AN ASSESSMENT OF GREEN GROWTH: THIRUVANANTHAPURAM CORPORATION WITH A CASE STUDY OF TWO WARDS

NITESH KUMAR
Centre for Development Studies, Thiruvanathapuram

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ABSTRACT

In the face of rapidly increasing urbanization and population, there is a constant pressure on the earth's resources. Keeping this in mind in our race for growth and development, it is very important to ensure this growth is green and sustainable.

Thiruvananthapuram, located in the serene beauty of the coast of Kerala, prided itself on being an 'evergreen city', in the words of Mahatma Gandhi. But with a growing influx of urbanization this paper tries to assess a few green growth components to determine Thiruvananthapuram's path ahead in the factors of Green Growth namely, Land use, Ecosystem and Biodiversity and Solid Waste Management. A spatiotemporal study is also conducted of two wards with respect to these components.

ACKNOWLEDGMENTS

This Research Project was made possible due to the support of various mentors, institutions and family.

I would first and foremost like to thank my institute, Centre for Development Studies and Professor Sunil Mani for having made this internship possible.

I would like to thank State Planning Board, Kerala for creating this opportunity to work on an upcoming and dynamic topic of Green Growth. I would like to thank Shri K. M. Chandrashekhar, Vice Chairman and Alok Sheel, Member Secretary for giving me this great opportunity to broaden my horizons about green growth practices.

I would like to acknowledge, with much appreciation, the constant support and guidance of Shri. K. Nair, chief of the Plan Coordination Division who conducted regular Status-Review meetings with all the interns so as to make sure we were on the right track in terms of our project.

I am especially extremely grateful for the guidance and support given to me by my mentor at State Planning Board, Dr. P. Rajasekharan, Chief, Agriculture Division. His valuable suggestions and pioneering ideas have made this project what it is today. I am thankful for his patience and help.

Finally, I am grateful for the support given to me by my family and friends.

INTRODUCTION

India has seen a rapid population surge, growing at the rate of 17.64%. India is under a demographic transition where about 632 million Indians (52.3%) are below the age 25 with 260 million (21%) between age 15 and 25[i].
The pressure of young and mobile population is increasingly felt on the urban sector and resources. Classified towns have increased from 5161 in 2001 to 7935 in 2011.Over the next few decades, India is expected to grow at a rate of 8 % by 2020 and during this period, it will build tremendous infrastructure, industrial capacity, vehicles stock, etc.

There is a growing demand for food, housing, create pressures for land use. Growth of this magnitude will come along with depletion of natural resources as well as environmental degradation.
The central question is how these demands can be meet or managed in a way that peoples are also better off with environment sustainability to create a vibrant city that has integrated land use with Minimum conflict between Green spaces and built up area

Work on a sustainable inclusive path for Thiruvananthapuram corporation through which services such as drainage ,sanitation ,waste management for increased demand can be provided along with protecting the environment ,conserving city natural resources and ensuring green growth. They don't necessarily come at cost of each other as usually suspected. This is simply because, technology increases the efficiency with which it uses resources and the adaptation of clean technologies is made possible due to the far reaching benefits they provide in the long run.

OBJECTIVES OF THE STUDY

- To define green growth in the context of Thiruvananthapuram Corporation by focusing on three vital components of sustainable Green Growth; Land Use Pattern, Ecosystem and Biodiversity and Solid Waste Management
- To study the adoption of Green Growth strategies in Thiruvananthapuram corporation within the framework defined by ICLEI-Local Governments for Sustainability and Global Green Growth Institute (GGGI) in the context of population growth and urbanisation.
- To study two wards for their land use pattern, pipe composting and biodiversity to understand how green growth practices should be varied according to the characteristics of a region.

METHODOLOGY

The analysis has been conducted with the help of secondary sources of data- Thiruvananthapuram Master Plan, Centre for Earth Science Studies, Thiruvananthapuram Corporation Data, and Census 2011. For the case studies, I visited Centre for Earth Science Studies to get relevant data on green growth components for Pattom and Vattiyoorkavu wards.

