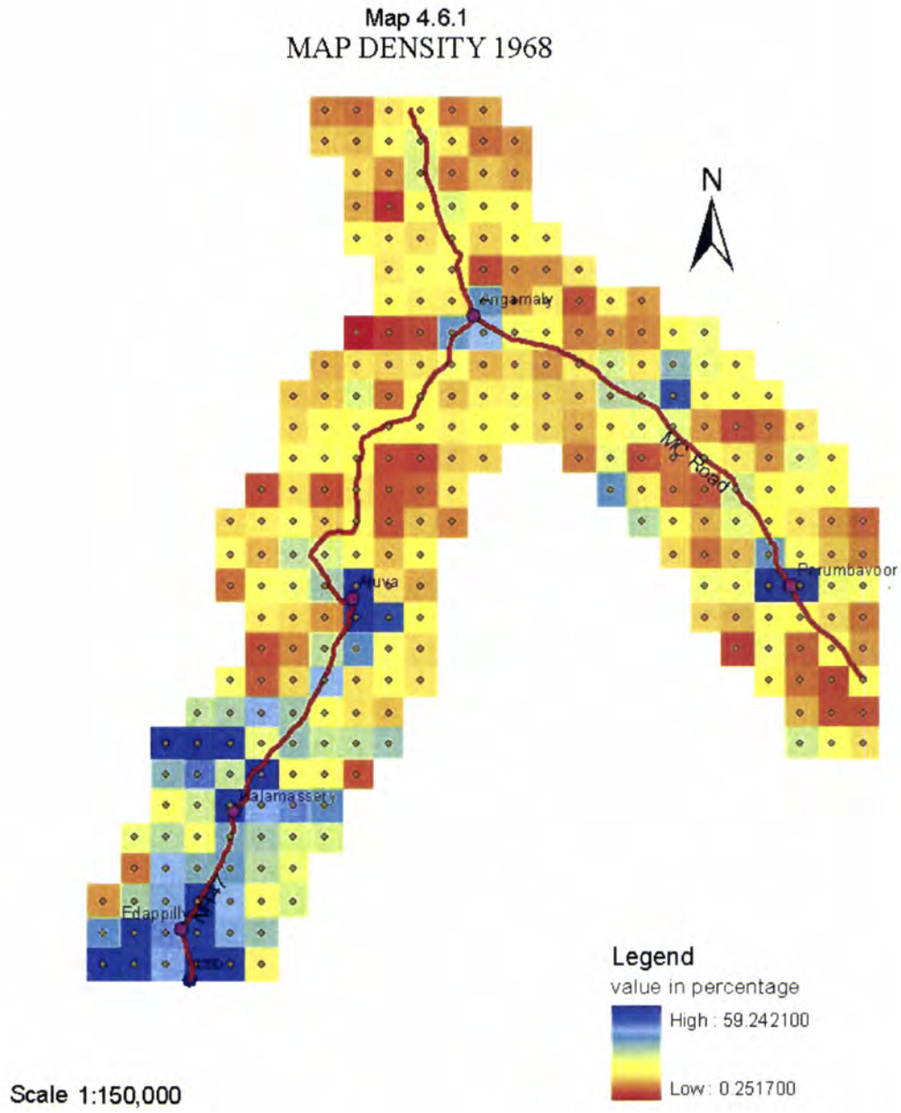
By dividing the built-up area in each 1km*1km grid with population of the grid, per capita built-up is calculated for the year 1968 and 2002. Per capita built-up map is prepared in the raster format for the years 1968 and 2002 (Map 4.8.1 and Map 4.8.2). In 1968 total area is divided into four zones namely very low per capita built-up, low per capita built-up, medium per capita built-up and high per capita built-up. Analysis for the year 2002 reveals that there are only two zones, low and medium.

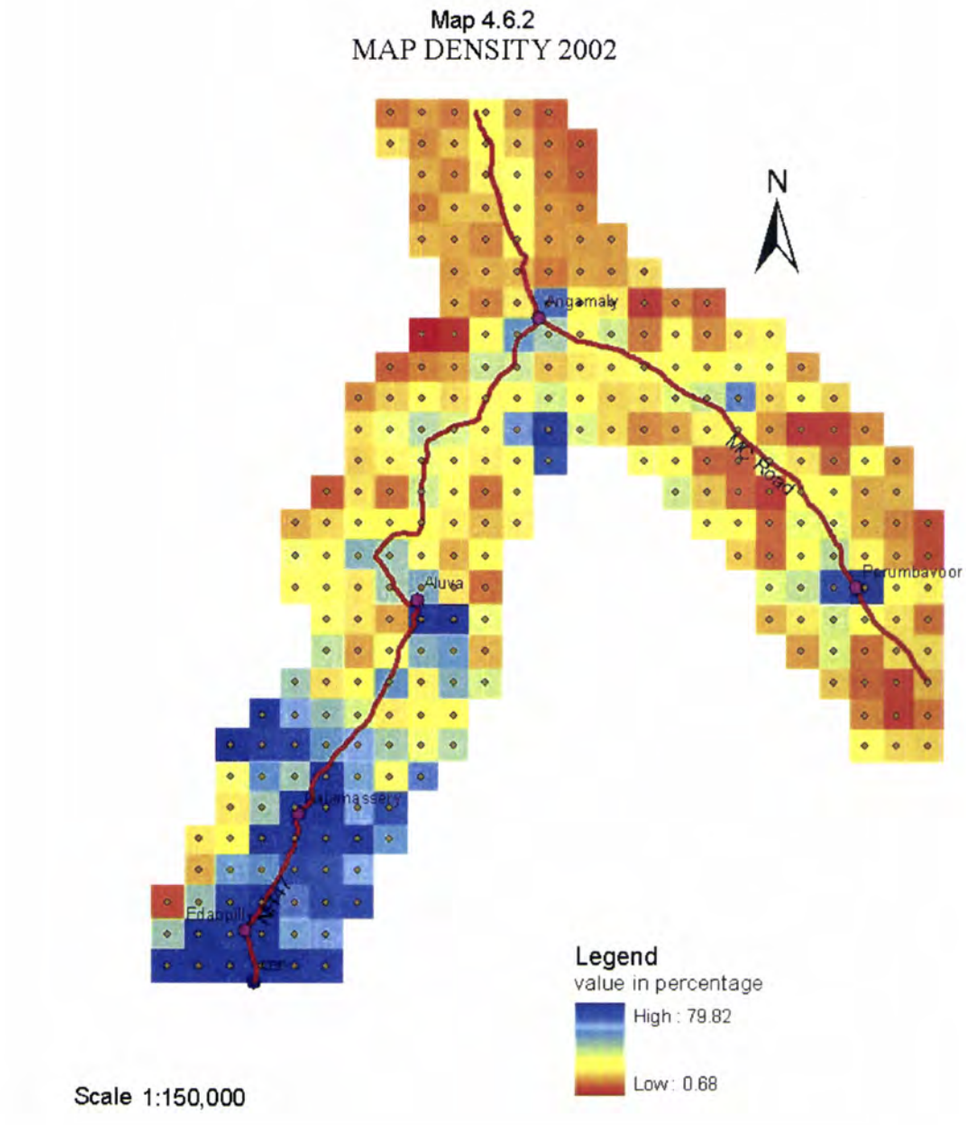
To know the tendency of grid-wise per capita built-up area change, the percentage change of per capita built-up area map is also prepared (Map 4.8.3 and Table 4.1). In 230 numbers of grids per capita built-up area increased, while in 51 grids per capita built-up area reduced.

Table 4.1

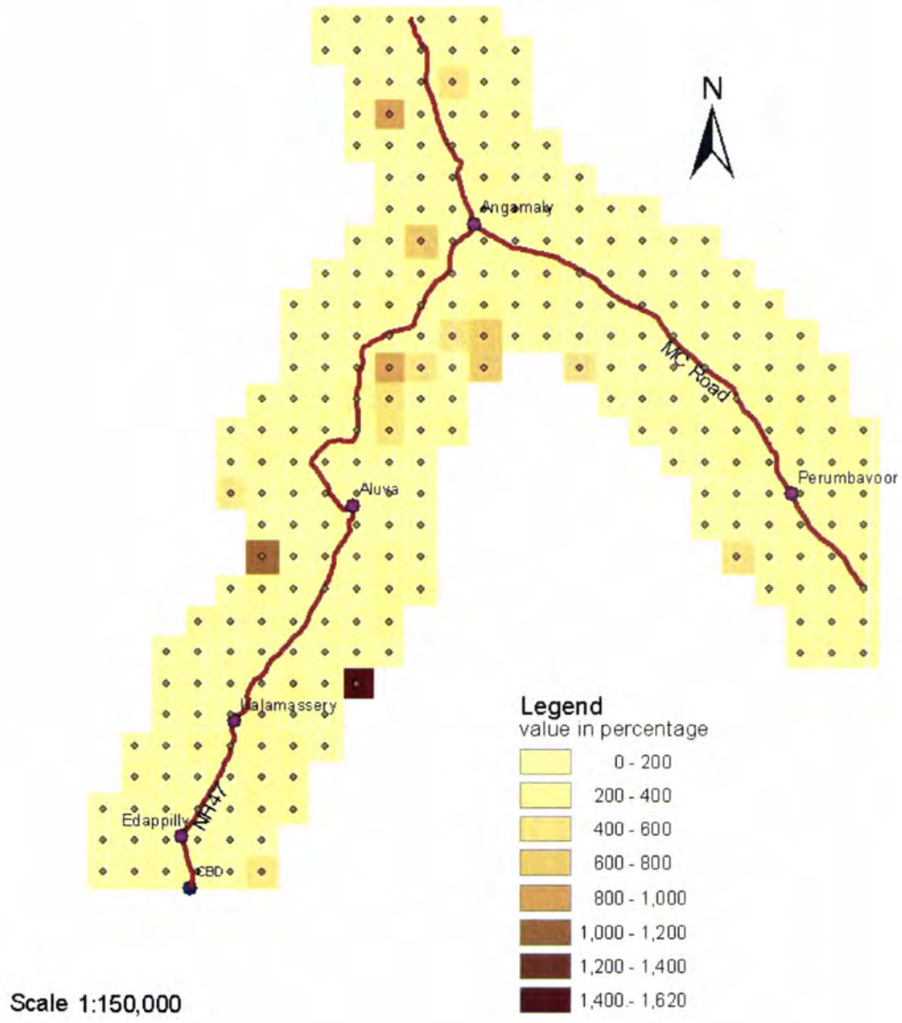
Change of per capita Built-up Area 1968 and 2002	
value	count
increased	230
decreased	51

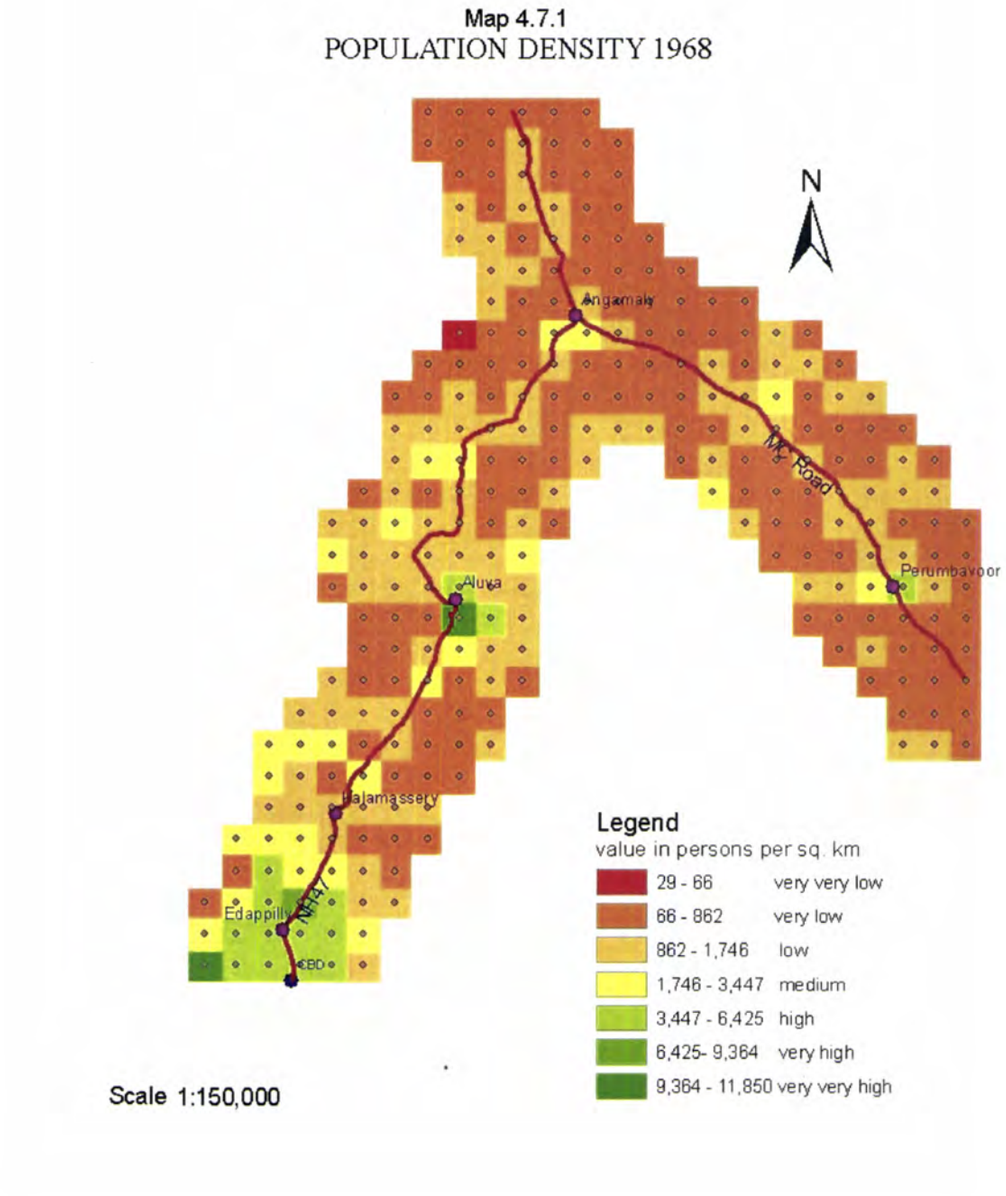
Increase in per capita built-up area may be attributed to the conversion of residential land use to non-residential land use effecting in outmigration of the people away from highway, CBD and intervening municipalities causing urban sprawl.

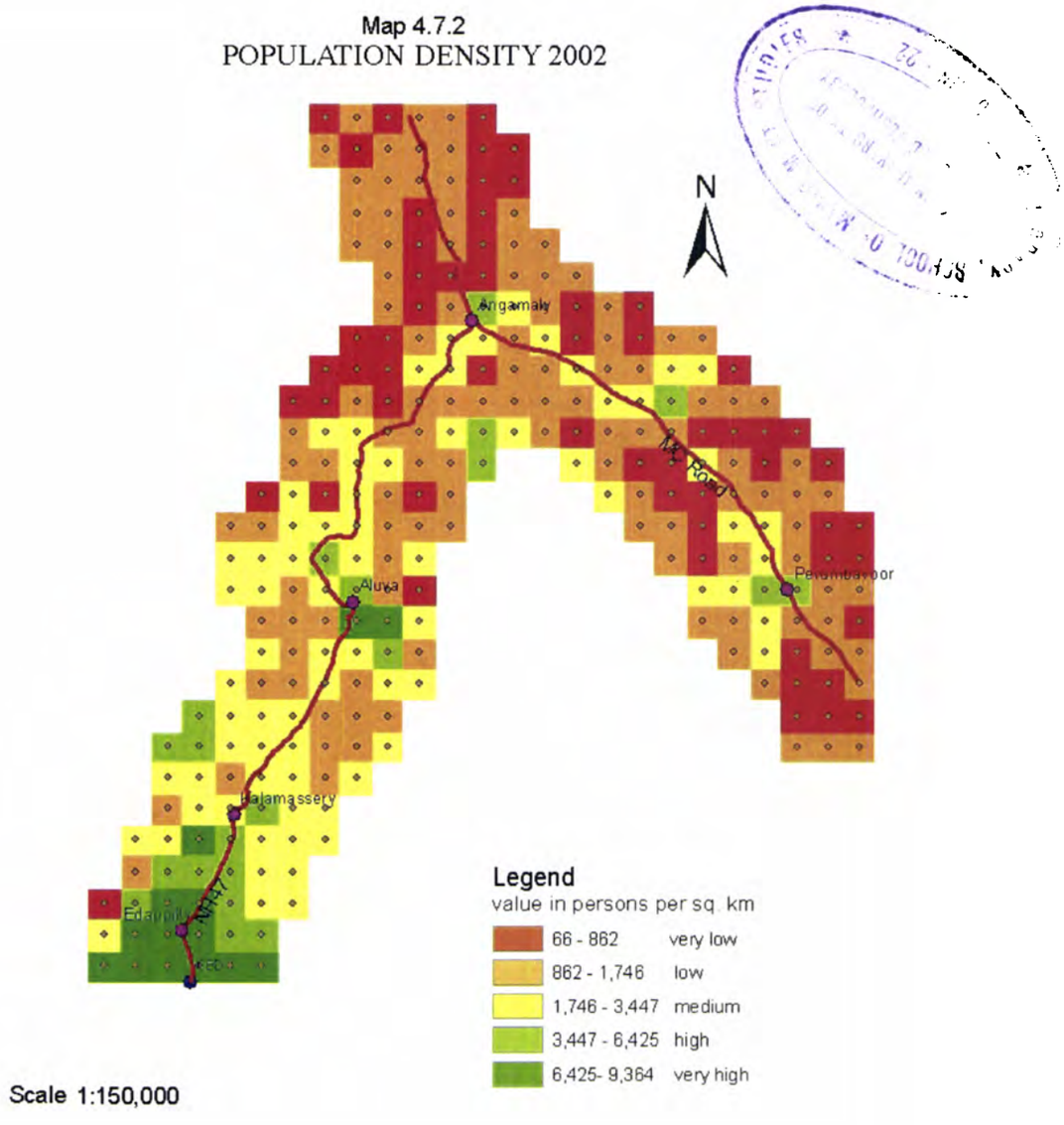

Map 4.6.1
MAP DENSITY 1968
N
Aluva
Perumbavoor
Kalamassery
Edappilli
Legend
value in percentage
High : 59.242100
Low : 0.251700
Scale 1:150,000

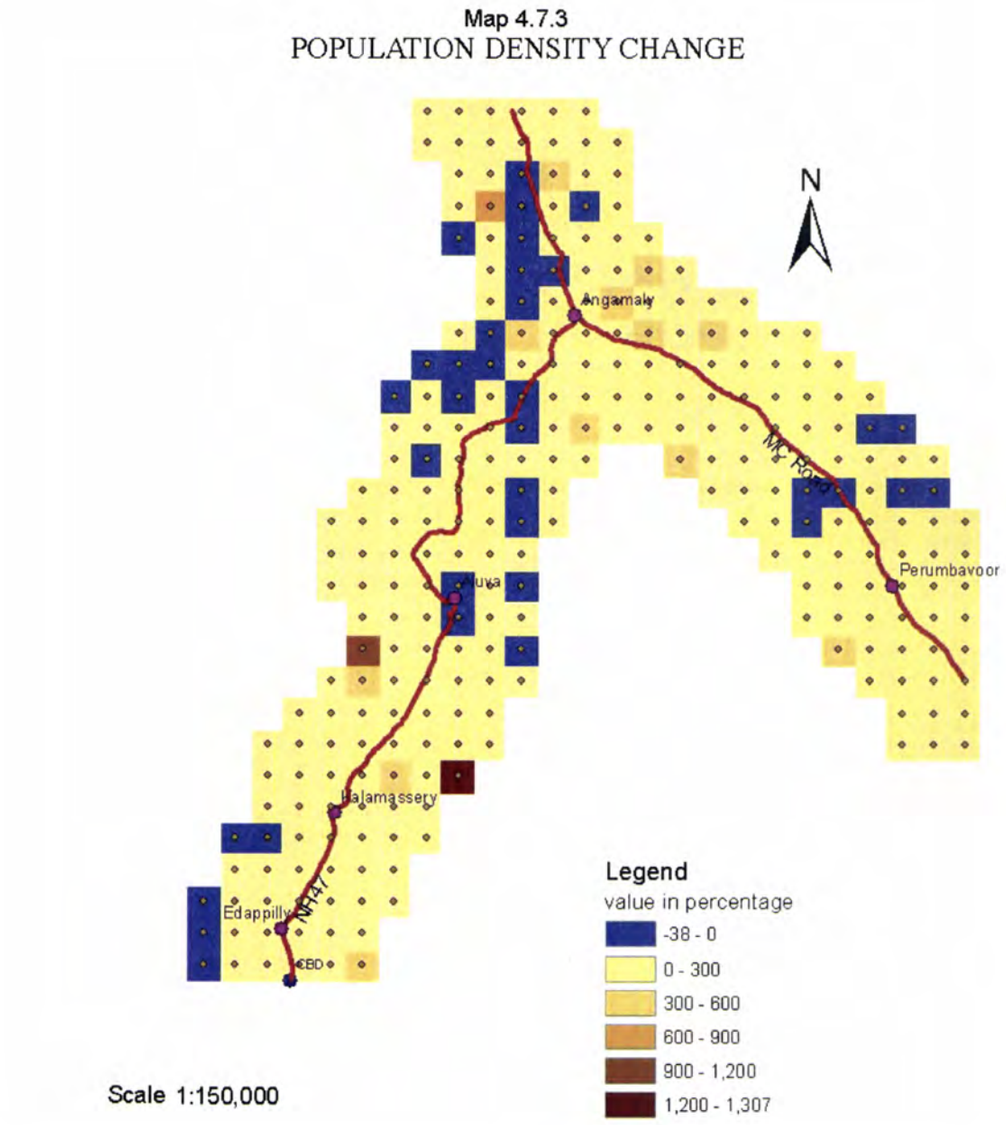

Map 4.6.2
MAP DENSITY 2002
N
Angamaly
M.C. Road
Aluva
Perumbavoor
Edapally
Legend
value in percentage
High : 79.82
Low : 0.68
Scale 1:150,000

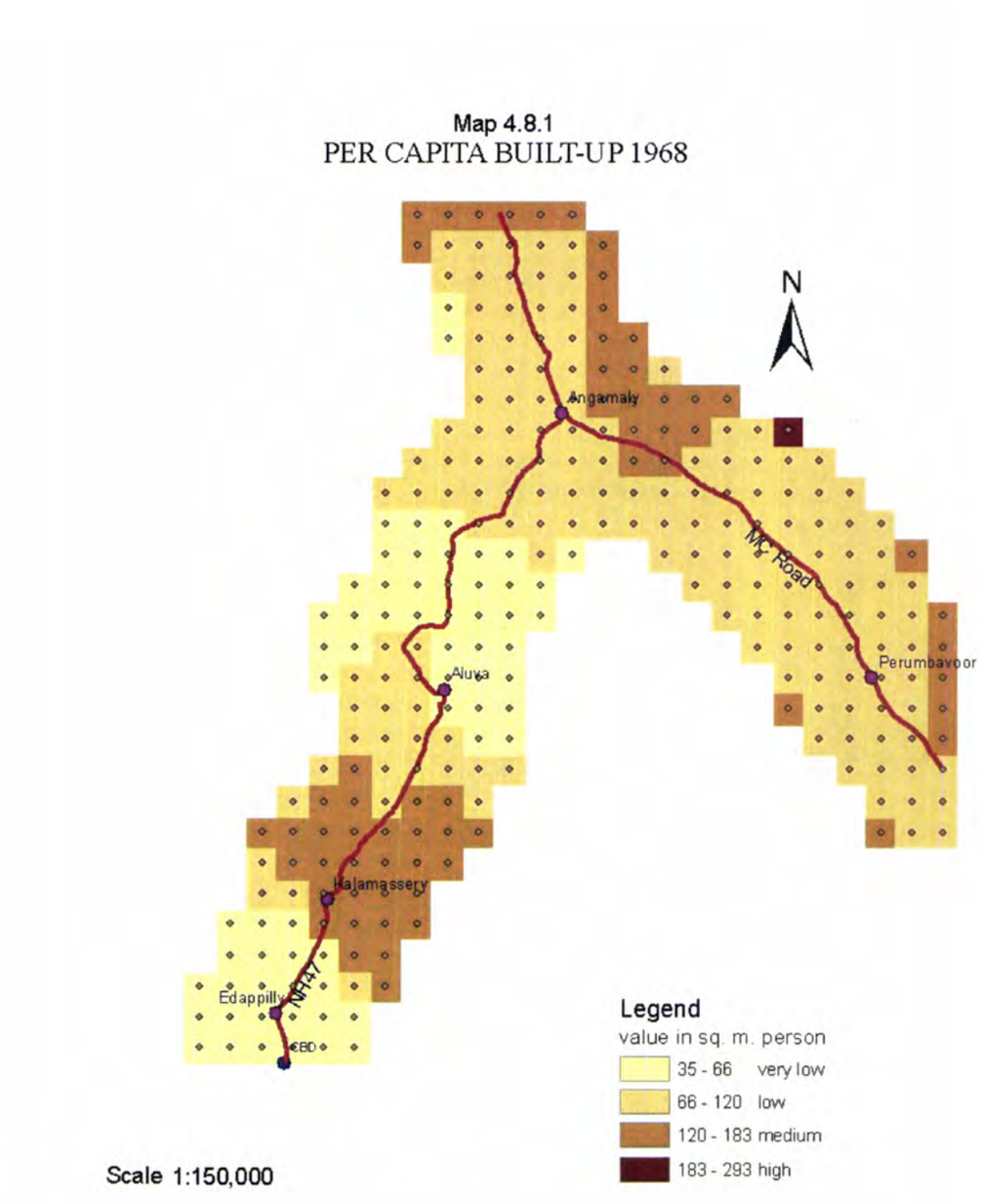
Map 4.6.3
MAP DENSITY CHANGE

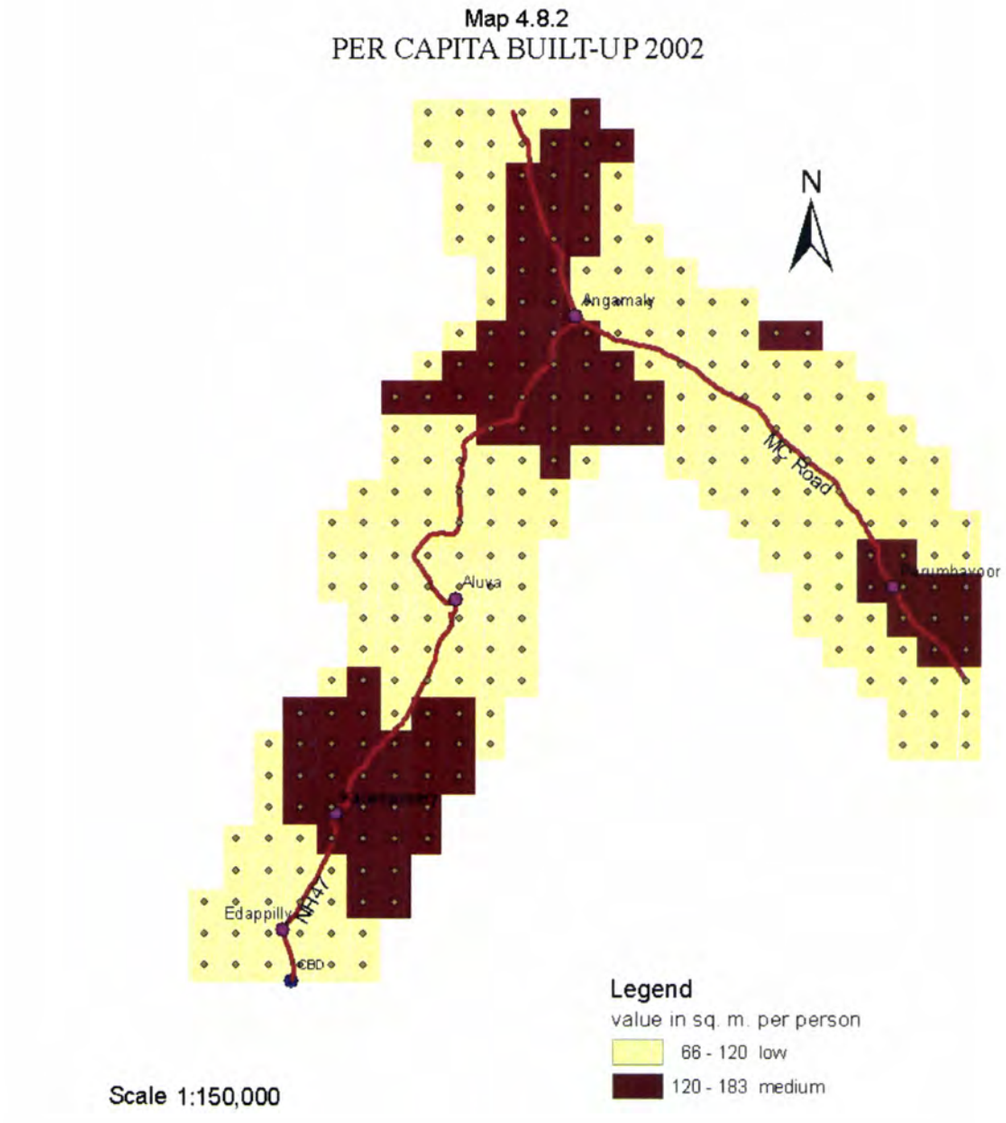


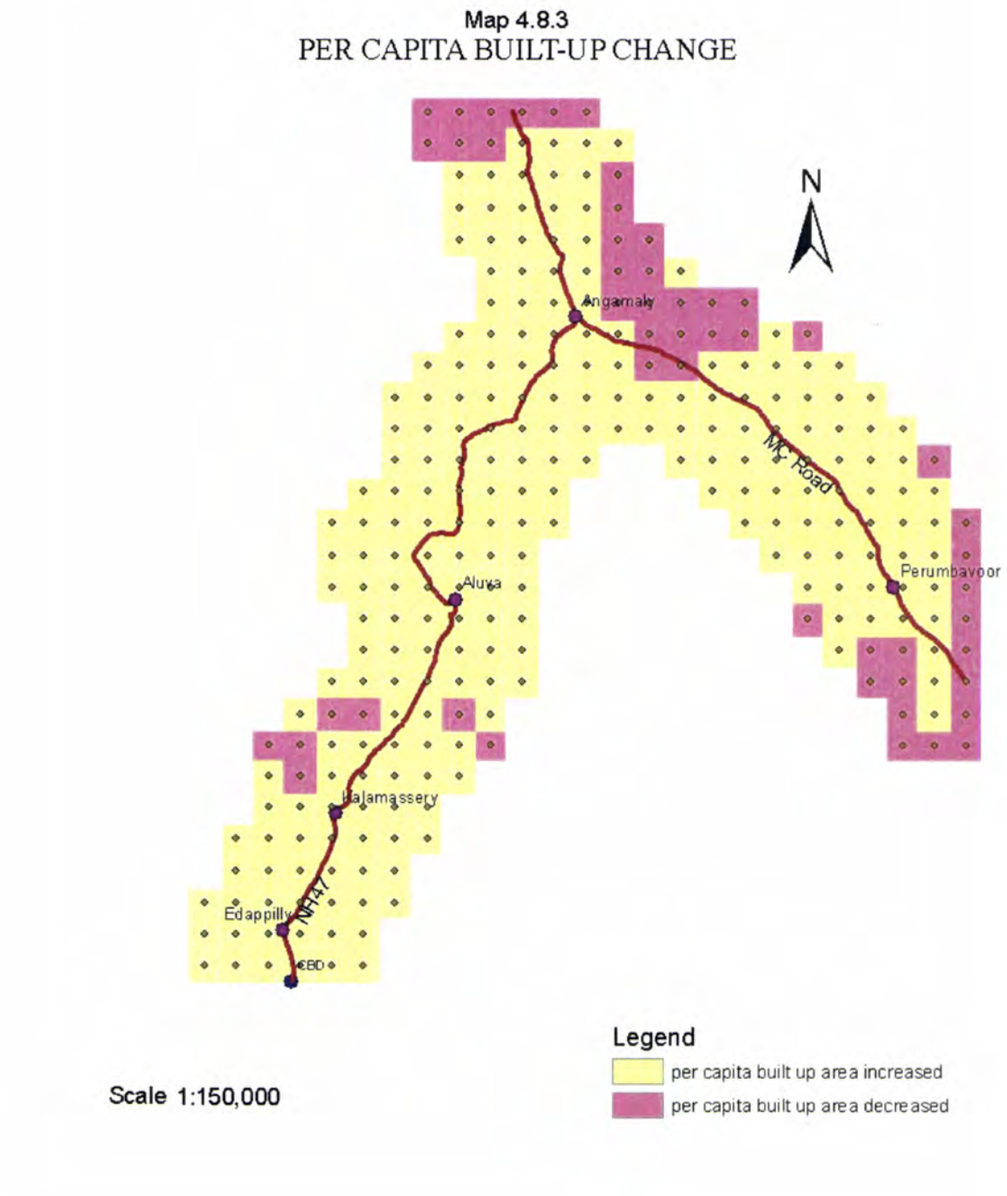

Map 4.7.1
POPULATION DENSITY 1968
N
Angamaly
M.C. Road
Aluva
Perumbavoor
Kalamassery
Edappilly
NH47
CBD
Legend
value in persons per sq. km
29 - 66 very very low
66 - 862 very low
862 - 1,746 low
1,746 - 3,447 medium
3,447 - 6,425 high
6,425- 9,364 very high
9,364 - 11,850 very very high
Scale 1:150,000


Map 4.7.2
POPULATION DENSITY 2002
N
Angamaly
M.C. Road
Aluva
Perumbavoor
Kalamassery
Edapally
NH47
Legend
value in persons per sq. km
66 - 862 very low
862 - 1,746 low
1,746 - 3,447 medium
3,447 - 6,425 high
6,425- 9,364 very high
Scale 1:150,000


Map 4.7.3
POPULATION DENSITY CHANGE
N
Angamaly
Perumbavoor
Aluva
Kalamassery
Edappilly
NH47
CBD
Legend
value in percentage
-38 - 0
0 - 300
300 - 600
600 - 900
900 - 1,200
1,200 - 1,307
Scale 1:150,000


Map 4.8.1
PER CAPITA BUILT-UP 1968
N
Angamaly
Aluva
Kalamassery
Edappilly
CBD
NH47
MC Road
Perumbavoor
Legend
value in sq. m. person
35 - 66 very low
66 - 120 low
120 - 183 medium
183 - 293 high
Scale 1:150,000


Map 4.8.2
PER CAPITA BUILT-UP 2002
N
Angamaly
Aluva
Edappilly
NH47
CBD
Legend
value in sq. m. per person
66 - 120 low
120 - 183 medium
Scale 1:150,000


Map 4.8.3
PER CAPITA BUILT-UP CHANGE
N
Angamaly
MC Road
Aluva
Perumbavoor
Kalamassery
Edappilly
NH47
CBD
Legend
per capita built up area increased
per capita built up area decreased
Scale 1:150,000

4.5 SHANNON'S ENTROPY ANALYSIS

Shannon's Entropy is calculated to check the urban sprawl and spare capacity (Yeh and Li 2001, Sudhira et al. 2003, S.Sekhar 2005).

Shannon's Entropy is calculated using the following formulae:

$Hn = -\sum P_i * Logpi$

Where Hn = the entropy

Pi= the proportion of the variable in the i^{th} grid

n = the total number of grids

Minimum and the hypothetical value of entropy is zero while the maximum value is Log n. Entropy of built-up area of the MSA is found to be very high which is nearer to Log n.

Entropy results are tabulated as below:

Table 4.2 Entropy Values of the MSA 1968 and 2002

Variable	Entropy 1968 $-\sum pi \ln pi$	Entropy 2002 $-\sum pi \ln pi$	n	Log n
Built -up area	5.401	5.410	281	5.638

Entropy calculations reveal that built-up area distribution is highly dispersed indicating the presence of urban sprawl and spare capacity. The entropy results have become worse between the years 1968 and 2002.

4.6 MULTIPLE REGRESSION ANALYSIS

Multiple Regression Analysis were carried out to model the 1968 and 2002 scenario of the Micro Study Area to check the trend and for any possible intervention on efficiency and sustainability point of view. In the Greater Kochi Micro Study Area there are so many factors which control the occurrence of built-up area.

Traditionally, like any other place in Kerala State, Greater Kochi Micro Study Area is also characterised by its scattered settlement pattern with their agricultural land spread all around the abodes. Water-based transport facility was most often adopted. Subsequently NH 47, Main Central Road (M.C Road) and rail transport have come. Once highways and railways were formed there was a modal shift from boat to buses and trains and the settlements have started occurring near the highways or in places where two highways meet. Goods transportation also had a modal shift from water-based to land-based.

With the available data on the Micro Study Area an attempt has been made to model the 1968 scenario. The Micro Study Area is divided into 281 grids, each one is of 1 km*1 km. The available information is the built-up area which is retrieved from the toposheet of the Survey of India and which is considered as the dependent variable. It is also assumed that the built-up area increases as the distance from municipalities decreases and the distance from road decreases. In 1968 distance from CBD may not be of high relevance. The most important factor which controlled the occurrence of built-up area is the population which is collected from the Census of India 1971 for each local body and converted to grid data of the MSA. Thus for the 1968 scenario

The dependent variable

bu68 (built up area for the year 1968)

Independent variables

pop 68 (population of each grid)

discbd (the distance from CBD)

dispt (the distance from municipalities)

disrd (the distance from highway)

Unlike 1968 there can be a change of trend as seen in the built-up 2002 map. Urban area based on municipalities started sprawling away from the municipalities and the relevance of Central Business District has started gaining momentum.

Thus for 2002 scenario

The dependent variable

bu02 (built up area for the year 2002)

Independent variables

pop 02 (population of each grid)

discbd (the distance from CBD)

dispt (the distance from municipalities)

disrd (the distance from highway)

The regression analysis has been carried out using the data analysis capability of Microsoft Office Excel 2007. Frequency distribution of population is positively skewed. And therefore log transformation of this variable is used for the regression analysis. Regression model with population variable before log transformation had heteroscedastic problem. However, log transformation of population variable addressed this problem. It holds for both 1968 and 2002. Residual plot of population before log transformation and after log transformation for 2002 are as per Chart 4.1 and Chart 4.2.

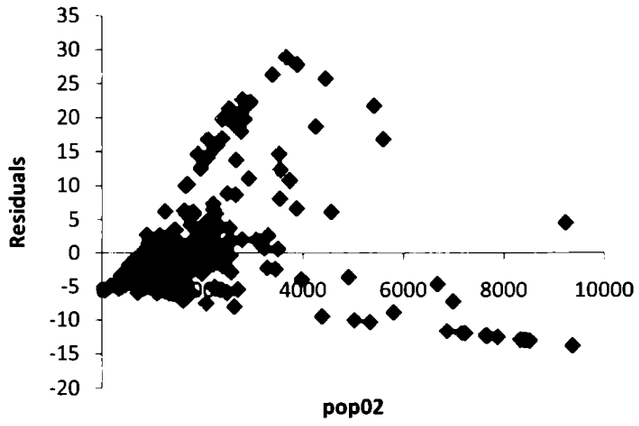


Chart 4.1 Residual Plot—Population 2002

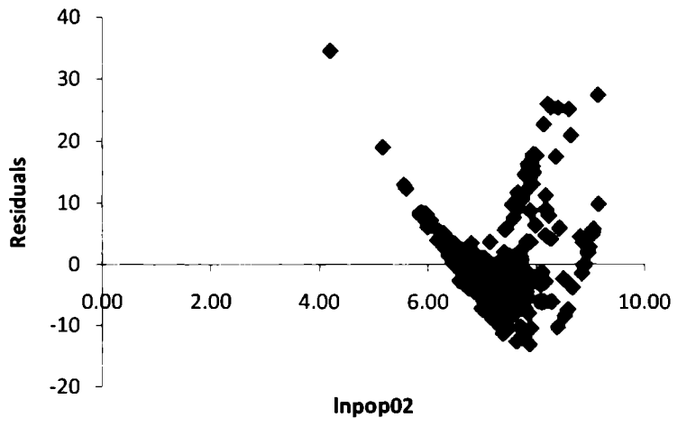


Chart 4.2 Residual Plot— Ln-population 2002

Comparison of the regression results 1968 and 2002

1. Two variable regression analysis gives significant p values for all variables.
2. But inclusion of all independent variables gives p value for two independent variables insignificant results. This reflects the multicollinearity problem.
3. However combining all these gives a better R^2 value and hence all independent variables are included in the final model for 1968 and 2002.

Between 1968 and 2002 the significance of dispt is lost and discbd has gained. This is an indication that the development of Greater Kochi Metropolitan Area has its focus changed from municipality-concentrated to CBD-concentrated. Greater Kochi Metropolitan Area is emerging as a big city focused on CBD.

Summary of regression calculations for 1968 and 2002 are attached as Table 4.3.1 and Table 4.3.2. Map showing the 281 data points are as per Map 4.4.2 and the values of dependent and independent variables are attached as Annexure 4.

1968 model

bu68=-34.6731+6.981579lnpop68-0.03441discbd-0.37763dispts-0.54502disrd

2002 Model

bu02=-78.4362+14.70746lnpop02-0.32722discbd-0.28643dispts-1.06272disrd

Table 4.3.1 Regression Results 1968

Regression Analysis for 1968																		
Dependent variable is BU68																		
Number of observations 281																		
sheet	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	
intercept	-41.4043		17.71504		15.6206		14.03066		-38.4507		-37.2861		-38.9404		-36.188		-34.6731	
std error	2.512078		1.017687		0.995611		1.021648		3.419433		2.915783		2.788203		3.030422		3.718447	
lnpop68	7.56035	***							7.269593	***	7.206041	***	7.377497	***	7.131345	***	6.981579	***
std error	0.367753								0.432709		0.38667		0.377154		0.390366		0.444846	
discbd			-0.45605	***					-0.05713								-0.03441	
std error			0.054052						0.044931								0.048865	
dispts					-1.70325	***					-0.50901	***			-0.4379	**	-0.37763	*
std error					0.265665						0.188672				0.196101		0.214126	
disrd							-2.4002	***					-0.708	**	-0.48085		-0.54502	
std error							0.530472						0.355424		0.36727		0.378729	
R2	0.60236		0.203283		0.12841		0.068361		0.60466		0.612507		0.607957		0.61489		0.615581	
std error	4.940071		8.992637		7.313832		7.561581		4.93462		4.885407		4.914003		4.879144		4.883589	
significance	***99%		**95%		*90%													
1968 model : bu68 = -34.6731 + 6.981579lnpop68-0.03441discbd-0.37763dispts-0.54502disrd																		

Table 4.3.2 Regression Results 2002

Regression Analysis for 2002																		
Dependent variable is BU02																		
Number of observations 281																		
sheet	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**	
intercept	106.9		42.3778		33.588		28.1531		-85.4626		-98.8943		-103.861		-82.9546		-78.4362	
std error	4.415824		1.64066		1.841688		1.955109		6.447937		5.23756		4.832963		6.608072		6.987968	
lnpop02	17.4496	***							15.27666	***	16.7266	***	17.22767	***	15.07584	***	14.70746	***
std error	0.601059								0.760239		0.649048		0.616935		0.767782		0.78802	
discbd			-1.2654	***					-0.32346	***					-0.28839	***	-0.32722	***
std error			0.08714						0.072834						0.0757		0.078027	
dispts					-3.842	***					-0.80785	***			0.48757		-0.28643	
std error					0.491428						0.292196				0.29747		0.314174	
disrd							-4.3441	***					-0.82038				-1.06272	*
std error							1.015155						0.536412				0.555595	
R2	0.751298		0.43047		0.1797		0.06159		0.76773		0.75795		0.753373		0.770004		0.773013	
std error	7.449477		11.27315		13.52918		14.47045		7.21144		7.36233		7.431665		7.189664		7.155407	
significance	***99%		**95%		* 90%													
bu02 = -78.4362 + 14.70746lnpop02 -0.32722discbd -0.28643dispts -1.06272disrd																		

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Chapter 5

DEVELOPMENT-PREFERENCE TOWARDS ENVIRONMENTAL EFFICIENCY

Contents

5.1 PROXY VARIABLES OF ENVIRONMENTAL EFFICIENCY

As already explained the study area has been divided into 281 zones of 1km*1km grid. In Chapter 2 most logically it is derived that HD/EFp is the most comprehensive and highly exhaustive efficiency indicator. There are clear-cut methodologies formulated by various agencies of the United Nations (UNDP, WWF and UN Habitat) to calculate the human development index (HDI), ecological footprint (EFp) and city domestic product. The HD/EFp of different nations, states and districts can be calculated by direct method. The quantification of the efficiency index HD/EFp at sub-district level may not be direct, unless it is supported by exclusive primary survey and dedicated agencies to work for the same. Hence in this thesis environmental efficiency index is calculated using proxy variables derived from the concept of HD/EFp based on the available and affordable information.

Proxy variables identified / used for the local HD/EFp calculations are:

1) Human Development-prone Facilities and Land Utility Index, μ

Human development achievement in any city or metropolitan area is a direct derivative of the human development-prone facilities. Human development-prone facilities include all the activities which directly or indirectly contribute the wellness, knowledge and productivity (per capita income) of the society. Human development-prone facilities in higher order cities are always more than the second order cities like Greater Kochi.

Concept of Land Utility Index **μ**

Public ownership of building land is potentially the most powerful tool for sustainable development (Jones in Jenks et al 2000, page 49). Suppose there is a parcel of land, it is assumed that the utility of the land depends on the number of owners/ beneficiaries of the land. The percentage of government land and the land occupied by the common facilities in each grid are common properties and the

beneficiaries can be as big as the population of the city. Also in the case of common areas of gated-communities and apartments, land utility is multiplied by the increase in the number of owners/occupants as facilities provided in the land are used by many.

Land utility of a particular grid $= \sum \mathbf{p_i x_i}$ where

$\mathbf{p_i}$ is the proportion of the i^{th} parcel of land with respect to the grid area

$\mathbf{x_i}$ is the weight given depending on the number of owners/beneficiaries of that parcel of land on the logic that more number of people will be benefitted towards human development.

Land utility index, $\boldsymbol{\mu}$ is the land utility of the grid divided by the minimum land utility of all the grids.

Due to the lack of supporting data, land utility of all the grids are assumed as same and hence value of one is given for land utility index $\boldsymbol{\mu}$ for all the grids.

2) Accessibility Index, α

Accessibility is a highly decisive factor of environmental efficiency index HD/EFp. Whatever may be the human development-prone facilities in the city/metropolitan area, unless it is accessible to the majority of the population, the facilities do not contribute substantially to the human development. In transport planning process evaluation of 'trip length' and 'trip time' directly indicates the level of accessibility.

In this thesis accessibility $\boldsymbol{\alpha}$ index is calculated for each grid with the available and reliable information of the study area. Distance from municipalities (dispts), distance from CBD (discbd) and distance from highway (disrd) determine

the accessibility level of a particular grid. Hence accessibility index α is calculated as below:

$\alpha = \alpha_{cbd} + 2\alpha_{pt} + \alpha_{rd}$ where

$\alpha_{cbd} = 1\text{-discbd/discbd}_{max}$

$\alpha_{pt} = 1\text{-dispt/dispt}_{max}$

$\alpha_{rd} = 1\text{-disrd/disrd}_{max}$

The accessibility index to municipalities α_{pt} is given a weight of two on the principles of sustainability and to modify the urban form to 'polycentric structure' (Burgess in Jenks et al, 2000, page 21) rather than a monocentric structure—for which more fossil fuel is to be burnt for transportation apart from loss of productive man hours for journey.

Square Function of Accessibility Index α in the HD/EFp Calculations

In the efficiency calculation based on HD/EFp concept, when the accessibility index increases human development increases. But when the accessibility index increases ecological footprint reduces owing to less fuel charges for transportation. People will have tendencies to walk, cycle or to use public transport. Hence α^2 is used in the HD/EFp calculations.

3. Per Capita Built-up β

In the ecological footprint calculations if per capita built-up area is high EFp is considered high and if per capita built-up area is less EFp is considered less. More per capita built-up area results in a less HD/EFp index and efficiency.

4. Disturbance Factor δ and Productivity-Multiplier 1/1+δ

The Living Planet Report of WWF 2008 in the Chapter 'Managing Biocapacity, an Eco system Approach' advocates for sound environmental management for landuse change on the consideration of sound externalities and spillovers as 'ecosystems don't obey the rules of private property'(MA 2005). Fragmented landuse changes often affect adversely the ecosystem services to be rendered including its productivity (Bhargav 2007).

Disturbance **δ** factor is calculated on the logically-derived assumption that when 1km*1km vector grid is undisturbed with built-up area, primary sector productivity will be the maximum as original ecosystem will be undisturbed. Ecosystem can be agriculture, forest or aquatic.

When the percentage built-up in the grid increases in an arithmetic way the productivity of primary activities reduces in a geometric way and the primary activity gets eliminated at a particular stage. Urban activities start gaining momentum due to compactness and economies of scale. There will be multiplying effect on the productivity after that. The productivity-multiplier value is calculated as **1/1+δ.** The conceptual sketch for the above explanation is given in Chart 5.1. Based on the above logically-supported conceptual sketch, fuzzy values for disturbance **δ** factor is assigned as per Table 5.1.

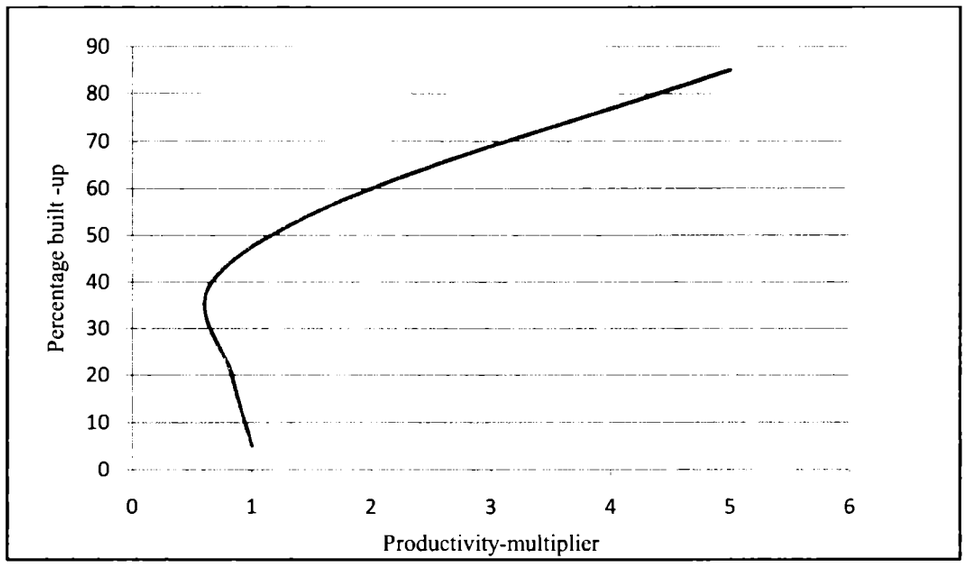


Chart 5.1 Built-up and Productivity Conceptual Relationship

Table 5.1

Built-up and Disturbance Factor

Built-up %	Productivity-Multiplier 1/1+δ	1+δ	Disturbance δ Factor
0-10	1	1	0
10-30	0.83	1.2	0.2
30-50	0.67	1.5	0.5
50-70	2	0.5	-0.5
70-100	5	0.2	-0.8

When the disturbance increases $1+\delta$ increases and productivity-multiplier value $1/1-\delta$ reduces which causes reduction in HD EFp till a particular stage. When urban activities dominate disturbance δ factor becomes minus and productivity-multiplier value increases. This means that it starts contributing towards

HD/EFp through multiplying increase in productivity through secondary and tertiary activities.

HD/EFp of the study area

Using all the above proxy indicators HD/EFp of a particular grid in the Micro Study Area is as per the following equation:

$$I_e = \mu\alpha^2/\beta(1+\delta),$$ where

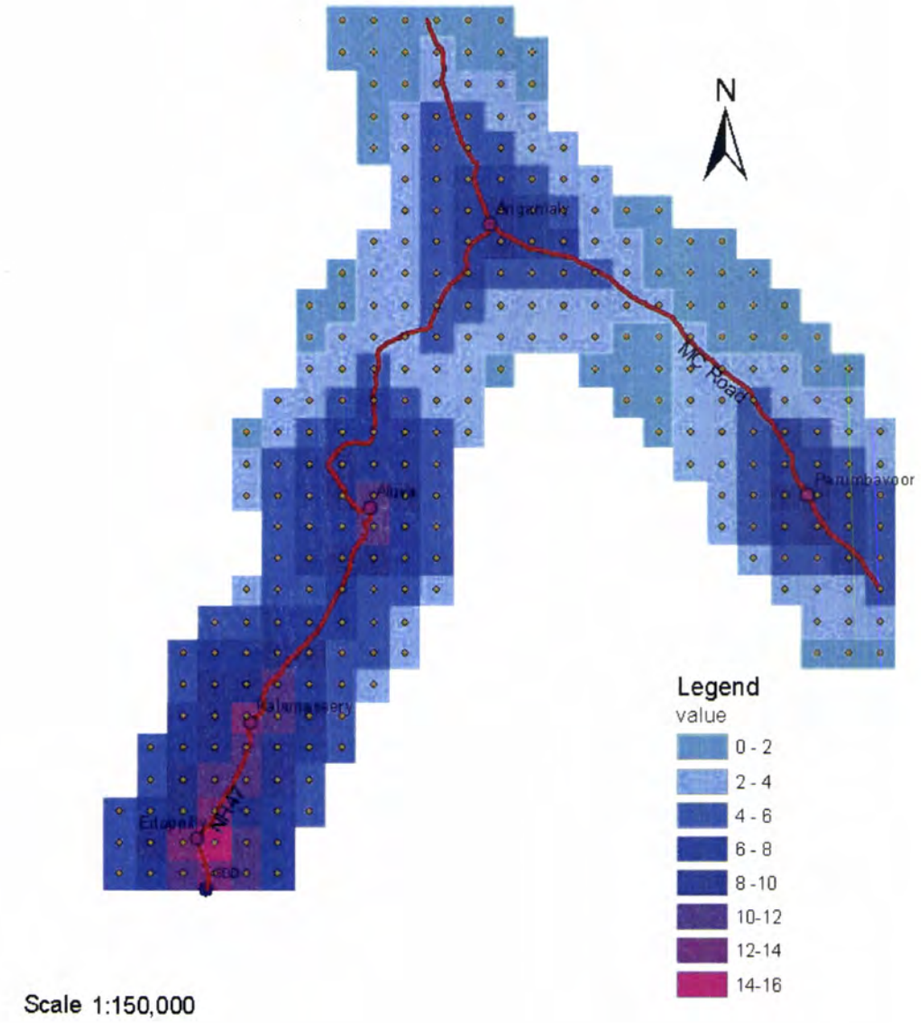
μ is the land utility index of the grid

α is the accessibility index of the grid

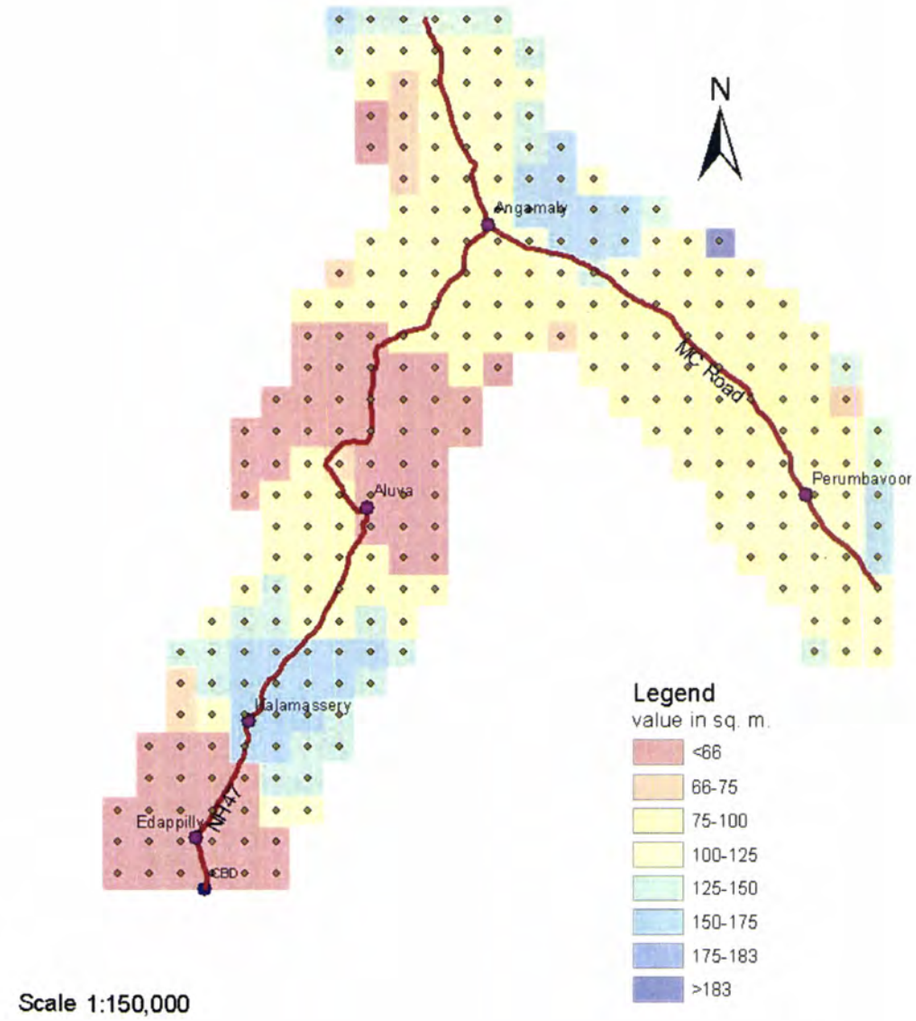
β is the per capita built-up area of the grid

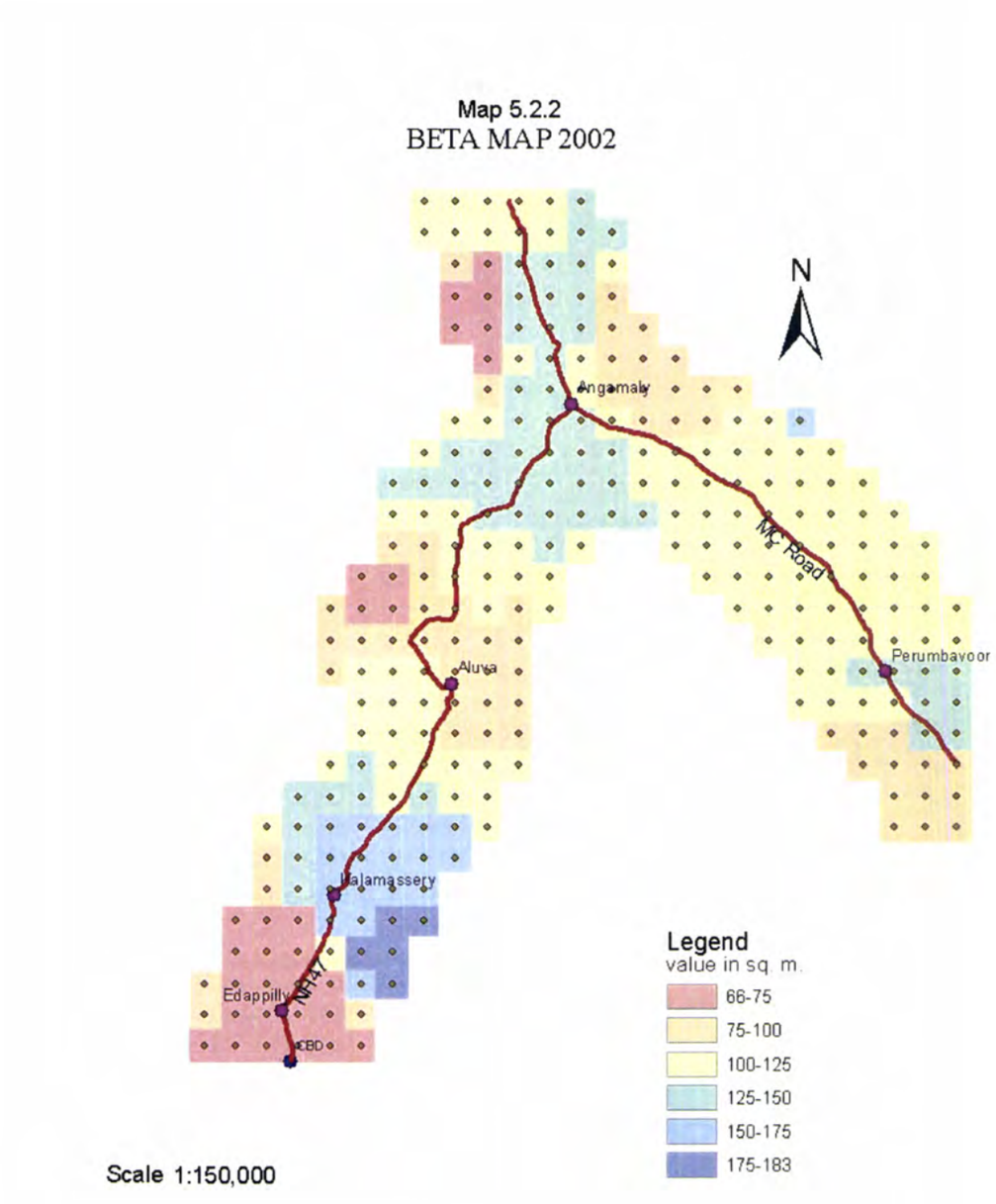
δ is the disturbance factor of the grid

Map 5.1
ALPHA SQUARE MAP

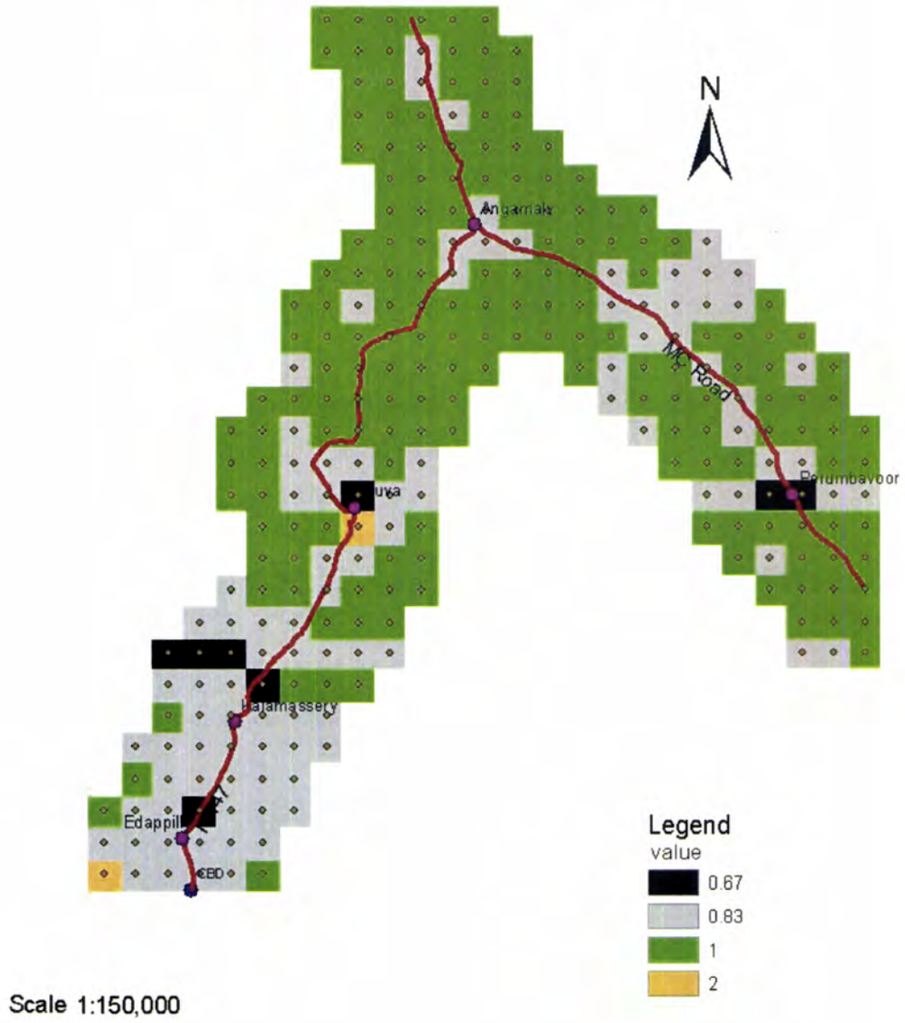


Map 5.2.1
BETA MAP 1968

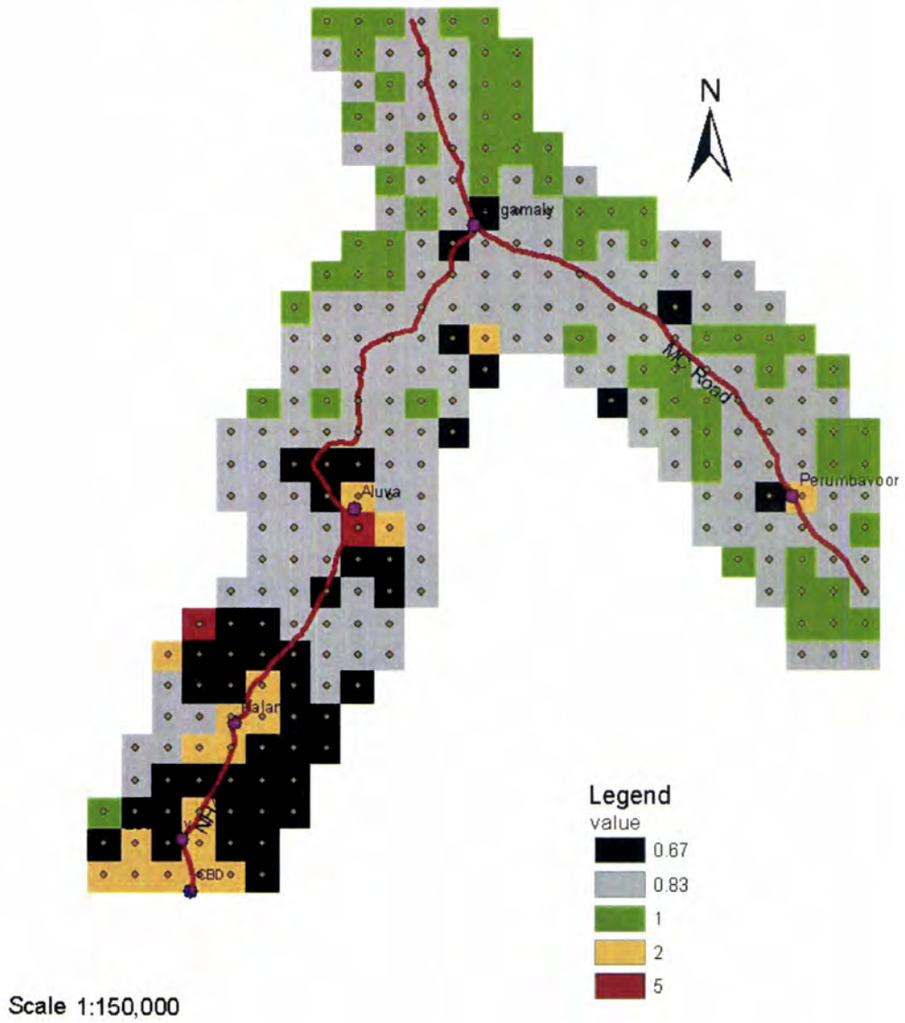



Map 5.2.2
BETA MAP 2002
N
Angamaly
MC Road
Perumbavoor
Aluva
Kalamassery
Edappilly
NH47
CBD
Legend
value in sq. m.
66-75
75-100
100-125
125-150
150-175
175-183
Scale 1:150,000

Map 5.3.1
PRODUCTIVITY- MULTIPLIER 1968 MAP



Map 5.3.2
PRODUCTIVITY- MULTIPLIER 2002 MAP



Alpha Square Map, Beta Map and Productivity-Multiplier Map for the years 1968 and 2002 for the Micro Study Area are as per Maps 5.1, 5.2.1, 5.2.2 , 5.3.1 and 5.3.2. The frequency distribution charts of values of the above Maps are as per Charts 5.2, 5.3.1, 5.3.2, 5.4.1 and 5.4.2

Alpha Square Map

Referring the Alpha Square Map, it is seen that the maximum value is 14.6, while the minimum value is 1.6785. Alpha Square Map is divided into 8 classes as below:

Value	Count
0-2	53
2-4	82
4-6	65
6-8	43
8-10	23
10-12	10
12-14	4
14-16	1

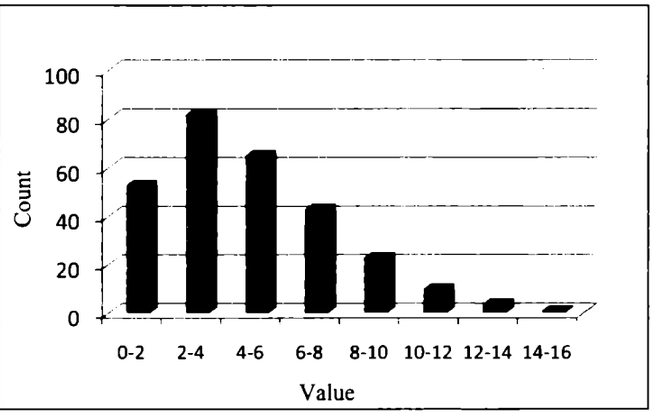


Chart 5.2 Frequency Distribution of Alpha Square Values

Beta 1968 Map

Referring the Beta 1968 map, it is seen that maximum per capita built- up value is 292.48 sq.m. while minimum is 35.10 sq.m

Value (sq. m.)	Count
<66	64
66-75	10
75-100	105
100-125	44
125-150	29
150-175	28
175-183	0
>183	1

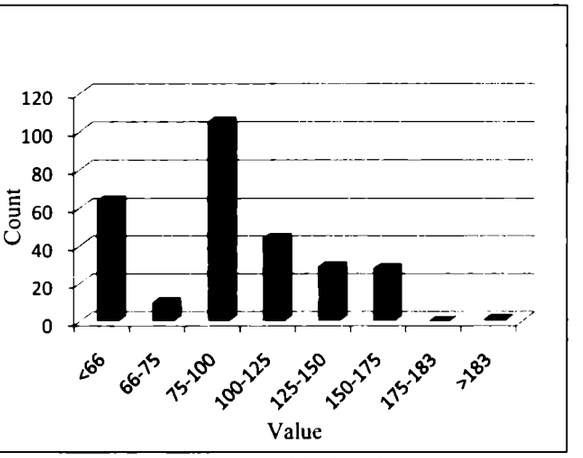


Chart 5.3.1 Frequency Distribution of Beta 1968 values

Beta 2002 Map

Referring the Beta 2002 Map, it is seen that the maximum per capita beta value is 182.6 sq.m. the while minimum value is 66.74 sq.m.. Values are divided into six classes as below:

Value (sq. m.)	Count
66-75	53
75-100	82
100-125	65
125-150	43
150-175	23
175-183	10

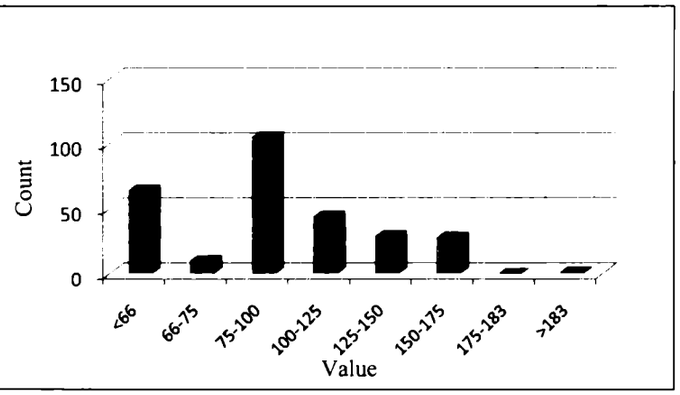


Chart 5.3.2 Frequency Distribution of Beta 2002 values

Productivity-Multiplier 1968 Map

When δ is the disturbance factor $1/1+\delta$ is considered as the productivity-multiplier.

Value	Count
0.67	8
0.83	96
1	175
2	2

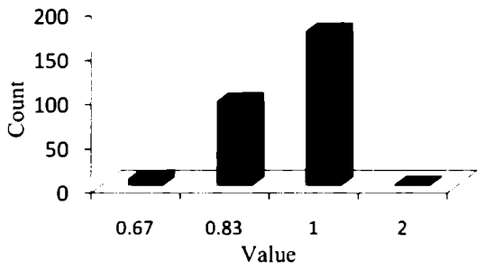


Chart 5.4.1 Frequency Distribution of Productivity-Multiplier Values 1968

Productivity-Multiplier 2002 Map

Value	Count
0.67	46
0.83	153
1	62
2	18
5	2

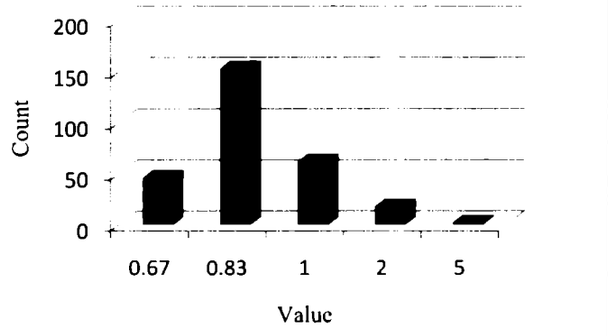


Chart 5.4.2 Frequency Distribution of Productivity-Multiplier Values 2002

Frequency distribution of the productivity-multiplier values depicts the low productivity scenario of majority of the vector grids and the situation has become bad to worse from 1968 to 2002. In 1968 there were 104 grids which were having productivity-multiplier value less than 1. In 2002 it increased to 199. In 1968 there were 175 grids which were having productivity-multiplier value 1, while in 2002 there were only 62 grids. However, in 1968 there were only two grids having enhanced productivity-multiplier value while in 20 grids are having enhanced productivity-multiplier value in 2002.

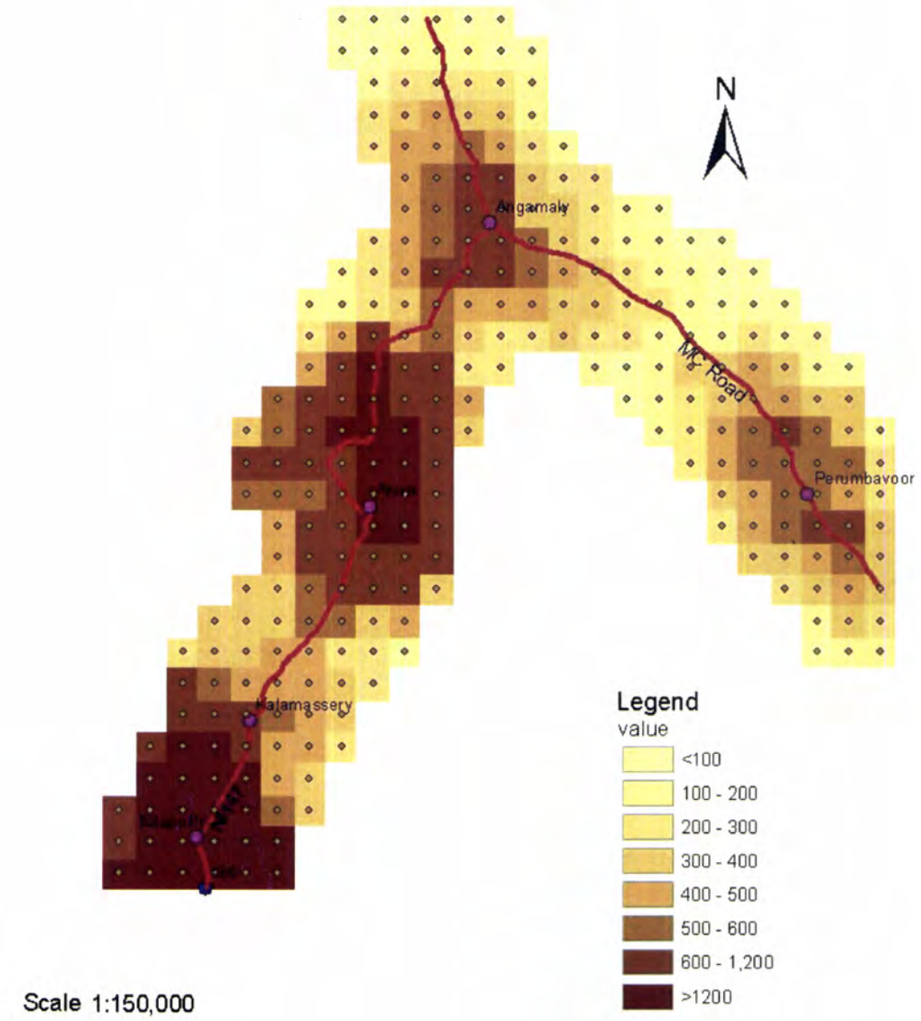
5.2 THE EFFICIENCY MAPS 1968 AND 2002

Efficiency maps for the years 1968 and 2002 are prepared using the equation formulated with the proxy variables,

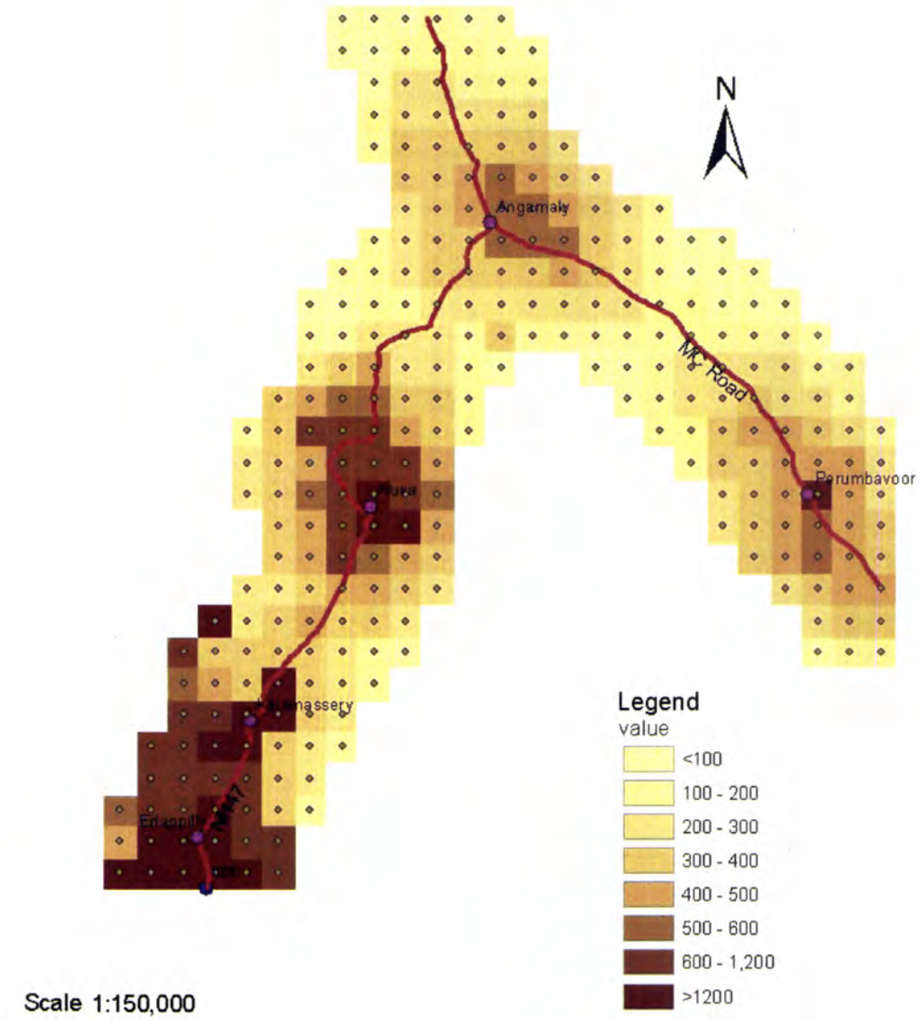
Environmental efficiency Index , $\mathbf{I}_e = \mu\alpha^2/\beta(1+\delta)$

The efficiency maps prepared are as per Maps 5.4.1 and 5.4.2 and Charts 5.5.1 and 5.5.2.

Map 5.4.1
EFFICIENCY MAP 1968



Map 5.4.2
EFFICIENCY MAP 2002



Efficiency Values 1968

Value	Count
0-100	29
100-200	51
200-300	57
300-400	56
400-500	28
500-600	17
600-1200	27
1200-6000	16

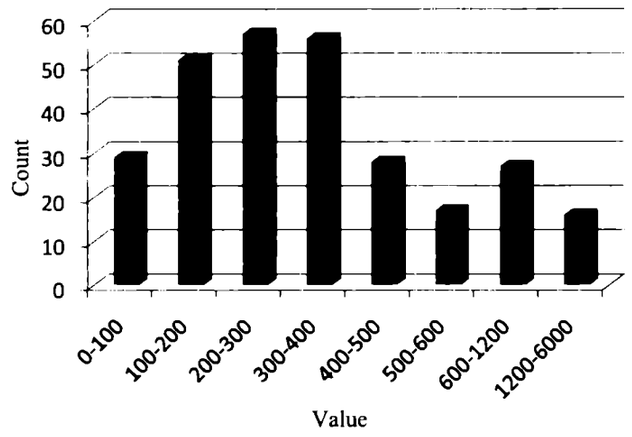


Chart 5.5.1 Frequency Distribution of Efficiency Values 1968

Efficiency Values 2002

Value	Count
<100	26
100-200	51
200-300	55
300-400	58
400-500	32
500-600	15
600-1200	25
>1200	19

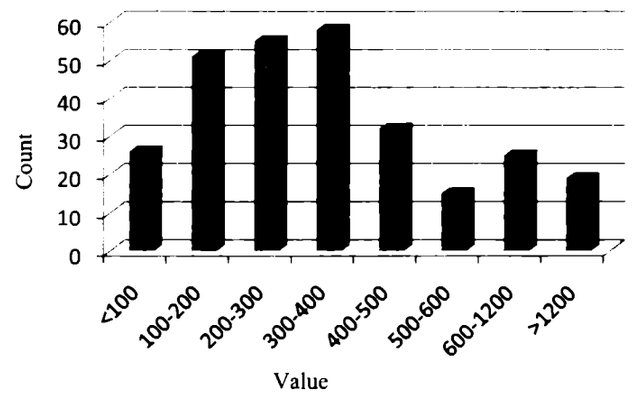


Chart 5.5.2 Frequency Distribution of Efficiency Values 2002

Total efficiency of all 281 grids are calculated for the year 1968 and 2002

Total efficiency = $\sum \mu\alpha^2/\beta(1+\delta)$

Efficiency of the individual grids 281 numbers are summed up to get the total efficiency for the years 1968 and 2002. The results are as follows:

Total efficiency 1968=156281.825

Total efficiency 2002=133224.741

This means that the overall efficiency of the Micro Study Area is reduced between the years 1968 and 2002.

5.3 EFFICIENCY PROJECTION 2021, BUSINESS AS USUAL SCENARIO

Projected Population Allocation

Population projection figures for the year 2021 is directly taken from the 'Spatial Development Plan for Ernakulam District' prepared and available in the district office of the Department of Town and Country Planning, Government of Kerala. Local body-wise population projection figures are taken from the document and local body-wise population figures are arrived at for the Micro Study Area, by taking the population proportionately, depending on the shape area of the local body (part or full) in the Micro Study Area. These population figures are summed up to get the total projected population of the Micro Study Area for the year 2021. This total population is redistributed to all the 281 grids as per the proportion of the population for the year 2002. Thus the population figures for the year 2021 are arrived at for all the 281 grids.

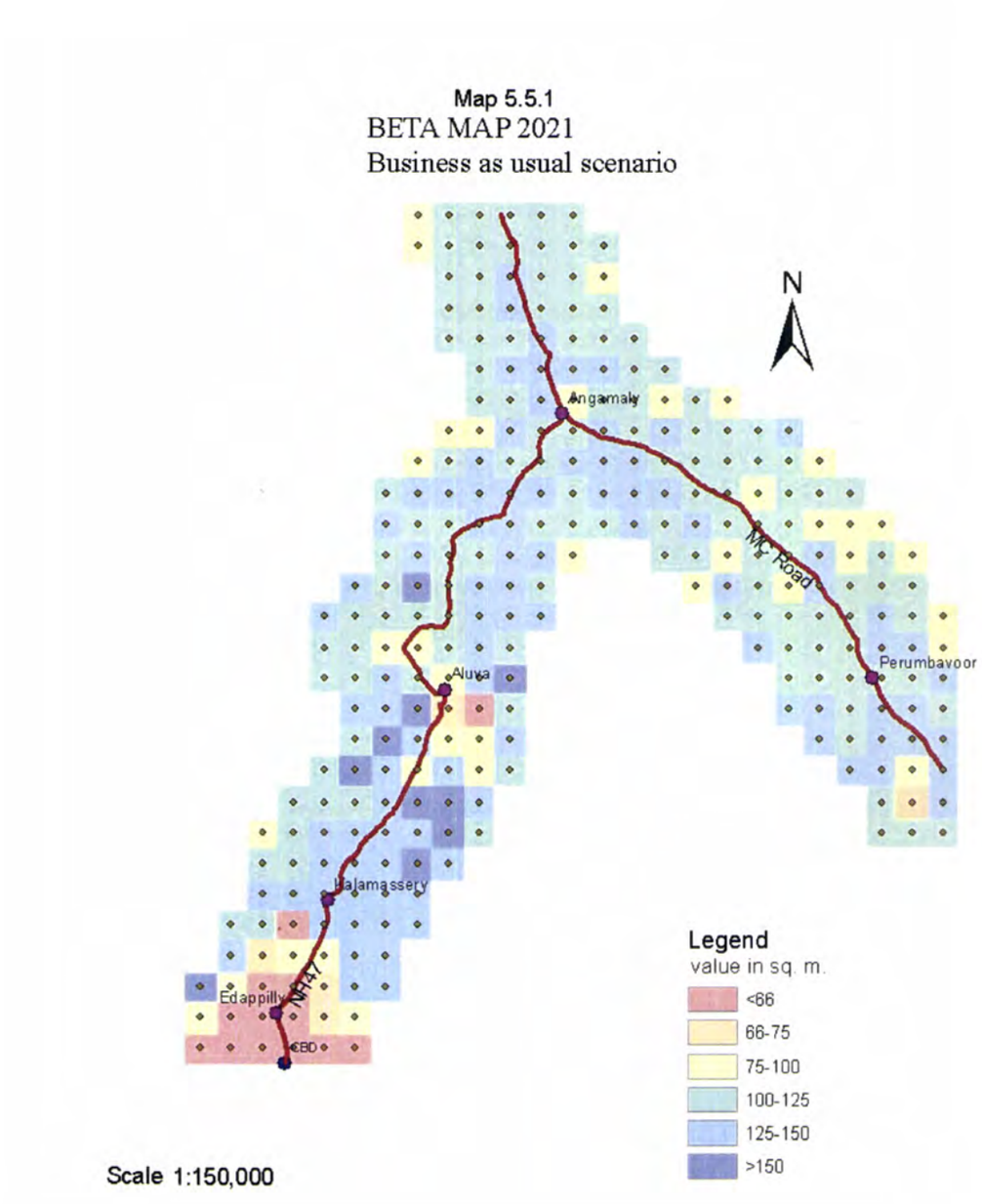
Predicted built-up area 2021_{BAU}

The grid-wise population figures are then substituted in the equation for the built-up area 2002 (2002 regression model) and thus the hypothetical built-up area distribution for the year 2021 is arrived at. Perusing the built-up area 2021 values it is noticed that the predicted built-up area for the year 2021 is reduced for certain

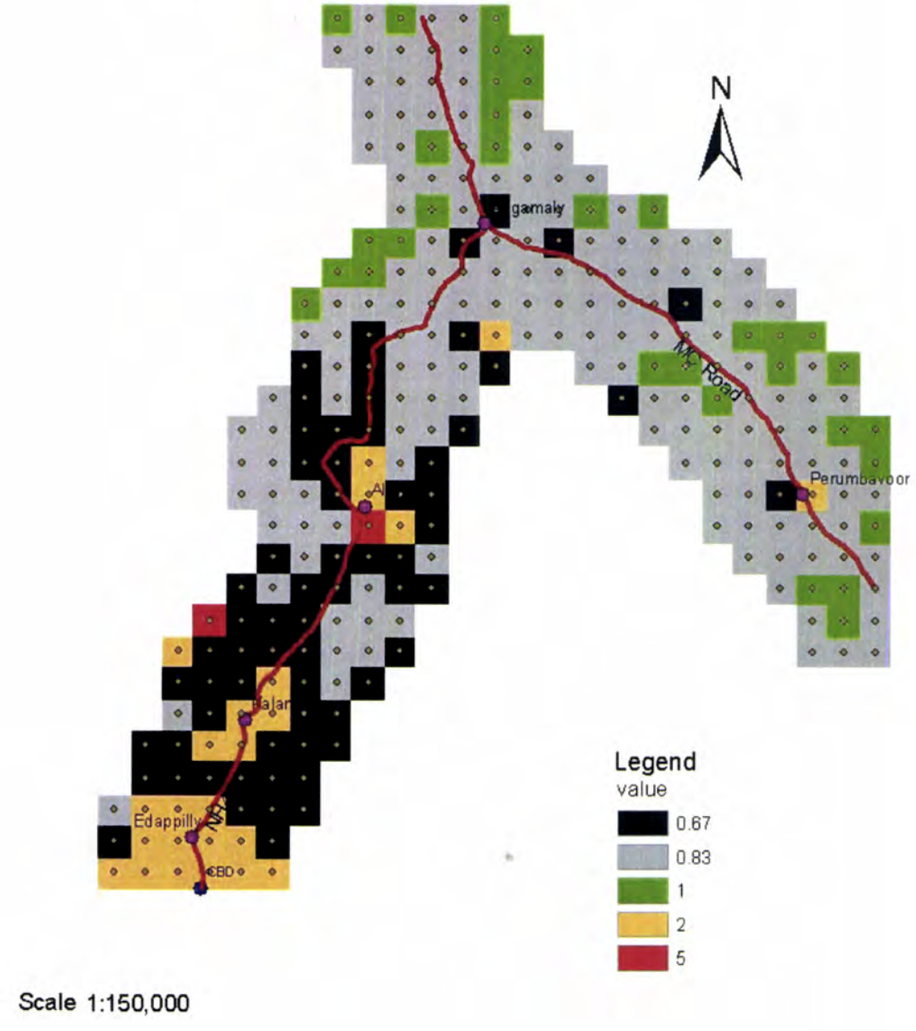
grids. In some grids it has gone minus. Both cases are quite unrealistic and hence for those grids built-up area 2002 are taken for the year 2021 also.

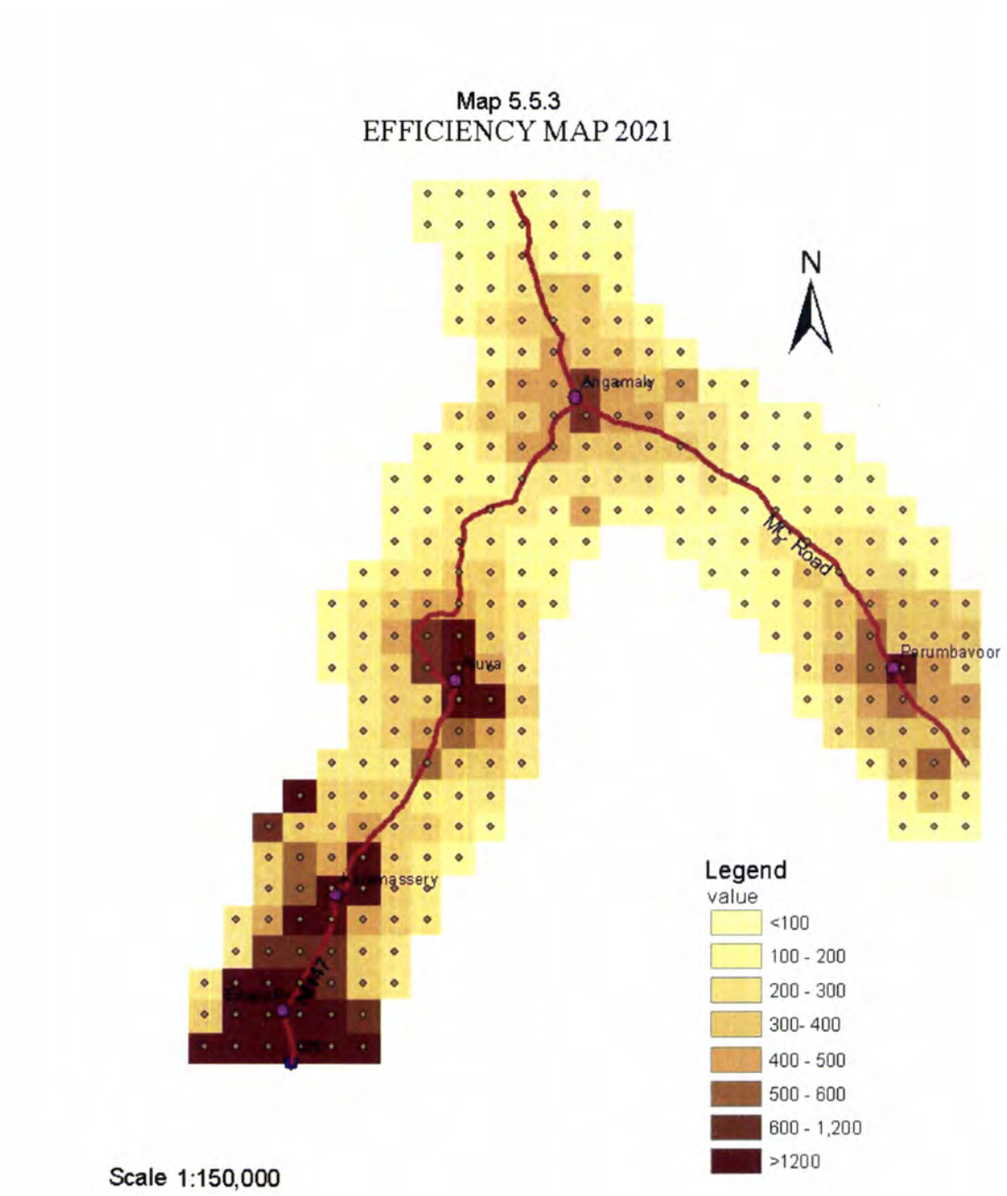
For the year 2021, beta map and productivity-multiplier map are prepared. They are as per Maps 5.5.1 and 5.5.2. Alpha square map is assumed as same for the year 2021 also. Efficiency values for the business as usual scenario for the year 2021 is calculated for the individual grids by substituting in the formula as below:

$$I_e = \mu\alpha^2/\beta(1+\delta)$$


Map 5.5.1
BETA MAP 2021
Business as usual scenario
N
Angamaly
MC Road
Perumbavoor
Aluva
Kalamassery
Edappilly
NH47
CBD
Legend
value in sq. m.
<66
66-75
75-100
100-125
125-150
>150
Scale 1:150,000

Map 5.5.2
PRODUCTIVITY MULTIPLIER 2021 MAP
Business as usual scenario




Map 5.5.3
EFFICIENCY MAP 2021
N
Angamaly
MC Road
Perumbavoor
Legend
value
<100
100 - 200
200 - 300
300- 400
400 - 500
500 - 600
600 - 1,200
>1200
Scale 1:150,000

Efficiency Map for 2021 is prepared as per Map 5.5.3 and frequency distribution is as per Chart 5.6 below.

Efficiency Values 2021_{BAU}	
Value	**Count**
<100	30
100-200	61
200-300	66
300-400	55
400-500	27
500-600	8
600-1200	10
>1200	24

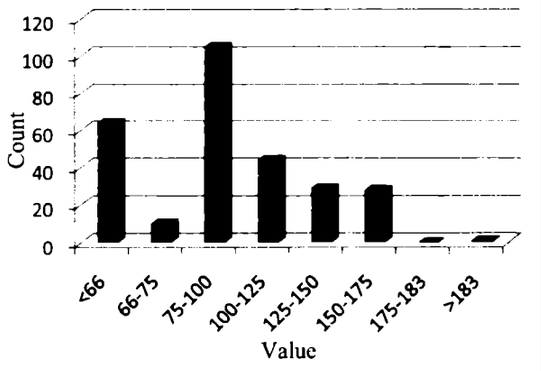


Chart 5.6 Frequency Distribution of Efficiency Values 2021_{BAU}

Total Efficiency 1968, 2002 and 2021_{BAU}

Total efficiency for 2021 business as usual scenario is worked out as 142692.281466 which is slightly greater than 2002 scenario. However, total efficiency for the year 2021 is a lesser value than the 1968 scenario (Chart 5.7).

eff_1968	eff_2002	eff_2021_{BAU}
156281.825	133224.741	142692.2815

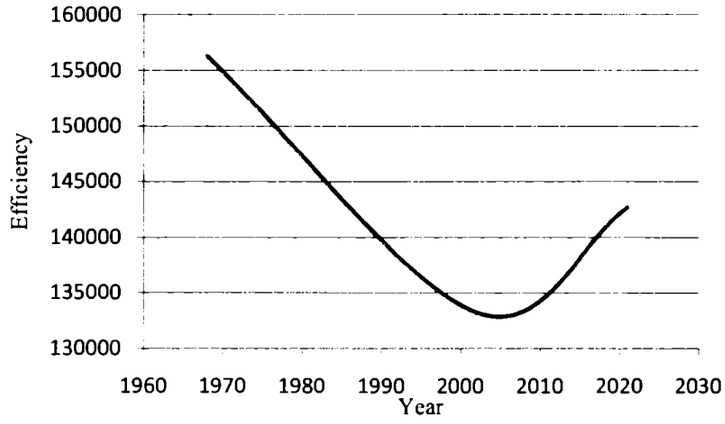


Chart 5.7 Total Efficiency 1968, 2002 & 2021 BAU

Efficiency value of low efficiency grids can be improved

1. By increasing the land utility by encouraging the common land ownership
2. By increasing the accessibility by providing good roads with efficient mode of transportation
3. By decreasing the per capita built-up area by providing planned, compact high density with compatible mixed landuse
4. By encouraging development where map density is high to increase the productivity-multiplier value $1/1+\delta$
5. By carrying out bulk development so that disturbance δ factor is minus and thus productivity- multiplier value is high.

Environmentally-efficient development management system is arrived at by formulating Development Preference Map. Two hundred and eighty one grids of the study area based on the year 2002 development trends have been assigned numbers indicative of the type of grid and the development preference maps are arrived at. Grids are numbered 100 series, 200 series and 300 series.

5.4 DEVELOPMENT PREFERENCE—100, 200 AND 300 SERIES MAPS

100 Series Map

For the year 2002 scenario the grids which are having productivity-multiplier value less than one is selected and ranked according to the accessibility index value. It is found that there are 199 grids which are having productivity-multiplier value less than one. This means that those grids are underperforming and the productivity is less than the original agricultural/primary productivity. Those grids are bundled in multiples of 10 according to the alpha square rank and are assigned numbers 101 to 120. Map showing the 199 underperforming grids is prepared which is known as 100

Series Map (Map 5.6.1). 100 series grids are given first development preference as efficiency attainment will be more. This is due to the multiplying increase of productivity-multiplier value as disturbance will be reversed (as proposed percentage built-up is 70-100 range).

200 Series Map

For the year 2002 scenario the grids which are having enhanced productivity-multiplier value is selected and ranked according to the availability of vacant land. Grids are classified as 201 and 202. For an environmentally-efficient development management system those grids are given second preference which comes only after all the 100 series grids are full. As 200 Series grids are mostly at core areas transport infrastructure up-gradation is to be carried out to accommodate high density population in 100 Series grids, effecting in urban renewal of those grids (Map 5.6.2).

300 Series Map

For the year 2002 scenario the grids which are having productivity-multiplier value 1 is selected and ranked from 301 to 306 according to the alpha square values. 300 series grids must be preserved for primary sector activities (Map 5.6.3). Combining 100, 200 and 300 series grids total development preference map is prepared (Map 5.6.4).

Population Allocation

From Table 5.2 it is seen that the total population of all the 100 series grids of 2002 is only 3,87,223. The minimum per capita built-up area of 2002 scenario is 0.006674 hectares.

Table 5.2

Population Allocation Table for 100 Series Map

β=0.006674 hectares**					
Grid No	**Numbers**	**Spare land in hectares***	**Population 2002**	**Total Population infill development**	**Total Population redevelopment**
101	10	395	45416	104600	144705
102	10	409	28300	89583	142360
103	10	471	22917	93490	134173
104	10	484	26720	99239	148945
105	10	567	22992	107948	146494
106	10	602	16307	106507	146267
107	10	533	19576	99439	144439
108	10	556	18606	101913	144266
109	10	480	19161	91080	133499
110	10	632	13435	108132	148944
111	10	627	15706	109651	147725
112	10	601	14814	104864	144539
113	10	609	16576	107826	149443
114	10	587	17105	105059	149840
115	10	648	14204	111295	149484
116	10	585	16546	104200	142337
117	10	564	14571	99079	135319
118	10	581	17166	104220	144429
119	10	599	14524	104274	139466
120	9	479	12581	84353	116536
Total	199	11009	387223	2036752	2853210
* 80% of the land only is considered for population allocation.					
**per capita built-up β is assumed as β_{min} of 2002 scenario.					

hectares. Assuming this per capita built-up for the future population allocation 20 lakhs people can be allocated in the 100 series grids if the spare land only is utilised (infill development). If total redevelopment is proposed in the 100 Series grids about

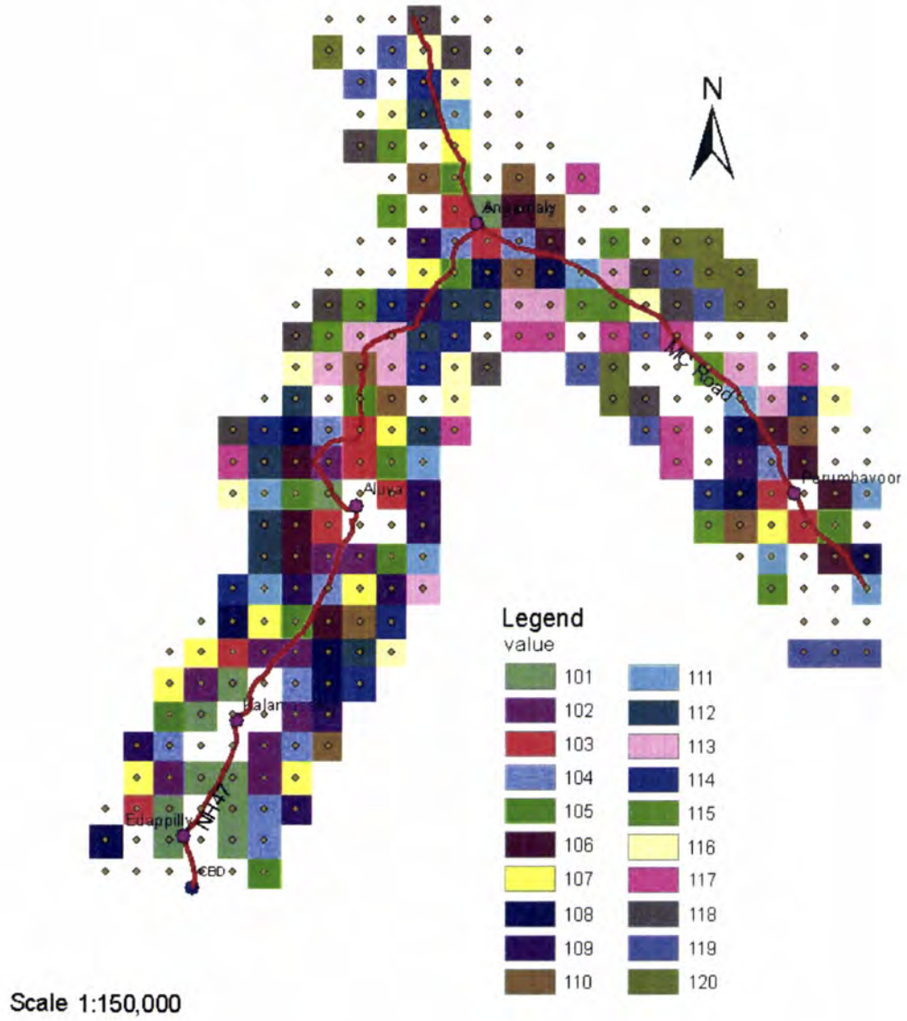
28.5 lakhs people can be accommodated in the underperforming 100 Series grids. There will be multiplying effect on the efficiency value due to the enhanced productivity-multiplier value as disturbance is reversed and starts contributing to efficiency.

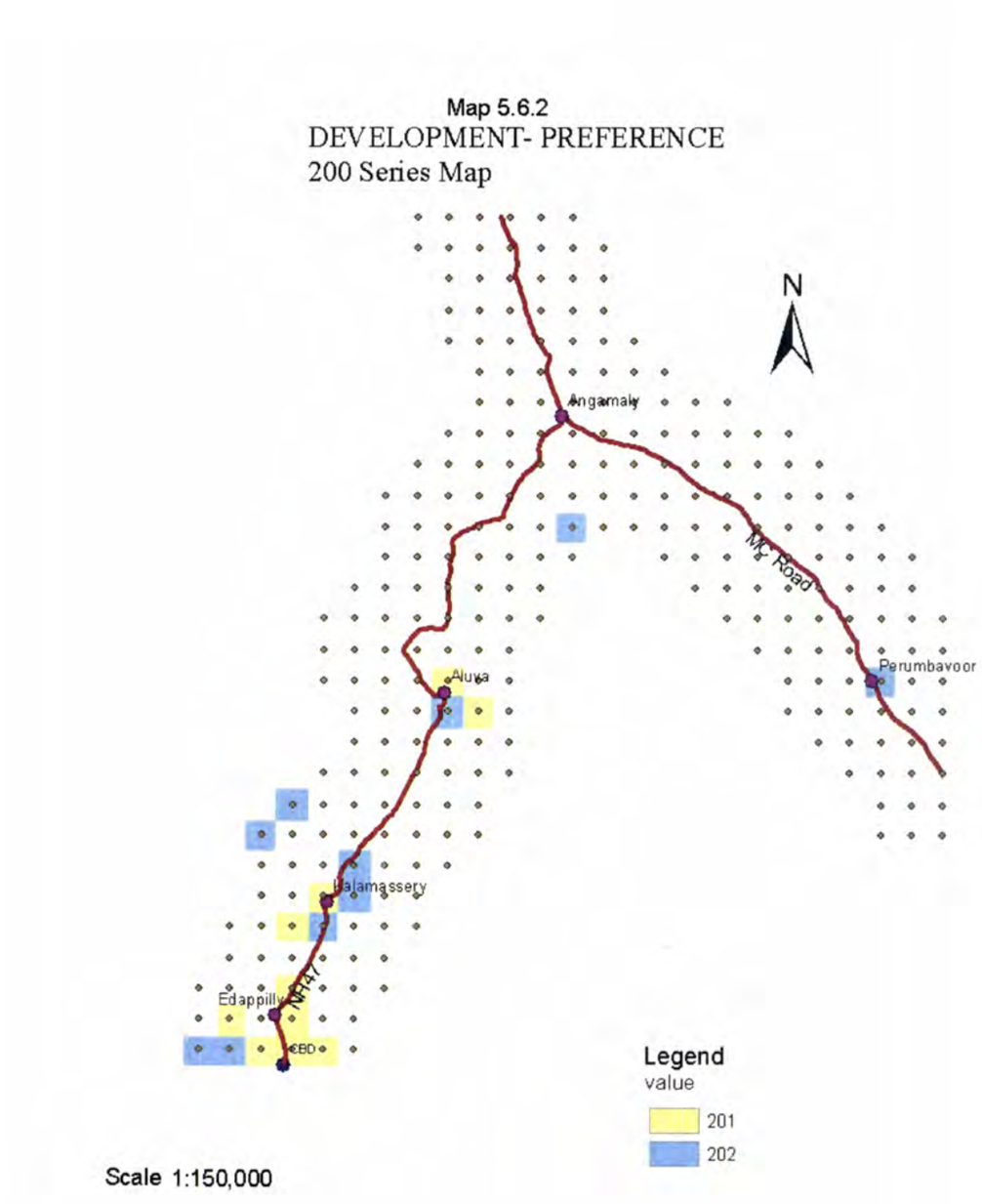
When the efficiencies of the grids are more overall efficiency of the city will be high, so that there will be pull factors towards Greater Kochi Metropolitan Area and people from other districts, states and nation will start putting up ventures as profitability will be more. Thousands of agriculture, forestland and wetland of the nation/globe can be saved apart from the savings on thousands of tons of fossil fuel.

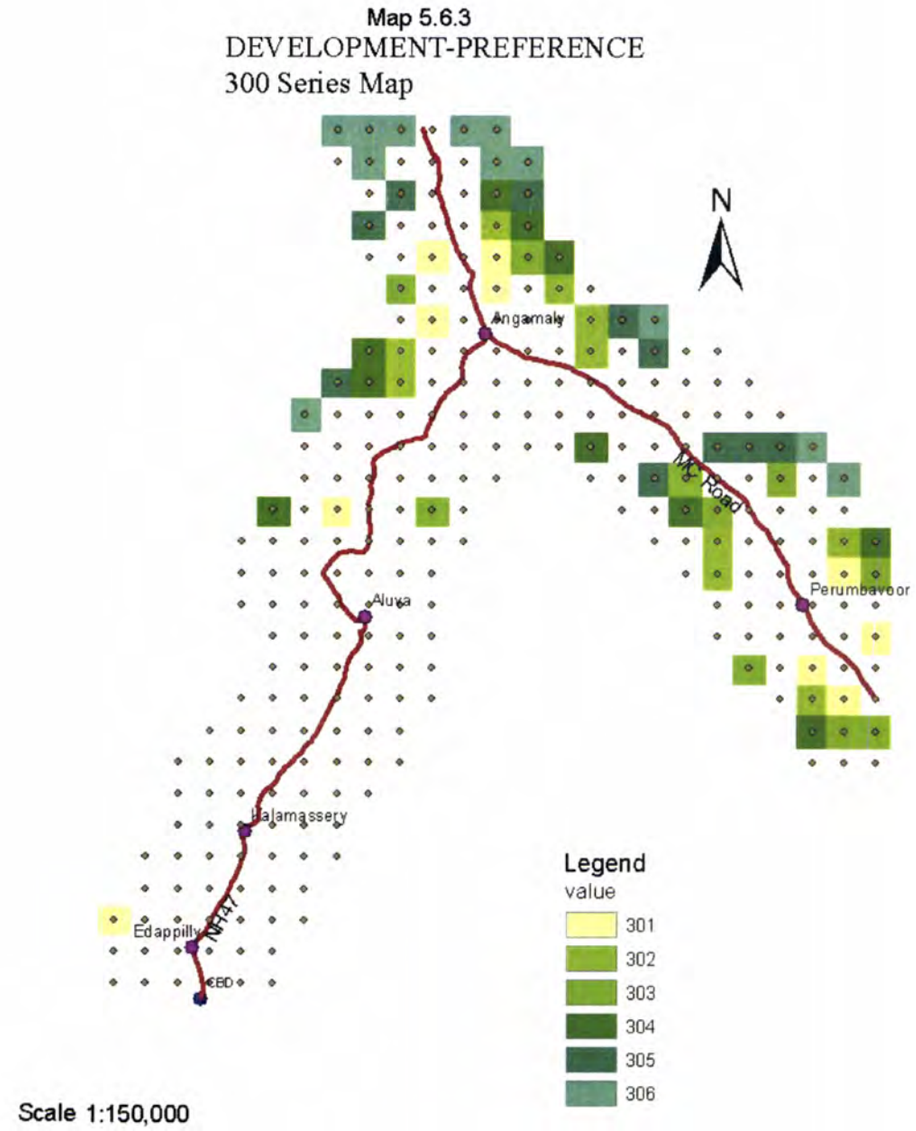
Per capita Built-up β on Efficiency$_{2021}$ Calculations

In the efficiency calculations it is assumed that as per capita built-up decreases the land footprint reduces and the efficiency increases. In Greater Kochi Metropolitan Area the per capita built-up is high due to the traditional scattered horizontal settlement pattern and hence minimum per capita built-up of the grids is taken for future population allocation. For the year 2002, the average per capita built-up area of the Micro Study Area is 112 sq.m., while the minimum per capita built up is 67 sq.m. Strategic approach should be in such a way that per capita built-up should be reduced stage by stage with prudent site planning and applying scientific innovations in vogue without compromising the convenience and comfort of people.

Map 5.6.1
DEVELOPMENT- PREFERENCE
100 Series Map

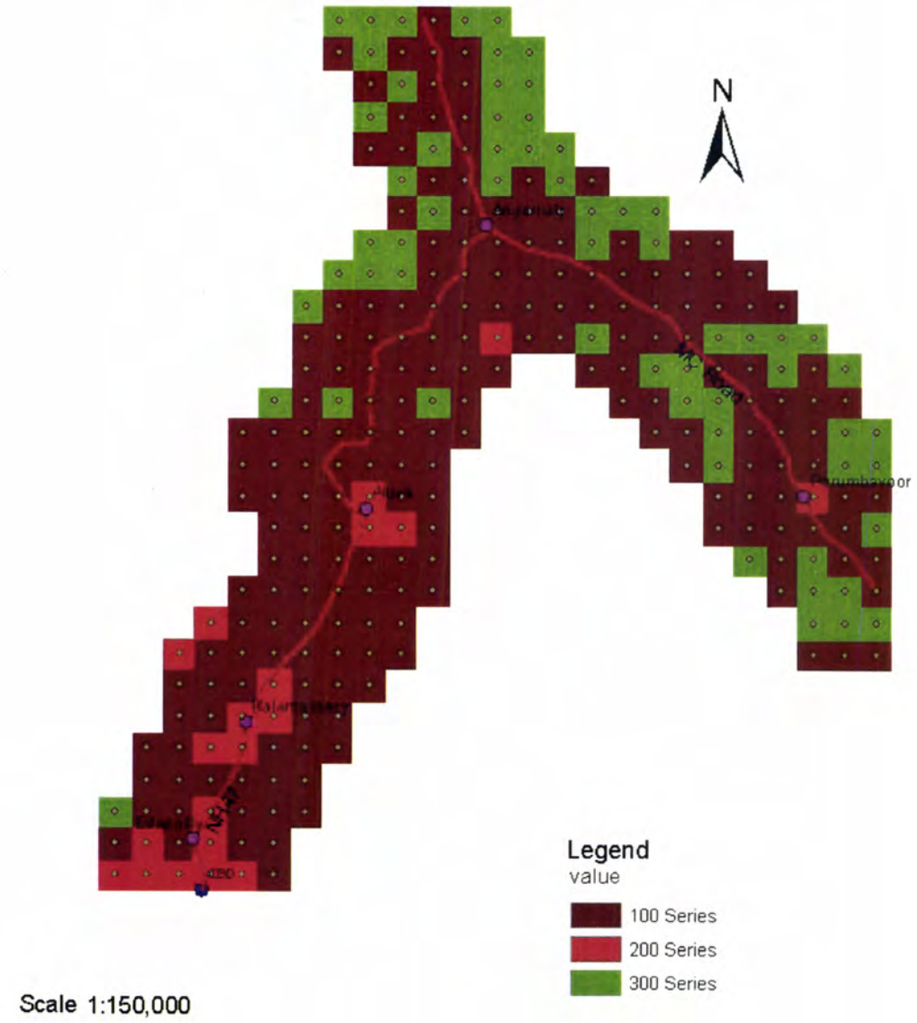



Map 5.6.2
DEVELOPMENT- PREFERENCE
200 Series Map
N
Angamaly
MC Road
Aluva
Perumbavoor
Kalamassery
Edappilly
NH47
CBD
Legend
value
201
202
Scale 1:150,000


Map 5.6.3
DEVELOPMENT-PREFERENCE
300 Series Map
N
Angamaly
MC Road
Aluva
Perumbavoor
Kalamassery
Edappilly
NH47
CBD
Legend
value
301
302
303
304
305
306
Scale 1:150,000

Map 5.6.4

TOTAL DEVELOPMENT-PREFERENCE MAP



5.5 LIMITATIONS OF THE STUDY

1. Due to the lack of supporting data the land utility index, μ is assumed as one. The land utility index is a highly deciding factor of efficiency of each grid.
2. Alpha Square Map is assumed as same for the years 1968, 2002 and 2021. But in actual case for the year 2021, it may not be true as there are chances of high capacity roads coming up in the study area by the year 2021.
3. Local body-wise population details of 1968 and 2002 are approximated as that of 1971 and 2001 of Census of India.
4. Equal weights are given for the proxy indicators for the quantification of environmental efficiency. However extensive research is required to quantify the relative weights to be given for different proxy indicators identified.
5. Built-up data 2002 of the Micro Study Area obtained from the classified LISS III map of National Remote Sensing Agency is having 23.5 m resolution only. Built-up area less than 23.5 m resolution and which have come after 1968 is not taken into account for the calculations.
6. Local body boundaries are taken from the available district maps (raster data) which do not accurately coincide with the natural boundaries in the toposheet.
7. Disturbance factor and productivity-multiplier values are taken from the conceptual diagram formulated based on the theories of 'Ecosystem Approach' mentioned in Living Planet Report 2008 and the concept of 'Urban Containment' (Downs 1994). Extensive research is to be carried out to know the actual relationship between disturbance to the ecosystem and the productivity-multiplier values.
8. Only highways are considered for accessibility and distance from road calculations. However, medium quality roads supported with public transport system contributes more to accessibility than high capacity roads without public transport facilities.

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Chapter· 6

IDEAS, STRATEGIES AND PROGRAMS TOWARDS BETTER ENVIRONMENTAL EFFICIENCY

Contents

6.1 SMART GROWTH INITIATIVES OF THE WEST

The compact high density development with compatible mixed land use can go a long way in getting multiplying effect on the HD/ EFp index which is known under the pet name of 'Smart Growth'. Increased traffic congestion, loss of open space, infrastructure cost, desire for choices, social insecurities all have made 'Smart Growth' an increasingly powerful strategy for building and revitalising communities. Evidence of this trend is everywhere. Cities and towns across the globe are re-examining and changing comprehensive plans, zoning and other building regulations to make smart growth possible (LGC et al. 2003). Many states and localities are creating neighborhoods that offer a variety of transportation options, access to parks and recreation, a wide range of housing types, economic opportunities, lively streets and quiet residential neighborhoods. Ironically many communities pursuing these goals often inadvertently impede their achievements by opposing density, a feature key to smart growth and to the success of so many great places.

Often blamed for more traffic, crime, parking shortages and ugly architecture density faces broad opposition. Objections to density are without basis and it is an asset rather than a liability. But density can backfire if it is not properly designed, which often creates public frustration. A common community response has been to oppose any and all density.

Density creates great places to live by creating walkable communities (LGC et al. 2003) with mixed land use. High density development contributes to the viability of a wide range of businesses in nearby locations. This, in effect, creates walkable communities.

Also high density development supports housing choice and affordability. In contrast to conventional development in which housing tends to be similar in style and size, higher density projects can provide town houses, apartments, accessory

units and even live-work spaces to accommodate a broad range of life styles. Higher density means less land per unit which reduces the site preparation cost, foundation cost, less road per house and less per capita capital cost for water supply, sewage etc. Thus high density development reduces the cost price of the unit dramatically, which ultimately increases the affordability of the buyer and profit of the seller.

Density also expands transportation choices, walking, cycling and even makes mass transit options like bus and rail a viable enterprise as user can avail the facility at an affordable price, while the entrepreneur will be highly profited as more passengers can be collected from the transit points. From all the above it is seen that density improves community's fiscal health as it reduces the energy spent on personalised vehicles, avoids infrastructure duplication and minimises the traffic blocks. All these savings are pocketed as cash, which is shared by the buyer and the seller.

In a region depended on agricultural production compact high density development helps to protect valuable farmland. The protection of farmland in effect protects the forestland as it curbs the invasion of forestland. Thus high density development contributes to environment. Less traffic block and less dependency of personalised vehicles reduce the green house gas emissions. The concentrated development and people within a small geographical area protect the valuable open space, habitats and ecologically sensitive areas. It also helps in minimising water pollution and air pollution.

Density also improves security. The common perception is that density increases criminal activity. This belief disregards the fact that criminals tend to favour desolate rather than busy places (LGC et al. 2003). Density has the potential to increase social interaction and deter crime. The concept sometimes referred to as the 'eyes on the street' reflects the possibility of less chances of emptying out of streets and common areas.

High density compact development can strengthen the tax base of the local governments and reduces the taxload of the residents. As the development is concentrated revenue expenditure on public services can be minimised, while revenue receipts can be maximised. This may be where the shoe pinches[2] for the state and local governments of Kerala State in which revenue expenditure is alarmingly very high, while revenue receipts are very low. The public debt is skyrocketing to an unrecoverable heights and the scattered settlement pattern prevalent in Kerala State may be a very strong reason for the high revenue deficit.

Smart growth neighborhoods with proper land use zoning can ensure cheaper land supply in the city for productive purposes like industries and commerce and contributive purposes like provision of physical and social infrastructure which often leads to economic development and job opportunities.

All the above illustrations depict the high scope for smart growth communities to make the cities livable, by ensuring less 'Ecological Footprint' and high 'Human Development'. Smart growth enables increase in human development due to better accessibility, reduction in fossil fuel consumption due to proximity and mass transport viability. Thus, there will be multiplying effect on the efficiency index HD/EFp.

Mega cities of India are overflowing with population due to migration which often exceeds the capacity of the system to accommodate and is often identified as a sustainability issue. Population concentration beyond the system capacity is also dangerous as it backfires and spoils the entire system by creating frustration, traffic block, congestion, chaos, miseries etc. If smart growth is launched as a national policy and smart growth with infill development and redevelopment are encouraged, it can check the migration of people from other parts of the nation to the mega cities. This can ensure environment, economy and safeguards the aspirations of the people of today and tomorrow.

The need of the hour is the propagation of the concept of smart growth with compatible mixed landuse at the grassroot level to ensure public acceptance, while legislative and policy level initiatives are to be ensured from the top. Smart growth can definitely contribute to more livable cities of tomorrow.

6.2 RETENTION AND DETENSION OF RAIN WATER

Three most important water-related sustainability-issues prevalent in the cities of the developing countries are urban floods, depletion of underground water table and water pollution resulting from urbanisation and industrialisation.

Anywhere in the world increase in paved areas is synonymous with urban development resulting in faster run-off, and percolation to ground is substantially reduced. Also the fast run-off results in carrying of more silt leading to siltation of canals and drains. Increase in run-off combined with reduced discharge capacity of drains leads to urban floods for a long time after heavy downpours. Urban flooding creates very unpleasant situation with long hours of traffic block resulting in fuel waste and time loss. Also, when roads get flooded for long hours bituminous roads get damaged resulting in huge maintenance cost of roads. During urban floods there is every possibility of rainwater mixing up with sources of contamination which often results in diseases like leptospirosis, jaundice etc. Also urban floods cause stagnant water pockets, which act as a breeding place for mosquitoes which spreads vector-borne diseases like malaria, dengue fever etc. Urban flood often causes inundation of low level areas, which may be often occupied by low income groups and economically weaker sections of the society.

Pumping of underground water for day-to-day activities with reduced ground percolation often results in depletion of ground water table. This results in consumption of more electricity for pumping out water. Also in coastal areas depletion of ground water leads to salinity intrusion, which results in land

degradation leading to loss of local flora and agriculture. If the aquifers are confined and lie between layers of aquicludes of thick organic clay withdrawal of ground water with no recharge of rain water may lead to compaction of aquifers resulting in irreversible land subsidence (Benjamin 1998).

Water pollution, as a result of urbanisation and industrialisation, often causes surface water pollution leading to treatment of drinking water more tedious. Water scarcity looming in different parts of the city often leads to inflow of tanker lorries creating traffic chaos.

All the above-mentioned problems make the life in city very unpleasant and abatement of the same cost a lot of energy which could have been used for some other developmental activities for the city contributing to the overall quality of life. Solutions to all the above problems are the practice of retention and detention of rain water. Retention is often known as rainwater harvesting and artificial recharge of ground water (ARGW) of urban areas and detention is the water shed management practices of rural areas. In the case of RWH in containers the harvested water is pumped out for day-to-day activities, while ARGW is done mainly to combat the urban floods and other water-related sustainability-issues with a long-term perspective. Watershed management is practised for proliferation of agricultural activities of the rural areas.

The Concept of 'Zero Run-Off'

This is the hypothetical situation wherein there will not be any surface run-off and the total rainwater is going either as underground water or lost through evaporation back to the atmosphere. Rainwater harvesting or artificial recharge to ground minimise the surface run-off which, in turn, slows down the fast run-off. The slow run-off enables percolation of rainwater and thus underground water gets

diluted and subsurface water table rises. This prevents saline water intrusion in the off-season of rains.

Rain water harvesting in Urban and Rural Areas

RWH in urban areas is relatively a new concept evolved once the underground water in urban areas reduced substantially. It was made mandatory with building permits in cities like Chennai, Delhi, Jaipur etc and nowadays it is made compulsory in all new constructions in most of the states as per the directives of the Ministry of Urban Development and subsequent amendment of the building rules of the state governments. The RWH practices in urban areas

1. Provide drinking water
2. Increase ground water recharge
3. Reduce storm water discharges and urban floods
4. Reduce overloading of sewage treatment plants
5. Reduce saline water intrusion in coastal areas etc.

Urban RWH practices

For drinking and other domestic purposes water from roof top is harvested. Water from road and other open spaces can be harvested for gardening and other purposes. Rain water can be collected and stored in ready-to-use containers above ground or below ground or it can be recharged to aquifers.

Amount of water that can be collected

Urban Scenario

The total amount of water received from any area from rainfall is known as rainfall endowment of that area. The total amount of water which is effectively harvested is called the water harvesting potential of the area.

The water harvesting potential = rain fall endowment x collection efficiency Collection efficiency is calculated based on factors like run-off coefficient and first flush wastage.

Suppose the area of the roof is 100 sq. m.

Rainfall, e.g. average rainfall of India is 1170mm

The volume of rainfall from 100 sq. m. area is 117000 lit.

Assuming a collection efficiency of 90 %

The volume of water collected =0.90 * 117000 =105300 lit

For a five member family the amount of water required per day for drinking and cooking is assumed as 250 litres /day, the water is sufficient for 420 days, which is in excess of the annual requirement.

Rural Scenario

In rural areas water can be collected from roof top, from monsoon runoff by capturing water from swollen streams and from flooded rivers. Assuming that the average population of an Indian village as 1200, and rainfall being 1170 mm, if half of this water can be captured the average Indian village needs only 1.12 hectares of land to capture 6.57 million litres of water it will need for cooking and drinking. These calculations show the vast scope of rainwater harvesting. If the rainfall is uniform throughout the year it can be stored in ready-to-use containers of high capacity ferro cement water tanks.

Rainwater Harvesting Structures

1. Recharge / percolation pit
2. RWH through open well
3. RWH through bore well
4. Recharge well (deep/large)

Artificial Recharge of Ground Water (ARGW)

Recharge of ground water aquifers. Design considerations

Three most important components to be evaluated for designing the artificial recharge structures are:

1. Hydrogeology of the area including nature and extent of aquifers, soil cover, topography, depth of water level and chemical quality of ground water
2. The area contributing to run-off, land use and general built-up pattern of the area
3. Hydro meteorological characteristics such as general pattern, intensity and duration of rainfall.

Artificial Recharge Structures

1. Percolation or absorption pit
2. Percolation well
3. Percolation well cum bore pit
4. Artificial recharge through injection well

Watershed Management Practices of Rural Areas

There are vegetative methods and mechanical methods. Mixed cropping, multi-tired cropping, growing legumes and grass, and mulching are some examples of vegetative methods. Some of the mechanical methods of watershed management practices are contour bunds, contour trenches, check dams and subsurface dams. This not only checks the soil erosion, but allows the rainwater to percolate to ground resulting in reduced surface runoff.

Rainwater Retention and Detention—Success Stories

Revival of the dying river of Rajastan

The Arvari river in Alwar in the State of Rajastan was dying due to the depletion of ground water table and it was almost dried up by the year 1984. The non-governmental organisation Tarun Bharat Sangh (TBS) lead by Shri Rajendra Singh has since 1985 built 4500 earthen check dams to collect rainwater in around 850 villages in 11 districts of the arid region of eastern Rajastan and he revived the dried-up Arvari River. The Government of India honoured him by giving Ramon Magsaysay Award for community leadership for the year 2001. He is known as the 'Water Man of Rajastan'.

RWH and metro water board in Chennai

For a rain-deficient, coastal city of Chennai the importance of RWH needs no justification. There is a persistent threat posed to the fragile aquifer by the possibility of saline water intrusion by the indiscriminate extraction of ground water. Keeping this in view as a macro level strategy the Govt of Tamil Nadu introduced 'Chennai Metropolitan Area Ground Water (Regulation) Act, 1987 which covers the whole of Chennai city and 243 revenue villages around it. It is due to the implementation of this Act, the water table in the southern part of Chennai city, which was on an average depth of 8 meters before 1988, has risen upto an average depth of 4m below ground level. The implementation of this Act coupled with certain measures like construction of check dams improved the situation to such an extent that metro water board is able to increase the drawal from 55 mld to 100 mld of water to meet the 50% of the city supply.

The Delhi experience

A comparison of water levels from 1960 to 2001 shows that the water levels in major parts of Delhi are steadily declining because of overexploitation. During 1960 the ground water level was by and large 4-5 meters and in some parts the water-logged conditions existed. During 1960-2001 the water levels have declined by 2-6 metre in most parts of the alluvial areas. Decline of 8-20 metre had been recorded in south and south-west district. These areas have been identified as priority areas for taking up artificial recharge to ground water by rooftop rainwater harvesting and this technique is implemented in RASHTRAPATHI BHAVAN. The Central Ground Water Board is taking the leading action for this cause in Delhi.

The importance of Retention and Detention of rainwater in Kerala and Greater Kochi

It is learnt that in Kerala and Greater Kochi Region, due to its terrain conditions, only 5% of the rainwater is recharged to ground, while at the national level it is 12.5%. The rainwater in Kerala has fast runoff and it is reported that rainwater from the eastern hills reaches the sea within 48 hours. Water-shed management practices are very important for the people of Kerala and Greater Kochi Region for the sustainable agricultural activities and urban-related activities as they depend on groundwater and river systems for drinking and other household activities. Watershed Management Practices in the hinterland can definitely reduce fast runoff and allow base flow ensuring round the year fresh water flow in the rivers. This, in turn, curbs the salinity intrusion of rivers in the summer season.

All the above illustrations give a promising future for retention and detention of rainwater for the efficiency enhancement of cities resulting in a better HD/EFp. However artificial recharge structures, unless scientifically erected and managed, can

be disastrous as it changes the sub-surface flow pattern, which causes instability of sloppy terrains causing land slides.

All over India detention and retention of rainwater shall be given proper institutional support in terms of technology and financial subsidy as it is an inevitable requirement for the sustainability of the cities of tomorrow, to provide the city with the drinking water, to save the city from urban floods and related issues, and to flourish agriculture in the hinterland. Hastily pumped out underground water will be replaced only with long years of recharge.

6.3 REGIONAL PLANNING APPROACH

Macro economic growth models often adopted at national, state and regional level were aggregative and sectoral in character which cannot be expected to take care of the extraordinary details of physical, cultural and economic dimensions. Though the articulation of spatial development strategy for regions more or less coincided with the efforts for the national economic planning, nonetheless the importance of physical dimension in the national planning has scarcely been understood or appreciated. There has been growing recognition of the need for the development programs in the country to be conceived in terms of region (spatial) defined by economic, social and geographic considerations. In order to achieve regional balance in terms of development the idea of regional planning[12] was introduced by the Government of India in the third Five Year Plan.

Hierarchy of Planning Regions

Depending on the geographical scope within which various developmental programs to be effectively organised and dealt with, it is possible to visualise three major areas of operation, macro, meso and micro. Metropolitan regions are coming under micro regions.

The specific criteria that should be considered for delimiting the region must be laid down as follows as reported (TCPO 1982):

1. The planning region must be large enough to contain a range of resources, conditions and attitudes that would help to establish the desired degree of economic viability, but at the same time not too large as to make the comprehensive approach too general.
2. It should have adequate resources of diverse origin to enable a production pattern to be developed both for consumption and for exchange.
3. There should be an organisation in terms of nodal points either developed or developable to satisfy the organisational needs of the region as a total entity.
4. Planning is a mechanism for dealing with resource development problems. Therefore the ideal region for planning purpose must be those in which the area-wise approach to these problems is both feasible and desirable.
5. Planning deals with anticipating the future and an area with common potentials and probabilities of development would be logical for planning purposes.
6. Since planning requires the development of insight into the consequences of various alternatives, a contiguous, internally-cohesive area within which various alternatives can be projected and analysed has importance. Such internal cohesion may be the result of homogeneity of resources or their linkages through complementarity and intra- areal activity or flows.
7. As the ultimate objective of planning is to facilitate the making of rational decisions an area where some degree of social unity exists is desirable, so that the public can identify their problems and accept responsibility for meeting them.
8. The planning regions cannot completely ignore the basic administrative units. They are in fact derived by grouping the smallest administrative units in right

combinations. The advantage of keeping the smallest administrative unit in fact lies in the availability of data by such units and the existence of a system of administrative communication, which provides the mutual feed backs and appraisal of results for the guidance of future problem-solving techniques.

9. Planning regions should be essentially operational in character. Therefore a high degree of flexibility and elasticity is required in their conception as well as in their delimitation.

Delineation of a viable Greater Kochi Resource Region

A study conducted under the aegis of the Ministry of Environment and Forests, Government of India, has identified a region which is the catchment area of Vembanadu estuary system to which five west-flowing rivers are merging. The region extends to 13182 sq. km. spread across six districts of the state either part or full. To coincide with the administrative boundaries four districts in full can be considered for comprehensive regional planning. A viable Greater Kochi Resource Region can be formed by combining the districts of Ernakulam, Kottayam, Idukki and Alapuzha. A variety of ecosystems can be found in this region, marine, estuarine, riparian, wetland, forest etc apart from the fact that it is the most urbanised region of the state and has great socio-economic and cultural achievements.

Strategic Approach

The strategic approach of Greater Kochi Resource Region should be in such a way that the carrying capacity index CCI = Bc/EFp is not less than one, where Bc is the bio-capacity and EFp is the ecological footprint. Regional planning must be aiming to get an increased value of biocapacity and a reduced value of ecological footprint. Biocapacity can be increased by measures to increase the productivity of the eco-system. Ecological footprint can be decreased by planned compact high

density development with compatible mixed land use zoning. This can be achieved as per the following:

1. Identify the potential ecosystems in the region and bring regulations to preserve the value of the ecosystem and to prevent from further disturbance.
2. Introduce the disturbance reversal if possible to bring back the rural values.
3. Urban renewal of the already-performing urban areas through infrastructural up-gradation.
4. Least performing areas may be identified to inculcate planned compact high density development.
5. Existing scattered settlements in areas with rural values shall be encouraged to stand on their own with the least dependence on the public infrastructure. Those settlements may be encouraged to set up biogas plants, solar panels, rainwater harvesting units and artificial recharge wells etc.

Effect of preservation of rural values of Ecosystems

The literature support on the ecosystem services rendered by the biosphere and direct anthropogenic threat to bio-diversity are explained in Chapter 2. Preservation of rural values of ecosystems and discouragement of built-up disturbance can enhance the efficiency of ecosystem resulting in increased productivity. This, in turn, reduces the ecological footprint as the resources can be transported from the region to metropolitan area rather than from other states or countries. Increased productivity also results in better HD values due to increase in per capita income, giving a better HD/EFp.

6.4 TRANSFERABLE DEVELOPMENT RIGHT (TDR)

Traditional town plans, zoning and land use regulations often created desktop maps which were seldom implemented in its true spirits, as it may not be compatible with the aspirations of the public. Very often individuals are forced to compromise

for public interest which was never compensated in a time-bound manner. The resulting tendency is to violate the plan stipulations and zoning regulations. Political compulsions also arise to violate/vary the land use and zoning regulations. Due to these reasons the development authorities/local and state governments were not getting enough political support to go ahead with the implementation proposals. Land acquisition procedures also face public protests and litigations.

It is high time for government to think about alternate development strategies which would take public in confidence with fair amount of equity. 'Transferable Development Right' gives a promising future for effective implementation of master plans and zoning regulations. TDR enables the preservation of natural areas, agricultural land and heritage structures. It also helps in curbing development in disaster-prone areas and ecologically-fragile ecosystems. Transferring the development rights from low efficiency zones to high efficiency zones can create multiplying results and is beneficial to both public and government. Infrastructural upgradation is also effective through TDR technique as developer gets his profits multiplied with higher order infrastructure.

What is TDR?

TDR is an implementation tool that encourages the voluntary shift of development from places that communities want to save called sending areas to places that communities want to grow called receiving areas. With TDR the landowners of the reserved land as per master plan receive compensation by selling their development rights in return for voluntarily surrendering their land or for reserving/retaining their default activities. TDRs are purchased by developers in receiving areas, the places that are appropriate for development.

When TDR works, sending area property owners are given 'development right certificate' which can be sold to a prospective developer in the receiving area.

In the case of agricultural land reservations land owners are often allowed to continue owning the land and receive non-development income from it, while enjoying the development rights to a sending area. Receiving area developers enjoy extra return on their investments, while contributing to land reservation as per landuse plan. Finally TDR allows communities to achieve their landuse goals with compensation to property owners without public exchequer. TDR is indeed a market-based preservation technique.

Compact cities of Curitiba and Sao-Paulo in Brazil used the TDR tool as early as 1960s to achieve their development targets. In the United States Montgomery County in Maryland has preserved over 40,000 acres of farmland and New Jersey Pinelands saved 31,000 acres of farmland using TDR tool. India also has sufficient TDR experience.

TDR experience in Mumbai

Rule 34 of the development control regulations for Greater Bombay, 1991, defines TDR as under:

'In certain circumstances the development potential of a plot of land may be separated from the land itself and may be made available to the owner of the land in the form of transferable development rights. Development control regulations lay down the rules for grant of TDR. The owner of the land which is reserved for public purpose and additional amenities are eligible for transferable development certificate which is known as *Development Rights Certificate* (DRC). The landowner may use the right himself or transfer to any other person. When the owner constructs an amenity on the surrendered plots at his cost he may be granted a further development right'.

Different Types of TDR Practised

1. Slum TDR

When the developer or owner surrenders his land to the government and agrees to rehabilitate slum dwellers free of cost he is issued a TDR certificate that gives him additional construction rights in the designated areas. Slum TDR is effectively practised in Mumbai.

2. Heritage TDR

A landowner who cannot develop his property despite unutilised floor space index as the existing structure is a heritage building, can use or sell the development rights in the open market. Builders who buy the TDR can use the right in designated areas. The aim of heritage TDR is to protect the heritage buildings without penalising the landowner.

3. Agricultural land TDR

In the United States TDR is effectively used for the protection of farmland and ecologically sensitive zones.

4. Amenity/ road TDR

If any of the amenities mentioned in the master plan is constructed by a party, in lieu, he is given a TDR in a designated area.

For an environmentally-efficient development management system 'Transferable Development Right' is an indispensible tool to be applied for effecting development in the efficient zones and discouraging development in inefficient zones.

Making TDR a Success

Conditions to be complied for making TDR a success are:

1. The scale of the TDR program should be large enough to provide a large pool of potential sellers and purchasers.

2. The underlying landuse regulations are sufficiently restrictive relative to the market demands to encourage participation.
3. Program must offer significant benefits as incentives for landowners to participate.
4. Receiving area should have sufficient capacity to accommodate high density development.

TDR contributes to environmental efficiency HD/EFp due to the following reasons:

1. It increases the land utility index by bringing the ownership of the land from a single ownership to collective ownership by providing more and more amenities.
2. Road TDR always expedites the road formation which, in turn, increases the accessibility.
3. TDR reduces the disturbance to ecosystem of the sending areas.
4. TDR increases the productivity-multiplier value of receiving areas.
5. TDR in receiving areas causes less per capita built-up consumption.

Development Authorities, Where the shoe pinched? and the Remedy

The activities of the development authorities are highly contributing to environmental efficiency through the implementation of town planning schemes, as they increase the land utility, increase the accessibility, reduce the per capita built-up and carry out bulk development, so that productivity-multiplier values were high. However, land reservations without compensation were highly detrimental to the interest of the individual landowners and thus the development authority lost the goodwill of the public. TDR is a remedial tool to effectively implement the environmental efficiency through the land reservation in town planning schemes.

6.5 GREEN BUILDINGS

The Concept

The concept of Green Buildings envision a new approach to save water, energy and material resources in the construction, operation and maintenance of the buildings and can reduce or eliminate the adverse impact of buildings on the environment and occupants.

Green building concept rightly coincides with the environmental efficiency index HD/EFp, as it concentrates on increase in human development by increasing the comfort level with reduction in ecological footprint by energy saving measures.

The salient feature which contributes to human development is improved air and water quality for health and comfort, resulting in increased productivity while the salient features of the green building contributing to reduction in ecological footprint are:

- Effective use of soil and landscape
- Efficient use of water
- Energy-efficient and eco-friendly equipments
- Effective control and building management system
- Use of renewable energy
- Use recycled/recyclable materials.

Unlike a conventional building, green buildings intend to achieve operation and maintenance savings, reduction in initial investment, while there is strong concern for human comfort, indoor environment and safety.

Green Building Movement in India

The Indian Green Building Council (IGBC)

To enable construction industry to be environmentally-efficient Confederation of Indian Industries-Sohrabji Godrej Green Business Centre (CII-Sohrabji Godrej GBC) in Hyderabad has established Indian Green Building Council (IGBC). IGBC is a consensus driven not-for-profit council representing the building industry consisting of more than 350 committed members. The vision of IGBC is to usher a green building movement in India and aim India to become one of the world leaders in green building.

The green building movement in India has been spearheaded by IGBC since 2001. IGBC continuously works to provide tools that facilitate the adoption of green building practices in India.

LEED-India (Leadership in energy and environment design) is the rating program adopted by IGBC to facilitate rating of buildings with respect to energy and environmental efficiency and the technology support is given by the United States Agency for International Development (USAID).

Services offered by IGBC towards green building concept are :

- LEED India certification
- LEED workshops
- Green Building Congress
- Publication and information dissemination
- Membership services
- Green building tours
- LEED AP Examination

In LEED India rating system life cycle cost of building materials are considered and the incremental cost is offset by operational savings.

Levels of certification by LEED India are LEED Certified, silver, gold and platinum.

Green Buildings in India

Four platinum-rated green buildings in India alongwith plinth area, incremental cost and payback period are as below:

Table 6

Cost and Payback period, Platinum-rated Green Buildings

Name of the building	Plinth area in Sq.Ft.	Incremental cost	Payback period
CII-Godrej GBC (2003)	20,000	18%	7 years
ITC Green Centre,Gurgaon(2004)	170,000	15%	6 years
Wipro Gurgaon(2005)	175,000	8%	5 years
Special Service Consultants office, Noida	15,000	8%	4 years

Source: www.igbc.in

IGBC Green Homes rating system addresses the features under the following categories:

1. Site efficiency
2. Water efficiency
3. Energy efficiency
4. Materials
5. Indoor air quality
6. Innovation

6.6 HD/EFp CONCEPT AND COASTAL ZONE REGULATION (CRZ) RULES

For regulating developmental activities the coastal stretches within 500 meters of high tide line of the land-ward side are classified into four categories namely I,II,III and IV.

CRZ I, Areas which are ecologically sensitive and important ecosystems.

CRZ II, Areas which have already been developed.

CRZ III Areas which are relatively undisturbed and considered as rural areas.

CRZ IV Coastal stretches in Andaman and Nicobar, Lakshadweep and small islands except those designated under CRZ I,II or III.

As per CRZ rules vide Kerala Coastal Zone Management Plan, the Greater Kochi Metropolitan Area is coming under three zones namely CRZ I, II and III. All the coastal municipalities and Cochin Corporation are coming under CRZ II, while all the coastal panchayats are coming under CRZ III.

Building regulations as per Kerala Coastal Zone Management Plan are framed in such a way that building activities in CRZ II zones are encouraged, while the building activities in CRZ III are discouraged by framing more relaxed rules in CRZ II Zones. No new construction activities are permitted in CRZ I zone.

Kerala Coastal Building Regulation contributes to HD/EFp concept as building activities are prohibited/discouraged in sensitive ecosystems and relatively undisturbed areas, while building activities are encouraged through relaxed rules in already disturbed zones which result in a better Productivity Multiplier Value '$\mathbf{1/1+\delta}$'where, δ is the disturbance factor.

6.7 TOWN PLANNING SCHEMES AND GLOBAL FAR CONCEPT OF GREATER COCHIN DEVELOPMENT AUTHORITY

Detailed town planning schemes which are being implemented by the Greater Cochin Development Authority (Annexure 2) under the aegis of Town Planning Rules contribute greatly to HD/EFp due to the following reasons:

1. As it transformed the land ownership from single to collective.
2. As it invariably provided/ attracted human development-prone facilities.
3. It always improved the accessibility to human development-prone facilities of the city by providing good quality roads.
4. It encouraged compact development with good common facilities with less per capita built-up area.
5. It always created bulk development, so that disturbance factor is minus and thus productivity-multiplier value is high.

Apart from a master plan for the Central City Area ($1/3^{rd}$ core area of the Greater Kochi Metropolitan Area), there are 24 detailed town planning schemes which are in its various stages of implementation (Annexure 2).

Global FAR in Cochin Marine Drive Scheme

The Global FAR concept is used in the Cochin Marine Drive Scheme which is successfully implemented by the Greater Cochin Development Authority. The DTP scheme was sanctioned by Government as early as in 1971 for an area of 25.29 hectares, the global FAR adopted being 1.7. The total built-up area permissible throughout the scheme is 1.7 times the area of the scheme which was prudentially distributed to a few plots with compact vertical development resulting in large open spaces, wide roads and recreational areas. The landuse break-up is as follows:

Commercial	-	1.6	hect.
Residential	-	3.5	hect.
Residential /Commercial	-	5.0	hect.
Public	-	0.7	hect
Transportation	-	0.8	hect.
Park/Open space	-	3.6	hect.
Walkways	-	3.0	hect.
Utility	-	0.2	hect.
Roads	-	*5.0*	*hect.*

Source: Greater Cochin Development Authority

Global FAR concept improves the land utility which contributes to efficiency HD/EFp as the resources/facilities provided in land are converted from a single ownership to common ownership. This results in better human development-prone facilities at walking distance for many.

Global FAR provision in the Master Plan

Although the term global FAR is not used the concept is included in the Structure Plan (prevalent Master Plan for Greater Kochi Central City) through variation effected on 31st May 2007. By the introduction of clause 4.13 (ix) in which it is mentioned that large scale development proposals in area not less than 2 hectares, exceeding an investment of Rupees 50 crores, which provide direct employment (after commissioning of the project) to the tune of not less than 500 may be permitted in agriculture and developed landuse zones, subject to the recommendation of the committee to be constituted by Government for this purpose. Maximum FAR of two for a minimum access width of 12 meter is permissible.

Although the concept is nearly acceptable on efficiency consideration the clause is to be modified to fit the efficiency index HD/EFp and the proxy efficiency index $\mu\alpha^2/\beta(1+\delta)$. This can be achieved by giving compliments for reduced per capita built-up with ample human development-prone facilities under common

ownership and for putting up construction in relatively disturbed area, leaving the ecosystems and agricultural areas undisturbed.

6.8 PRECISE AND OBJECTIVE DECISION-MAKING THROUGH GEOGRAPHICAL INFORMATION SYSTEM (GIS)

GIS integrates hardware, software, data, personnel and procedure for capturing, managing, analysing and displaying all forms of geographic information. It is a technological tool for comprehending geography and making intelligent and smart decisions.

GIS organises geographic data, so that a person reading a map can select data necessary for specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a base map of real-world locations. GIS can be integral to fashioning system-based solutions to our environmental challenges.

Relevance of GIS maps

Creation of traditional paper maps are costly and time-consuming. It is difficult to combine and store large volumes of data associated with the map, while in GIS maps huge amount of data can be added as attribute information, which can easily be retrieved, manipulated, updated and analysed. It is possible to integrate GIS maps with satellite imagery, so that spatio-temporal analysis can effectively be done.

Salient Events in the history of Remote Sensing and GIS

- **Pre200 AD** They neither had computer nor paper, they did have clay.
- **1351** The Medici Sea Atlas is published
- **1441** The World Map is prepared by Fra Mauro
- **1541** Mercator prepares a globe
- **1675** The Royal Observatory at Greenwich
- **1752** Jean Baptiste publishes a map of India

- **1767** East India Company establishes Survey of India
- **1802** GTS Survey commences in Madras
- **1930** Survey of India maps are published
- **1957** First National Atlas of India in Hindi
- **1958** NASA is established
- **1966** IIRS is established
- **1969** ISRO is established, ESRI is founded
- **1975** Aryabhatta is launched, NRSA is established
- **1981** ESRI launches Arch/info
- **1982** Insat 1A is launched
- **1983** Insat 1B is commissioned
- **1985** GPS becomes operational, GRASS package is developed
- **1987** TYDAC releases SPANS GIS
- **1988** IRS is commissioned with IRS-1A
- **1989** Intergraph launches MGE
- **1991** MapInfo Professional is launched, IRS-1B is launched
- **1994** IRS – P2 is launched
- **1995** IRS – 1C is launched
- **1996** ESRI India is formed, IRS – P3 is launched
- **1997** CSDMS is launched, GIS@Devpt is launched, IRS – ID is launched
- **1999** IKONOS is launched, Autodesk India Ltd is formed
- **2005** Google has published Google Earth, Cartosat 1 of NRSA is launched
- **2007** Cartosat 2 is launched
- **2008** Cartosat 2A is launched.

GIS Softwares, Available Packages

1. Arc//Info by ESRI (1981)
2. GRASS by OSGeo Foundation (1985)
3. SPANS GIS by Tydac (1987)
4. MGE by Intergraph (1989)
5. MaoInfo Professional by MapInfo Corporation (1991)

6. ArcGIS by ESRI

Infrastructure requirements of GIS are Computer Hardware, Software, Geographic data, Personnel and Procedure. Geographic data includes both spatial and attribute information.

Process in GIS

Process in GIS involves the following:

1. Procurement of spatial data
2. Projection
3. Geo-referencing and Vectorisation
4. Creation of Topology and Editing
5. Addition of attribute information
6. Analysis
7. Creation of maps and presentation of results

Usual spatial data are either in raster format or in vector format. Sources of data are toposheets, paper maps, satellite data, GPS data from field surveys etc. Toposheets, paper maps etc. are scanned. There are raster scanners as well as vector scanners. In raster scanners data is entered as raster data (in the form of pixels), while GPS data in digital form can be directly entered. Classified satellite data can be entered as raster data, which can be converted to vector format in GIS. Projection involves bringing the data to a common co-ordinate system. Georeferencing involves registering the data to the real world coordinates. Scanned data in raster format can be vectorised/digitised in GIS platform. Once the raster data is georeferenced and vectorised, topology is created to establish the relationship between features. After editing they are stored as shape files, which can be exported to the geodatabase to create feature classes. Attribute table associated with each feature class invariably contains object ID, the shape area and shape length of features. Any number of fields

can be created to which attribute information can be added. Attribute information can be in the form of text, integer data or floating data. Once feature classes are created and attribute information are added, analysis can be done.

Operations involved in different analysis modules available in ArcGIS are geographical analysis, spatial analysis, network analysis, geo-statistical analysis, survey analysis etc. Geographic analysis is also known as vector analysis. There are umpteen number of tools in geographic analysis package such as clip, erase, update, union, intersect etc. Spatial analysis is also known as raster analysis in which data is created in the form of pixels/grids with specified values.

Once analysis is completed, the results can be presented in the form of maps, which can be formed by combining different feature classes in the table of contents associated with the ArcMap.

Application of GIS

GIS has versatile applications. Apart from environmental management it can be used for business studies, disaster management studies, pollution studies etc. It is a powerful tool for precise and objective decision-making with great amount of transparency and accountability. The main drawback of developmental decision-making is its arbitrariness and subjectivity which can easily be overcome by GIS-enabled objective decision-making and hence for attaining environmental efficiency application of GIS is invariably required.

6.9 FORMATION OF ENVIRONMENTAL EFFICIENCY INDICATOR SYSTEM AND 1000 CITIES PROGRAM OF UN-HABITAT

A serious problem associated with environmentally-efficient development management is the lack of organised data for efficient evaluation and monitoring. There is an urgent need for capacity-building at local level. Collection of data, creation of statistics and formulation of indicators and indices enable monitoring and

evaluation. This, in turn, enable policy formulation and intervention towards better environmental efficiency.

Indicator Initiatives

The United Nations Conference on Environment and Development (UNCED), the Earth Summit held in Rio de Janeiro 1992 was attended by 120 heads of state. A large number of documents on various issues concerning mankind and to save the earth were prepared for global action. The action program called upon countries, particularly developing countries, to initiate programs in the area of governance for sustainable development. The program covered various aspects like capacity building, fine-tuning of the existing institutional framework, good governance, need for better policy formulation and improved planning and management of the environment. Initiation of CSD indicators of sustainable development was one of the major outcomes of the UNCED. The key areas of CSD indicator framework are social, environmental, economic and institutional.

In the Habitat II Conference held in Istanbul (1996) member countries committed themselves to implement the Habitat Agenda through policy and plans of action designed at each level in cooperation with all interested partners. All partners were asked to monitor and evaluate their own performance in working towards adequate shelter for all and sustainable development in an urbanising world.

United Nations Centre for Human Settlements (UNCHS), in close partnership with United Nations Development Program (UNDP), World Bank and other organisations conceived and developed Urban Indicators Program (UIP). The emphasis of UIP is adopting a partnership approach involving decision-makers at the government level and stake-holders who have interest in urban development issues. The program was envisaged to be implemented through the setting up of a system of observatories at the global, regional, national and local levels. The key areas of

Urban Indicator framework are socio-economic development, infrastructure, transportation, environmental management, governance and housing.

Setting up of an indicator system for efficiency evaluation at city/metropolitan area and carrying capacity evaluation at the regional level is highly essential for decision-making and policy formulation to guide the development in the optimum path.

Indicators of Environmental Efficiency

Some of the indicators which can be evolved from HD/EFp concept towards environmental efficiency are:

Life expectancy at birth

- Life expectancy at birth of both male and female
- Death rate due to accidents
- Death rate due to epidemics
- Morbidity rate
- Percentage of people suffering from life style diseases
- Percentage of people dying of cancer

Adult literacy rate

- Adult literacy rate of male and female
- Percentage of people well versed in English
- Number of professionals
- Overall skills achievement (swimming, cycling, driving etc)
- Budget Allocation for R&D activities

Gross Enrolment ratio

- Gross enrolment ratio of male and female
- Enrolment ratio of primary education
- Enrolment ratio of secondary education
- Enrolment ratio of tertiary education

Per capita income

- Per capita income from the primary sector
- Per capita income from the secondary sector
- Per capita income from the tertiary sector
- Per capita income of male and female workers
- Workers participation ratio
- Percentage of 60^{+} and 75^{+} population

Per capita energy consumption

- Per capita energy from hydel power
- Per capita nuclear energy
- Per capita fossil fuel consumption
- Percentage of non-conventional energy
- Transportation trip length and trip time
- Percentage trips by public transport
- Percentage trips by walking and cycling

Per capita built-up area consumption

- Built-up area break-up based on use
- Ratio of non-residential to residential use
- Ratio of floor area to built up area of the city (city FAR)
- Percentage of government land

- Percentage of occupied land
- Percentage of occupied buildings
- No of high rise buildings

Some of the proxy indicators of efficiency identified are:

- Land utility index
- Accessibility
- Per capita built-up area consumption
- Productivity-multiplier value derived from the ecosystem disturbance factor
- Effective space/land utilisation constant of shared communities
- Human development prone facility index of the city
- Per capita floor area to built-up area ratio of the city

Three of the above proxy indicators are used in this thesis for efficiency evaluation and preparation of efficiency map.

There is an urgent need for Greater Kochi Urban Observatory to be formed in line with the Global Urban Observatory Program of UN-Habitat to obtain the infrastructure and methodologies to incorporate efficiency-related indicators to quantify and monitor the efficiency of the development management system. For an application made by the Greater Cochin Development Authority, it is informed by UN-Habitat that the Greater Cochin Development Authority has been certified as a member of the Global Urban Observatory Network by successfully meeting the general criteria for the establishment and implementation of a Local Urban Observatory for the Greater Cochin Metropolitan Area. The said communication is attached as Annexure 5. In India Bangalore Metropolitan Regional Development Authority is a member of the Local Urban Observatory Network of UN-Habitat.

1000 Cities program of UN-Habitat

ESRI and UN-Habitat jointly formed the 1000 cities program in which ArcInfo software is available free of cost to those cities, universities and research organisations which take up Local Urban Observatory and Urban Indicators Program most successfully.

6.10 PROPERTY TAXATION BASED ON EFFICIENCY

Property taxation prevalent in Greater Kochi is often unscientific and arbitrary. For an environmentally-efficient development management system property taxation based on efficiency is a powerful tool to achieve the objective. The formula based on proxy variables to evaluate the environmental efficiency in chapter five holds good for sustainable taxation also.

Efficiency index , $I_e = \mu\alpha^2/\beta(1+\delta)$

μ = land utility index

α = accessibility index

β = per capita built-up

δ = ecosystem disturbance factor of the grid in which the building is located.

In the case of residential buildings efficiency evaluation formula can be further modified to accommodate the effective space utilisation constant.

Concept of effective space utilisation constant of residential buildings

Common facilities provided in apartments or gated communities directly contribute to human development as those facilities are adjacent to residence and the chances of using the facility are more. Usual common facilities attached to apartment complexes are jogging track, swimming pool, health/yoga clubs, shuttle court, basket ball court, table tennis, libraries etc., which contribute to health and education

component of human development. Per capita ecological footprint of common facilities is less as it is under common ownership and the facilities are shared.

Suppose in an apartment complex, there are 'x' number of apartments. Individual area of each apartment is Ai and common area is Ac.

Effective area of each apartment is Ai+Ac, while actual area is Ai+Ac/x,

Effective space utilisation constant= Ai+Ac/Ai+Ac/x

where, Ai, the area occupied by individual apartment
Ac, the common area of the apartment
x, the number of units.

Mode of Taxation, Occupied Buildings

In the case of occupied buildings property tax charged shall be inversely proportional to the efficiency of the building to encourage people to put up their residence in high efficiency areas which, in turn, inculcate human development with less ecological footprint.

Mode of Taxation, Vacant Land and Buildings

In the case of vacant land in high efficiency grids, taxation shall be exorbitant to discourage people to keep the land vacant as it is non-performing.

Similarly in the case of vacant buildings in high efficiency locations, property taxation shall be exorbitant to prompt the landowner to rent it out, so that it shall be contributing to human development with less ecological footprint.

6.11 SUSTAINABLE FOREST MANAGEMENT THROUGH THE HD/EFp ENHANCEMENT OF METROPOLITAN AREAS AND VICE VERSA

It is already explained and demonstrated that inefficient development management of cities causes urban sprawl. This causes fragmentation of agricultural land and disturbance to ecosystem which affects the agricultural productivity. When agricultural land becomes less productive people refrain from doing agriculture there

and invade forestland for agriculture and allied activities. This causes disturbance to forest ecosystem through fragmentation.

Going through the literature it is reported that the forests are among the first casualties as human population explodes. It is scientifically established that fragmentation of shrinking of forests into smaller patches honeycombed with human settlements, highways, dams, mines or developmental projects is the most serious threat to bio-diversity and forest conservation. When a large block of forest gets fragmented the edges of all the bits come into contact with human activities, resulting in the degradation of the entire forests. As continuity of forested landscapes and corridors getting disrupted, populations of single species and the composition of entire animal communities are affected. Rare inferior forest species are replaced with common, adaptable 'trash' species of plants and animals (Bharghav, 2007). A study on the 'Deforestation in parts of Western Ghats Region (Kerala)' (Chattopadhyay, 1985) reports that there is substantial depletion of forestland. 1905 estimate of 44.4% area under forest vegetation had declined to 27.7% by 1965 and 17.1% by 1973 and 14.7% by 1983. Achieving sustainable forest management results in a better biocapacity of the supporting region. This, in turn, again contributes to HD/EFp of the metropolitan area as the region becomes highly productive.

It is learnt that a sum of Rs 5000 crore corpus fund collected by imposing levies on many development projects in forest areas is available with Ministry of Environment and Forests, Government of India under the head CAMPA (Compensatory Afforestation fund Management and Planning Authority). Bharghav.P opined that disturbance to the forest ecosystem cannot be compensated by planting in nearby grasslands the exotic species such as Acacia, Eucalyptus and Casua rina, as it end up in destruction of two natural habitats.

Sustainable forest management can be effectively achieved by achievement of environmental efficiency of metropolitan areas as it curbs urban sprawl and invasion of forestland. This, in turn, again contributes to HD/EFp of cities due to Bc/EFp enhancement of the supporting region.

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Chapter· 7

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Contents

7.1 SUMMARY

Sustainable development is the most relevant topic of the era and it is to be achieved in a multidisciplinary platform. Major portion of sustainable development is explained by the achievement of environmental efficiency of the development scenario. It can be calculated by taking the output/input ratio of the total development which has social, economic and environmental (physical) dimensions.

The State of Kerala, the tiny state in the south-west corner of Indian Peninsula, is characterised by the unique settlement pattern with highly scattered form of development. With moderate climate and abundant rains the state is rich in bio-diversity. Although the gross density of population is third among the states of India (2001 Census), it lacks population concentration. The Greater Kochi Resource Region, the catchment area of the Vembanad Estuary system, is a viable region to support the metropolitan area. Kochi UA, contained in the Greater Kochi Metropolitan Area, is the only million plus UA of the state. The development management of the Greater Kochi Metropolitan Area is mostly done at local body and the district administration level and is intervened by the state government when exigencies arise. The two development authorities contained in the metropolitan area, GCDA and GIDA, are functioning with limited powers of development management.

SWOT analysis presented in the report reveals that Strengths and Opportunities of Greater Kochi overweigh the Weaknesses and Threats which can easily be overcome by sound and scientific development management system with due stress on environmental efficiency.

Referring the research on the topic at the international level, mainly by UN agencies, the theory of environmental efficiency is evolved. Considering that the total output of any development exercise is the human development, Human Development Index of UNDP can be considered as the output, while Ecological

Footprint of WWF can be taken as the input. In HD/EFp index the socio-economic aspects are taken care of by the numerator, while the physical environmental aspects are taken care of by the denominator. HD/EFp can be evaluated and monitored at global, national and state levels by adopting the methodologies formulated by UNDP (in the case of HD) and WWF (in the case of EFp).

Achieving environmental efficiency of human settlements deserves far more importance as nearly 60% of the world population is going to live in cities by 2030 as per the UN population estimates. If, at the international and national levels, HD/EFp is an index, at local and individual levels it is a core concept, which has got wide applications in the day-to-day decision-making. World countries' analysis based on UN published data demonstrates the effectiveness of HD/EFp. Carrying capacity index Bc/EFp is also introduced to achieve a better HD/EFp.

Literature review on compact cities reveals that planned compact cities with high density development can greatly contribute to HD/EFp. Concentrated decentralisation, linear transit-oriented development, infill densification, guided densification, urban containment etc. are terms which are obtained from literature which contribute to HD/EFp. Case studies of success and drawback stories of compact cities across the world are also presented.

Macro level analysis of socio-economy vis-à-vis urbanization pattern has been carried out. Kerala State has a very good track record of physical quality of life, while the Human Development Index is dampened by the low per capita income achievements. Comparing the urban land and urban population over the years, it is seen, in Kerala, urbanisation of land is taking place rather than urbanisation of people. People are found to be stagnant with low inter-district migration tendencies. During the decade 1981-1991 strong presence of urban sprawl is noticed as urban land has increased disproportional to urban population. Census 2001 reveals that urbanisation has reduced from 26.39% to 25.97%. This is due to the

underperformance of already declared urban areas, which were subsequently declassified. Also many of the Census Towns in 1991 Census are declassified as urban OGs for which the economic criteria of the Census of India are not satisfied. Presence of urban sprawl is noticed in Kochi UA also as UA area has drastically increased with reduction in gross density of population.

Urban sprawl leads to non-optimal density of population to support higher order urban infrastructure. Urban sprawl also causes loss of ecosystems, agricultural land and loss of fossil fuel for transportation.

It is noticed that the Kerala State, which contains the Greater Kochi Metropolitan Area, is presently characterised by the following aspects:

1. Halting human development
2. Spiraling ecological footprint
3. Diminishing biocapacity
4. Decreasing HD/EFp and Bc/EFp.

In order to demonstrate further the presence of urban sprawl, micro level analysis has been carried out on a 3 km buffered zone on either side of the major highways passing through the metropolitan area containing four out of the six municipalities and Cochin Corporation (part) included in the Greater Kochi Metropolitan Area. Micro level analysis has been carried out in a GIS platform using the software ArcGIS. Micro Study Area extends to 281 sq. km. which are divided into 281 grids of 1 sq. km. each. Population and built-up area of 1968 and 2002 alongwith other attribute information are compiled at grid level in GIS platform.

Micro level analysis in GIS platform revealed the strong presence of urban sprawl as the Shannon's entropy value is found to be nearer to entropy $_{max}$. This means that the built-up area distribution is highly scattered and disorganised with high spare capacity. Regression analysis revealed that between 1968 and 2002, for

the built-up distribution, significance of municipalities is lost and significance of the Central Business District (CBD) is gained.

To attain a concentrated decentralisation model leading to a poly-nodal metropolitan area the growth trend is to be intervened on sustainability consideration, to bring down the entropy value. Based on this concept efficiency formula have been derived from HD/EFp concept using proxy indicators of efficiency like land utility index, accessibility index, per capita built-up area and productivity-multiplier value based on the disturbance to the ecosystem. Human development-prone facilities of the city are also a deciding factor of the total efficiency of the city.

Without taking the land utility index it is seen that the total efficiency has drastically reduced between 1968 and 2002. Efficiency 2021 business as usual scenario is also worked out based on the projected population allocation and predicted built-up area distribution for the year 2021. Efficiency is seen to have slight increase compared to 2002. Development preference maps (100 Series, 200 Series and 300 Series) are prepared for the Micro Study Area based on grid efficiency and productivity-multiplier values. Population allocation tables are also prepared for infill densification scenario and redevelopment scenario.

Finally ideas, strategies and programs which contribute to the environmental efficiency are identified and presented. Smart growth, retention and detention of rainwater, regional planning approach, transferable development right, green buildings, detailed town planning schemes, precise and objective decision-making through GIS, formation of urban and regional efficiency indicator system, efficiency-based property taxation, sustainable forest management through HD/EFp enhancement of metropolitan area and vice versa, all can greatly contribute to better HD/EFp.

7.2 CONCLUSION

The term environmental efficiency is a powerful term. HD/EFp is an index as well as a concept useful for the humanity. Urban sprawl phenomenon shall be contained through GIS-based environmental efficiency evaluation and monitoring system to achieve sustainable development. It can be done at international, national, state and district levels. HD/EFp can be a guiding concept for micro level planning, prioritisation of projects and for individual decision-making.

7.3 RECOMMENDATIONS

Technical, institutional and legal mechanisms are to be introduced to effectively implement the concept of environmental efficiency.

The following **technical recommendations** are given:

- In line with the Global Urban Observatory Program of UN Habitat national, regional and local urban observatories are to be formulated with evaluation and monitoring mechanism of environmental efficiency. ArcGIS software should be availed free of cost under 1000 cities program of UN-Habitat.
- Master Plan exercise of the metropolitan area should give due weightage for environmental efficiency and the redelineation of metropolitan area shall be done on a scientific basis.
- More and more detailed town planning schemes/area development plans are to be formulated around human development-prone facility centers. This is to improve accessibility, accommodate more number of people and to cause bulk development.
- Environmental efficiency and degree of disturbance shall be a guiding principle for site location of new proposals to attain contained urbanisation.
- High FAR provisions in Kerala Municipalities Building Rules in unplanned areas shall be withdrawn, while very high FAR provisions shall be given in planned areas with high capacity infrastructure.

- Global FAR strategy shall be encouraged to facilitate more common facilities and open spaces, so that land utility index is high.
- Indian Green Building Rating System shall be modified to accommodate the environmental efficiency concept HD/EFp.
- GIS shall invariably be used for the finalisation of master plans and detailed town planning schemes based on environmental efficiency to enable transparent and objective decision-making.
- Scientific retention and detention of rainwater shall be practised to attain environmental efficiency.
- TDR should be introduced to save heritage areas, disaster-prone areas, agriculture land and sensitive ecosystems. Also TDR can be given for provision of low income houses in high efficiency areas and for contributing to infrastructure projects.
- There is an urgent necessity to identify a viable region for the Greater Kochi Metropolitan Area to inculcate regional dependency. This is through biocapacity enhancement measures and ecological footprint reduction measures to get an improved Bc/EFp leading to a better HD/EFp of the metropolitan area. Metropolitan Planning Board also shall be constituted after the scientific delineation of the Metropolitan area.
- Wherever there is dilapidated infrastructure redevelopment shall be taken up, while in spare capacity areas infill development is required to be taken up.
- Undisturbed areas shall be reserved through TDR technique for preserving agricultural land and sensitive ecosystems.
- Property taxation shall be more scientific and transparent, based on environmental efficiency in GIS.

- Vacant land as well as vacant buildings in high efficiency areas shall be exorbitantly taxed to encourage construction and leasing out, leading to better environmental efficiency HD/EFp.
- Disaster-prone areas shall be identified to discourage construction and TDR shall be given to high efficiency zones.
- All road projects shall invariably be supported by a detailed town planning scheme based on the concept of HD/EFp to attain environmental efficiency and to check urban sprawl.
- Metro rail proposal of Greater Kochi, if implemented shall be complemented with planned, compact high density development around stations to make it viable and thus to increase the HD/EFp.
- National level initiatives are required to formulate human development-prone facility index of all the 35 million plus UAs of the nation as per 2001 Census and further.
- HD/EFp technique shall be accepted as a Strategic Environmental Impact Assessment Methodology by the MoEF, Government of India. Also this can be developed as an effective tool for the Environmental Impact Assessment of individual projects.
- Corpus Fund collected in the name of CAMPA by the MoEF, Government of India, shall be used for framing up of compulsory GIS-based environmentally-efficient development management of all the UAs of the nation.
- IDDP/LDP initiatives of the Government of Kerala shall be modified to suit BC/EFp at regional level and HD/EFp at local level.
- Kerala State and Greater Kochi have unique characteristics with unsustainable trends. Extensive and dedicated research is required on this topic. Also there has to be enough qualified staff to supplement the institutional setup proposed. Hence multidisciplinary course on

environmental efficiency and urban development management shall be started and research on this topic shall be encouraged in universities in Kerala and Greater Kochi Metropolitan Area.

Following are the **legal requirements to formulate an institutional set-up** to implement the concept of environmental efficiency:

- New Urban and Regional Planning Bill under consideration by Government of Kerala shall contain necessary clause towards the attainment of environmental efficiency of human settlements and for the mandatory application of GIS for decision-making.
- In the new bill there has to be provision for the constitution of Metropolitan Planning Board and Greater Kochi Regional Planning Board to attain environmental efficiency HD/EFp and regional efficiency Bc/EFp.
- The new Urban and Regional Planning Bill shall contain provisions for the setting up of Local Urban Observatories with budget allocations, for evaluation and monitoring of environmental efficiency in a timely manner.
- TDR provisions shall be incorporated in the new bill supplemented with foolproof TDR rules to encourage investments in high efficiency zones for attaining environmental efficiency.
- The Apartment Ownership Act shall be made functional to enable registration of Apartment Owners' Association.
- Land Utilisation Order shall be modified to enable scientific reclamation of wetland in areas which are proposed for developed-landuse in the master plan/ DTP schemes prepared, based on the concept of environmental efficiency.
- The Energy Efficiency Act of the Government of India shall be modified to accommodate the environmental efficiency concept of human settlements. The site efficiency of the green building rating system shall be revised to accommodate the environmental efficiency proxy indices.

ANNEXURE 1

SWOT ANALYSIS PROPOSITION : TOWARDS GREATER KOCHI A LIVABLE METROPOLITAN AREA			
Name	type your name here		
Profession/Designation	type your profession/designation here		
Mob	type your mobile number here		
Criteria	**Strengths**	**Weaknesses**	**Criteria**
Nature and Resources	Type your opinion here	Type your opinion here	**Nature and Resources**
Infrastructure and Service Demand	Type your opinion here	Type your opinion here	**Infrastructure and Service Demand**
People and Competencies	Type your opinion here	Type your opinion here	**People and Competencies**
Political and Social	Type your opinion here	Type your opinion here	**Political and Social**
Economic and Financial	Type your opinion here	Type your opinion here	**Economic and Financial**
Any Other	Type your opinion here	Type your opinion here	**Any Other**
Criteria	**Opportunities**	**Threats**	**Criteria**
Nature and Resources	Type your opinion here	Type your opinion here	**Nature and Resources**
Infrastructure and Service Demand	Type your opinion here	Type your opinion here	**Infrastructure and Service Demand**
People and Competencies	Type your opinion here	Type your opinion here	**People and Competencies**
Political and Social	Type your opinion here	Type your opinion here	**Political and Social**
Economic and Financial	Type your opinion here	Type your opinion here	**Economic and Financial**
Any Other	Type your opinion here	Type your opinion here	**Any Dther**

ANNEXURE 2

DETAILED TOWN PLANNING SCHEMES IN GREATER KOCHI			
Sl No	Name of scheme	Area in Hects	Date of Government sanction and G O No
1	M G Road II	4.1	GO (MS)289/ 69/ DD Dtd 13.10.69.
2	Elamkulam West	62.87	GO (MS)290/69/ DD Dtd 15.10.69
3	Kaloor	45.94	GO (MS) 106/71/LAD dtd 21.7.91& RR dtd 12/12/94
4	Ernakulam Foreshore Reclamation	25.29	GO(MS)78/71 dtd 17/6/71
5	Pattupurackal Trikkakara	220	GO (MS) 126/71/LAD dtd 19.8.71
6	M G Road I	6.3	GO (MS) 133/71/LAD dtd 28.8.71
7	Thottakkattukara Alwaye	74	GO (MS) 207/73/ LA & SWD dtd 17/5/73
8	Thevara Perandoor Canal I	29.95	GO (MS) 228/73/LA &SWD dtd 30.5.73
9	Thevara Perandoor Canal I & II	14.5	GO (MS) 18/78 /LA &SWD dtd 25.1.78
10	Elamkulam North	57.32	GO (MS) 44 / 74/LA &SWD dtd 26.2.74
11	Rameswaram West	142	GO (MS) 129/74/LA &SWD dtd 14.6.74

DETAILED TOWN PLANNING SCHEMES IN GREATER KOCHI			
12	Ernakulam South Commercial Centre	11.53	GO (MS) 137/74/LA &SWD dtd 18.6.74
13	Elamkulam Road	86.75	GO (MS) 116/75/LA &SWD dtd 15.5.75
14	Alwaye Vicinity Control	6.6	GO (MS) 201/77/LA &SWD dtd 22.7.77
15	Elamkulam West Extension	118	GO (MS) 329/77/LA &SWD dtd 16.11.77
16	Perandoor Road	76	GO (MS) 345/77/LA &SWD dtd 30.11.77
17	Kadavanthra Road	23.48	GO (MS) 247/78/LA &SWD dtd 24.10.78
18	Vicinity Area of Cochin Shipyard	12.5	GO (MS) 264/80/LA &SWD dtd 24.10.80
19	Ernakulam Stadium Bus Stand Complex	56.68	GO (MS) 56/81/LA &SWD dtd 25.3.81
20	Church Landing Road I & II	16.47	GO (MS) 70/84/LA &SWD dtd 13.3.84
21	Ernakulam South Railway Station Area	40	GO (MS) 108/84/LA &SWD dtd 16.4.84
22	Alwaye Kottarakadavu	8	GO (MS) 100/85/LA &SWD dtd 16.5.85
23	Kaloor Palarivattom Road	76	GO (MS) 75/86/LAD dtd 7.4.86
24	Elamkulam East	76.5	GO (MS) 53/88/LAD dtd 30.3.88

ANNEXURE 3

LOCAL BODIES INCLUDED IN THE MICRO STUDY AREA*				
Name	**Area in MSA in Hect**	**popden68**	**popden02**	**popden21BAU**
Alangad	298.76	1285	1912	2302
Aluva(M)	1300.70	3218	3732	4825
Angamaly(M)	1627.24	952	1183	1433
Chengamanad	1263.88	1187	1799	2104
Cheranallur	262.28	1864	2485	2873
Choornikkara	982.21	1425	2623	3152
Cochin Corporation	2386.05	4308	6277	7528
Edathala	39.81	975	2259	2709
Eloor	738.89	1545	3173	3883
Kadungalloor	1189.72	983	1971	2375
Kalady	1488.67	1169	1644	2028
Kalamasserry(M)	1894.88	918	2340	2810
Kanjoor	1026.80	1030	1512	1857
Karukutty	1256.21	630	799	947
Karumalloor	442.01	936	1589	1913
Keezhmad	281.56	919	1779	2112
Koovappady	2531.70	846	1062	1282
Kunnukara	62.33	505	1041	1265
Mala CD block	725.55	630	1137	1441
Malayattoor-Neeleshwaram	125.15	294	735	889
Mookkannoor	378.49	409	1065	1243
Mulavukad	30.43	2518	1185	1444
Nedumbassery	1934.35	842	1312	1585
Parakkadavu	941.19	824	1216	1441
Perumbavoor(M)	1043.09	1432	1951	2277
Rayamangalam	295.93	602	922	1100
Sreemooanagaram	64.46	1052	1701	2110
Thrikkakara	663.33	845	2403	2935
Thuravoor	1306.55	377	1587	1958
Vazhakkulam	309.98	871	1745	2058
Vengola	1046.25	607	1202	1430

* Micro Study Area includes 4 out of six Municipalities and Cochin Corporation(part) of GKMA. Since it is a 3 km buffered area on both sides of the highways it includes panchayats outside GKMA also.

ANNEXURE 4

ATTRIBUTE INFORMATION OF 281 GRID POINTS
Distance in Kilometer, Area in Hectares

OBJECTID	pop68	pop02	discbd	dispts	disrd	bu68	bu02	pop21	$bu21_{BAU}$
1	233	735	27.294	7.81	3.5	3.881	7.4514	1442	16.82804
2	253	982	27.459	7.211	2.5	3.414	9.9568	1442	16.77467
3	502	772	27.658	6.708	1.5	6.779	7.8288	1440	16.6891
4	607	1615	27.892	6.324	0.5	8.2	16.3775	1441	16.62402
5	257	872	28.16	6.082	1.5	3.536	9.3588	1262	14.51104
6	360	423	28.46	6	2.5	5.051	5.8693	948	10.04337
7	423	1287	26.305	7.071	3.5	5.657	13.0458	1440	17.12674
8	529	845	26.476	6.403	2.5	5.567	8.5625	1441	17.08204
9	753	1137	26.683	5.83	1.5	7.906	11.5052	1441	17.01508
10	1096	1685	26.925	5.385	0.5	11.298	17.2973	1420	16.71253
11	659	962	27.202	5.099	1.5	7.095	11.6445	1094	12.63854
12	302	497	27.513	5	2.5	3.295	6.8877	947	10.33356
13	343	389	27.856	5.099	3.328	4.41	5.3916	946	10.20648
14	827	1326	25.495	5.656	2.5	6.382	10.4485	1441	17.39935
15	639	1105	25.709	5	1.5	4.303	8.1121	1441	17.33013
16	1236	1151	25.961	4.472	0.5	11.887	14.6161	1256	15.14952
17	334	1456	26.248	4.123	1.5	3.637	20.1648	947	10.74274
18	515	554	26.57	4	1.914	5.617	7.671	947	10.63859
19	431	542	26.925	4.123	2.736	5.175	5.6538	1039	11.94013
20	933	1085	24.515	5	2.5	5.062	7.9459	1441	17.71634
21	168	1534	24.738	4.242	1.5	1.124	11.2316	1441	17.64421
22	978	840	25	3.605	0.5	9.799	11.4362	1277	15.71368
23	1063	1419	25.298	3.162	0.5	11.589	19.6483	947	11.05003
24	738	634	25.632	3	1.5	8.045	8.7769	947	10.94199
25	587	944	26	3.162	2.5	8.084	8.2897	1114	13.30409
26	1511	1499	23.537	4.472	2.736	9.752	10.9738	1440	18.02208
27	1071	1416	23.769	3.605	1.914	7.163	10.3651	1441	17.95764
28	697	628	24.041	2.828	1.5	6.531	8.1032	1389	17.30819
29	887	1144	24.351	2.236	0.5	9.65	15.8395	984	11.94185
30	559	663	24.698	2	1.5	6.097	9.1829	947	11.24411
31	613	1073	25.079	2.236	2.5	8.417	9.5385	1110	13.54705
32	462	1251	25.495	2.828	3.328	7.814	9.4748	1243	15.14131
33	1015	1336	22.803	3.162	2.5	6.796	9.7997	1441	18.2701
34	1108	862	23.086	2.236	1.5	9.611	10.7015	1434	18.10417
35	862	814	23.409	1.414	0.5	8.041	10.9547	1367	17.26872
36	252	660	23.769	1	1.5	2.234	7.1594	1446	18.01056
37	293	1059	24.166	1.414	1.914	4.408	10.2836	1720	20.533
38	266	1133	24.596	2.236	2.5	4.32	9.8013	1551	18.81393
39	862	1404	25.059	3.162	2.736	7.142	12.7165	1564	18.79168
40	1106	1140	21.84	3	2.5	8.368	10.1993	1438	18.54976
41	803	595	22.135	2	1.5	7.201	7.9449	1433	18.40113
42	795	1040	22.472	1	0.5	7.124	13.8984	1433	18.29212

OBJECTID	pop68	pop02	discbd	dispts	disrd	bu68	bu02	pop21	bu21zw
43	1642	3878	22.847	0	0.5	16.888	41.4686	1797	21.62867
44	295	1768	23.259	1	1.5	4.86	17.0294	1958	22.80622
45	439	1465	23.706	2	1.5	7.244	14.1063	1958	22.66163
46	155	353	24.186	3	1.914	2.561	3.4028	1958	22.50637
47	463	863	24.698	4	2.5	7.634	8.3131	1958	22.34076
48	320	591	25.238	5	2.736	4.608	5.8051	1895	21.66647
49	29	66	20.615	4.123	2.736	0.252	0.6873	1553	20.12131
50	176	174	20.88	3.162	1.914	1.462	2.1295	1470	19.19651
51	243	1395	21.189	2.236	1.5	2.174	18.6423	1433	18.70712
52	1863	2494	21.54	1.414	0.5	16.694	33.3268	1433	18.59359
53	2075	2215	21.931	1	0.5	18.739	28.8112	1464	18.79407
54	1013	1387	22.36	1.414	0.5	10.31	15.7344	2785	28.47935
55	570	2549	22.825	2.236	0.5	9.332	24.5637	1953	22.90754
56	236	792	23.323	3.162	1.5	3.896	7.6233	1958	22.78552
57	295	1584	23.853	4.123	1.5	4.847	15.2518	1958	22.61408
58	323	818	24.413	5.099	1.914	3.847	8.6379	2006	22.80293
59	951	1127	25	6.082	2.5	8.641	13.7249	1638	19.51699
60	371	938	25.612	7.071	2.736	10.851	14.3907	1068	12.78539
61	711	499	19.416	5.385	2.736	5.237	5.8892	1554	20.51897
62	756	542	19.646	4.472	2.5	6.588	8.0342	1585	20.74633
63	717	656	19.924	3.605	1.5	6.244	9.7156	1583	20.63711
64	768	1814	20.248	2.828	0.5	6.699	25.4207	1546	20.17101
65	1159	1814	20.615	2.236	0.5	10.273	25.0513	1492	19.50916
66	607	832	21.023	2	1.5	5.419	11.3849	1459	19.03551
67	741	1027	21.47	2.236	1.5	6.631	13.7937	1445	18.74362
68	366	1428	21.954	2.828	0.5	4.516	15.2388	1740	21.4251
69	535	2017	22.472	3.605	0.5	7.187	20.1979	1983	23.2546
70	1189	1674	23.021	4.472	0.5	12.22	18.3258	2012	23.29882
71	724	1538	23.6	5.385	1.5	6.847	17.5844	2028	23.23254
72	1652	1779	24.207	6.324	1.5	15.619	20.3395	1913	22.14438
73	1118	1778	24.839	7.28	1.914	11.097	20.5794	1910	21.91598
74	687	775	25.495	7.28	2.736	7.977	9.0698	1992	22.34596
75	749	562	18.248	6.324	2.736	5.635	8.1721	1529	20.64901
76	658	789	18.439	5.83	1.914	5.735	11.6846	1585	21.13674
77	1337	1101	18.681	5	1.5	11.65	16.3151	1547	20.68775
78	377	859	18.973	4.242	1.5	3.289	12.7236	1585	20.96401
79	1030	1015	19.313	3.605	0.5	8.972	15.0312	1585	20.85404
80	638	1111	19.697	3.162	1.5	5.56	16.4517	1585	20.72983
81	831	1642	20.124	3	1.914	7.238	24.3258	1585	20.59171
82	850	1153	20.591	3.162	1.914	7.473	16.32	1505	19.64945
83	668	984	21.095	3.605	1.5	6.156	12.2945	1649	20.88235
84	626	1144	21.633	4.242	1.5	5.915	13.0802	2028	23.86878
85	1429	1961	22.203	5	0.5	13.511	22.4306	2028	23.68441
86	1414	2188	22.803	5.83	0.5	13.371	25.0244	2028	23.49033
87	2425	3536	23.43	6.708	0.5	22.929	40.442	1750	21.03522
88	814	1090	24.083	6.708	1.5	7.644	12.4709	1346	16.81421

OBJECTID	pop68	pop02	disch0	dispts	disrd	bu68	bu02	pop21	bu21sw
89	1133	1703	24.758	6.324	2.5	9.943	19.62	1304	16.11159
90	1001	1078	25.455	6.082	2.736	9.632	12.4461	1284	15.65002
91	1047	1159	17.262	5.385	2.5	6.222	13.0252	1711	22.68602
92	1523	1899	17.464	5.099	1.5	9.159	21.695	1924	24.41307
93	1687	2346	17.72	5	0.5	9.49	27.304	1897	24.11436
94	1024	1686	18.027	5	0.5	8.218	24.1793	1688	22.23182
95	1073	1049	18.384	4.472	0.5	9.018	15.2216	1613	21.42205
96	820	2663	18.788	4.123	1.5	7.144	39.4504	1585	21.02385
97	1044	4440	19.235	4	2.5	8.882	64.959	1594	20.96577
98	961	1780	19.723	4.123	2.736	7.992	23.2947	1499	19.86919
99	942	992	20.248	4.472	2.5	6.409	12.897	1499	19.69938
100	558	715	20.808	5	1.914	5.245	8.1437	1894	23.09134
101	839	886	21.4	5.656	1.5	7.724	9.8694	1921	23.11609
102	1185	1297	22.022	6.403	1.5	10.953	14.4134	1317	17.14812
103	1269	1546	22.671	6.403	0.5	11.477	17.7694	1141	14.74674
104	520	757	23.345	5.83	1.5	4.564	8.7308	1310	16.63877
105	248	258	24.041	5.385	1.5	2.152	2.9826	1282	16.08358
106	372	356	24.758	5.099	1.914	3.223	4.1114	1282	15.85165
107	826	729	25.495	5	2.736	7.08	8.4234	1282	15.61326
108	1504	1559	16.278	4.472	2.5	7.623	11.7611	2608	29.4435
109	1920	1585	16.492	4.123	1.5	8.243	14.3617	2820	30.5682
110	2112	2143	16.763	4	0.5	8.518	21.7904	2048	25.59395
111	553	2023	17.088	4.123	1.5	2.229	20.5688	2103	25.89368
112	488	1230	17.464	4.472	1.5	2.002	13.9594	1966	24.74296
113	661	1153	17.888	5	1.914	5.761	17.0807	1585	21.31497
114	986	3742	18.357	5	2.736	6.258	44.6495	1856	23.57452
115	450	1938	20	5.83	2.736	3.515	20.7795	1871	23.16604
116	1202	1595	20.615	6.403	2.5	10.74	17.0468	1420	18.75357
117	234	529	21.26	6.403	1.5	2.148	5.9613	979	12.86384
118	414	503	21.931	5.656	0.5	3.588	5.8026	866	10.77317
119	1190	1841	22.627	5	0.5	10.326	21.2558	1257	16.2401
120	824	1163	23.345	4.472	0.5	7.149	13.4294	1282	16.3087
121	518	536	24.083	4.123	1.5	4.493	6.1924	1282	16.06999
122	1338	1641	24.839	4	2.5	11.61	18.9503	1282	15.82545
123	646	755	25.612	4.123	3.328	8.419	8.7157	1281	15.5635
124	429	715	15.132	4.242	2.736	2.197	5.1795	1913	25.07978
125	1198	1758	15.297	3.605	1.914	6.476	13.1737	2510	29.17571
126	580	819	15.524	3.162	1.5	2.545	6.8645	3351	33.51687
127	1719	2457	15.811	3	0.5	6.933	24.9802	2104	26.314
128	610	1502	16.155	3.162	1.5	2.461	15.2735	2035	25.69334
129	736	642	16.552	3.605	2.5	2.969	6.5307	2021	25.45946
130	1451	1724	17	4.242	2.736	6.926	19.0465	1970	24.9241
131	1882	2300	19.849	6.708	2.736	16.815	24.5223	1857	23.10015
132	801	1076	20.518	5.83	1.914	7.129	11.5334	1407	18.64444
133	355	550	21.213	5	1.5	3.137	6.1061	1257	16.69747
134	321	269	21.931	4.242	1.5	2.788	3.1039	912	11.56381

OBJECTID	pop68	pop02	discbd	dispctr	disrd	bu68	bu02	[illegible]	[illegible]
135	1438	1342	22.671	3.605	0.5	12.473	15.4958	1282	16.52672
136	1087	1613	23.43	3.162	1.5	9.428	18.6203	1282	16.28121
137	912	891	24.207	3	1.914	7.91	10.2876	1282	16.02988
138	1309	937	25	3.162	2.736	9.421	10.8201	1281	15.76146
139	1129	1250	14.035	4.472	3.5	6.217	10.2312	2153	27.24016
140	1111	1724	14.142	3.605	2.5	6.899	12.479	1913	25.40001
141	1902	2485	14.317	2.828	1.5	10.151	18.5587	2710	30.6639
142	1189	2240	14.56	2.236	0.5	5.894	17.5448	4584	38.61507
143	1632	1984	14.866	2	0.5	7.386	17.6001	3130	32.68745
144	609	1409	15.231	2.236	1.5	2.477	14.2116	2038	26.01472
145	1318	1119	15.652	2.828	2.5	5.496	10.9574	2731	30.35
146	567	1296	16.124	3.605	3.5	3.73	14.2396	2770	30.41394
147	1408	1538	19.798	5.385	2.736	13.746	16.3949	1857	23.11664
148	849	1573	20.518	4.472	2.5	7.591	16.762	1857	22.88375
149	587	566	21.26	3.605	1.5	5.24	6.057	1150	15.32316
150	1304	1890	22.022	2.828	0.5	11.311	21.8161	1243	16.26469
151	957	1839	22.803	2.236	0.5	8.692	21.7466	1453	18.39679
152	783	909	23.6	2	1.5	6.811	10.512	1288	16.29755
153	533	684	24.413	2.236	2.5	4.621	7.9024	1282	15.96325
154	236	382	25.238	2.828	3.328	3.07	4.406	1281	15.68447
155	2194	2392	13.038	4.123	3.5	7.701	21.8483	2302	28.58491
156	984	2040	13.152	3.162	2.5	5.276	18.4912	2274	28.36108
157	1533	3232	13.341	2.236	1.5	13.351	30.8318	2919	32.11453
158	1746	3455	13.601	1.414	0.5	11.933	29.2774	3443	34.55264
159	1629	2703	13.928	1	1.5	8.071	20.6758	3260	33.61252
160	1188	1243	14.317	1.414	1.914	5.53	10.0319	3926	36.32653
161	1843	2247	14.764	2.236	2.736	8.947	17.4061	4666	38.81994
162	645	1061	19.849	4.123	2.736	6.13	11.3072	1857	23.10015
163	354	576	20.615	3.162	1.914	3.155	6.1576	1259	16.91519
164	632	1614	21.4	2.236	1.5	5.519	18.5853	1323	17.41875
165	1625	2095	22.203	1.414	0.5	16.849	26.1369	2075	24.03442
166	1044	1191	23.021	1	1.5	10.121	14.6189	2020	23.35944
167	653	833	23.853	1.414	1.914	5.961	9.8761	1465	18.18281
168	326	395	24.698	2.236	2.736	4.133	4.5709	1283	15.88297
169	728	1764	12.041	4	3.5	3.22	16.2481	2304	28.92066
170	1196	1853	12.165	3	2.5	9.653	18.6532	2357	29.22799
171	1096	1288	12.369	2	1.5	10.647	13.3586	2227	28.29529
172	1498	2791	12.649	1	0.5	14.215	28.791	2055	26.97679
173	4924	3969	13	0	0.5	25.889	31.6726	2663	30.82262
174	1348	1716	13.416	1	1.5	6.682	13.1316	2799	31.44898
175	905	757	13.892	2	2.5	4.992	6.366	4103	37.13766
176	1321	2002	20	3	2.5	10.863	22.5482	2016	24.30633
177	1023	2200	20.808	2	1.5	10.563	25.4842	1942	23.47367
178	3447	3550	21.633	1	0.5	36.459	44.7497	2277	25.63795
179	4310	5407	22.472	0	0.5	45.584	68.1693	2277	25.36657
180	1011	1500	23.323	1	1.5	10.692	18.9141	2277	25.09131

OBJECTID	pop68	pop02	discbd	dispts	disrd	bu68	bu02	pop21	bu21avg
181	672	1157	24.186	2	1.914	10.366	14.5821	2203	24.30744
182	707	1473	11.18	3.162	2.736	6.869	15.2801	2299	29.16597
183	642	1276	11.401	2.236	1.914	6.232	13.2282	2133	27.94958
184	463	946	11.704	1.414	1.5	4.47	9.79	2106	27.65696
185	10100	9233	12.083	1	0.5	59.242	79.826	3788	36.5025
186	4604	6670	12.529	1.414	1.5	22.818	51.3776	4595	39.30863
187	1523	2569	13.038	2.236	2.5	8.47	22.2212	2689	30.95876
188	513	936	19.416	3.162	2.736	6.176	10.0678	1912	23.68609
189	526	1227	20.248	2.236	1.914	5.483	13.8863	2009	24.17298
190	773	2106	21.095	1.414	1.5	8.317	23.2501	1799	22.21237
191	812	1548	21.954	1	0.5	8.603	18.6355	2193	24.9599
192	612	1065	22.825	1.414	0.5	6.471	13.4241	2277	25.25239
193	237	555	23.706	2.236	1.5	3.666	7.002	2278	24.97413
194	242	2522	10.198	3.605	2.5	2.355	26.1562	2329	29.68167
195	414	922	10.44	2.828	1.5	4.002	9.5616	2067	27.78026
196	1569	2027	10.77	2.236	0.5	12.967	20.5075	2532	30.77333
197	2168	3152	11.18	2	0.5	16.978	31.0791	3194	34.18893
198	1224	3500	11.661	2.236	1.5	7.892	32.7523	3487	35.37415
199	1173	1118	12.206	2.828	2.5	6.313	10.6305	2331	29.04527
200	181	983	19.723	2.828	2.736	1.653	9.3834	1446	19.31928
201	937	2352	20.591	2.236	1.914	10.375	22.4267	1430	18.86853
202	273	667	21.47	2	1.5	3.015	6.3861	1535	19.66666
203	763	1032	22.36	2.236	0.5	8.065	13.0073	2261	25.29507
204	305	1002	23.259	2.828	0.5	4.715	12.6235	2278	25.11871
205	1179	2537	9.055	4	2.736	10.288	28.5514	2768	32.68945
206	217	1000	9.219	4.123	1.914	2.752	12.9896	2194	29.08613
207	651	1532	9.486	3.605	1.5	6.192	17.3969	2499	30.98824
208	2303	3307	9.848	3.162	0.5	18.672	33.2555	3119	34.25679
209	813	1434	10.295	3	1.5	6.589	14.4218	3152	34.27298
210	1192	3072	10.816	3.162	1.914	9.661	30.8885	3152	34.10446
211	726	2349	11.401	3.605	2.736	6.906	23.6405	3140	33.85696
212	756	1182	20.124	3.162	2.736	8.376	11.27	1430	19.01959
213	310	642	21.023	3	1.914	3.431	6.117	1430	18.7288
214	234	399	21.931	3.162	1.5	2.115	3.7189	1515	19.31719
215	663	1201	22.847	3.605	0.5	7.788	10.4465	1247	16.04692
216	1081	4248	8	3.162	2.736	12.842	56.363	3883	38.20159
217	1021	2925	8.062	3	1.914	13.742	38.8073	3530	36.72551
218	1414	2210	8.246	3.162	1.5	19.19	29.6793	3532	36.67465
219	1424	1981	8.544	3.605	0.5	14.37	23.4297	2907	33.60324
220	811	998	8.944	4.123	0.5	9.787	13.5197	2937	33.6307
221	507	1334	9.433	4	1.5	6.509	16.6659	2969	33.63808
222	682	1656	10	4.123	2.5	5.527	16.655	3147	34.34415
223	481	810	20.615	4	2.736	5.328	7.7215	1430	18.86077
224	271	337	21.54	4.123	1.914	2.377	2.9432	1242	16.4083
225	215	853	22.472	4.472	1.5	2.38	7.0464	1100	14.25206
226	2519	5597	7.071	2.828	3.328	33.553	64.635	3461	36.7445

OBJECTID	pop68	pop02	[illegible]	[illegible]	[illegible]	hu68	hu02	pop21	hu21 [illegible]
227	2980	3525	7	2.236	2.5	40.129	46.8921	3856	38.41845
228	2030	2838	7.071	2	1.5	33.197	46.8333	2923	34.16355
229	672	1961	7.28	2.236	0.5	11.112	33.0309	2608	32.354
230	892	2285	7.615	2.828	0.5	14.894	38.7963	2781	33.22681
231	763	1662	8.062	3.605	1.5	12.749	28.2304	2810	33.2407
232	790	1260	8.602	4.472	1.914	13.145	21.3737	2811	33.07147
233	995	2546	9.219	5.099	2.736	14.388	26.946	2907	33.38491
234	899	1613	20.248	5	3.328	12.486	15.3829	1430	18.97948
235	931	1348	21.189	5.099	2.736	10.162	12.6695	1362	17.93082
236	611	1458	22.135	5.385	2.5	6.858	12.075	1103	14.40267
237	2080	2216	6.082	2.236	2.736	15.247	20.7987	2918	34.4573
238	1577	2660	6	1.414	1.914	20.664	34.4065	3550	37.4788
239	760	1703	6.082	1	1.5	12.556	28.7455	2663	33.06032
240	1949	3394	6.324	1.414	0.5	32.558	57.6401	2810	33.80288
241	488	2098	6.708	2.236	1.5	8.15	35.6304	2810	33.67867
242	440	896	7.211	3.162	1.914	7.354	15.2192	2810	33.51597
243	170	2392	7.81	4.123	2.736	2.363	40.6342	2810	33.32221
244	1071	1671	5.099	2	2.5	7.469	13.7569	3800	38.80986
245	1282	2262	5	1	1.5	12.23	28.581	3540	37.75916
246	1506	2959	5.099	0	0.5	25.149	50.2553	2810	34.19911
247	1158	3664	5.385	1	0.5	19.333	62.2216	2810	34.1066
248	1214	2261	5.83	2	1.5	20.177	38.4174	2810	33.96267
249	1268	2612	6.403	3	2.5	16.959	44.4728	2812	33.78819
250	2269	2068	4.472	3.162	2.736	10.852	13.809	7528	49.45623
251	2918	2630	4.123	2.236	1.914	13.344	17.5537	7158	48.79919
252	2104	6989	4	1.414	1.5	10.256	51.2094	6629	47.66609
253	1019	3886	4.123	1	0.5	15.802	62.7893	3152	36.26938
254	862	2774	4.472	1.414	1.5	13.985	47.3948	2825	34.48325
255	776	2795	5	2.236	1.914	11.516	49.4076	2876	34.5858
256	784	1907	5.656	3.162	2.736	11.671	34.6516	2929	34.65257
257	729	1614	3.605	2.828	2.5	3.332	10.7759	5703	45.4953
258	4139	5334	3.162	2.236	1.5	18.928	35.6065	7528	49.87996
259	3365	5018	3	2	0.5	15.386	33.4974	7277	49.41432
260	2600	4553	3.162	2	0.5	16.337	46.1082	4868	43.22016
261	963	2391	3.605	2.236	1.5	13.236	43.4827	2929	35.31599
262	791	2104	4.242	2.828	2.5	10.809	38.3421	2935	35.14121
263	771	476	3.605	3.162	2.736	4.375	4.6529	6701	47.95889
264	2991	4377	2.828	2.236	1.914	13.678	29.2127	6504	47.75437
265	4005	6863	2.236	1.414	1.5	18.314	45.81	7347	49.80769
266	7616	7870	2	1	0.5	34.824	52.5408	7273	49.72938
267	3914	5798	2.236	1.414	1.5	18.684	40.6176	7059	49.1968
268	916	2767	2.828	2.236	1.914	10.084	44.4922	331	2.259645
269	977	2527	3.605	3.162	2.736	11.763	46.0571	2935	35.34725
270	3432	3286	3.162	3	2.5	16.894	28.3079	6406	47.4144
271	5258	8451	2.236	2	1.5	24.045	56.4084	7481	50.08381
272	4361	7219	1.414	1	0.5	19.944	48.1864	7430	50.24519

OBJECTID	pop68	pop02	disch[illegible]	dispts	disrd	sbu68	bu02	pop21	[illegible]
273	5326	8518	1	0	0.5	24.354	56.8551	7528	50.57928
274	4024	5329	1.414	1	1.5	18.398	35.5715	7112	49.57696
275	2875	4907	2.236	2	2.5	14.418	39.0881	6497	47.92941
276	11850	9364	3	3.162	2.736	51.056	62.5053	7528	49.93236
277	5280	8327	2	2.236	1.914	24.143	55.5827	7225	49.62823
278	4259	7670	1	1.414	1.5	19.477	51.1943	7528	50.57928
279	6406	8401	0	1	0.5	29.292	56.0758	7528	50.90274
280	6425	7629	1	1.414	1.5	29.38	50.9242	7424	50.36676
281	1571	7159	2	2.236	2.5	7.184	47.7872	7197	49.56891

ANNEXURE 5

UN-HABITAT

United Nations Human Settlements Programme

Programme des Nations Unies pour les établissements humains - Programa de las Naciones Unidas para los Asentamientos Humanos
P.O. Box 30030, Nairobi 00100, KENYA Telephone: (254-20) 62 1234 Fax. (254-20) 624266/7 (Central Office)
Email: infohs.pitar@unhabitat.org Website: http://www.unhabitat.org

Nairobi, 20.6.2005

Dear May Mathew,

I am pleased to inform you that the Greater Cochin Development Authority has been certified as a member of the Global Urban Observatory Network by successfully meeting the general criteria for the establishment and implementation of a Local Urban Observatory for the Great Cochin Metropolitan Area, India.

The Global Urban Observatory looks forward to building a partnership with the the Greater Cochin Development Authority and other local partners for the further development of the Local Urban Observatory. As a next step, we propose to jointly develop a workplan for the Urban Observatory with concrete steps and achievable results.

Please do not hesitate to contact me for any further information or clarification.

Yours sincerely,

Eduardo Lopez Moreno
Chief, Global Urban Observatory

May Mathew
Town Planner
Greater Cochin Development Authority
Cochin-682020
India