To analyse the ground level penetration of green growth practices in the municipal corporation of Thirvuvananthapuram, I have chosen two wards, Pattom and Vattiyoorkavu. The idea behind choosing these wards is to demonstrate that there should be a different approach to implementing green growth practices in areas which vary in land use patterns and population density. Pattom ward is located in the heart of Thiruvananthapuram corporation area with a population density of 6000-7500 persons per sq.km, while Vattiyoorkavu has a population density of 3000-4500 persons per sq.km. Hence with such varying densities, I want to analyse the performance of these wards in green growth practices in relation to the city average and the possible reasons for performance.

For the assessment of the biodiversity of the two wards, field trips were conducted to two ponds being maintained by Kerala Biodiversity Board in Pattom and Vattiyoorkavu wards. I also interviewed the surrounding households about solid waste disposal and cleanliness of the ponds.

LIMITATIONS

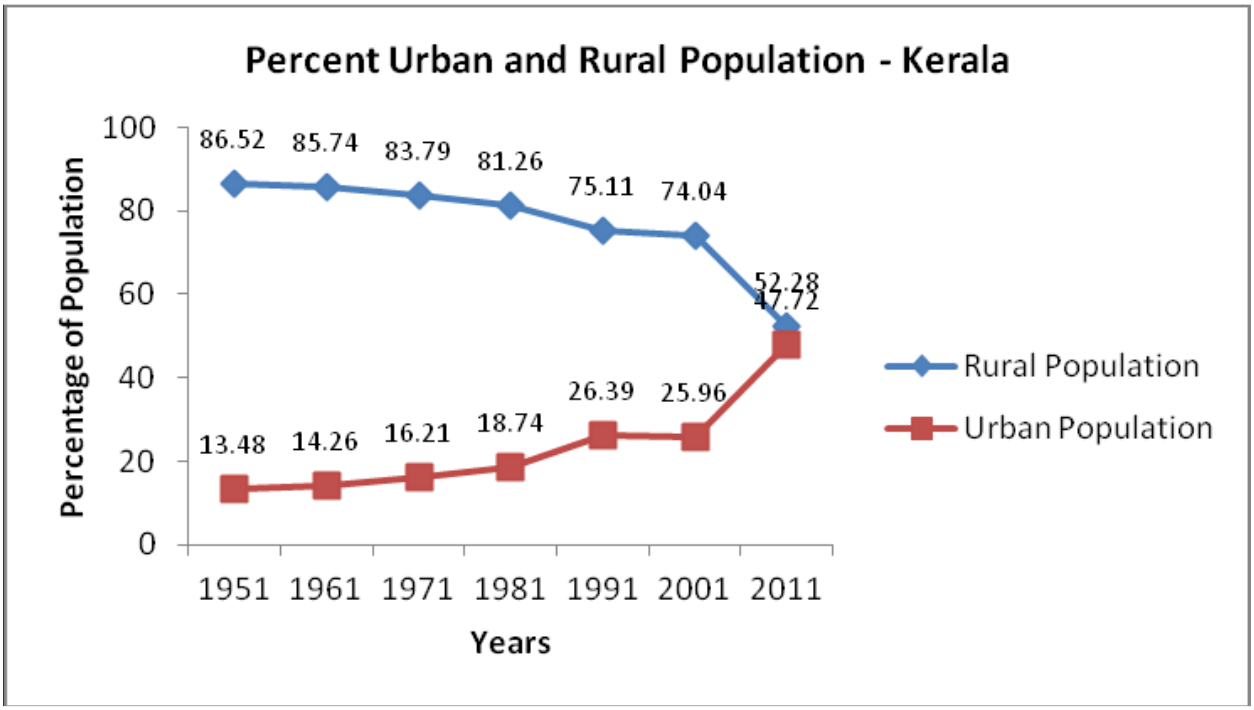
Since this is a relatively new field of research, there exists a severe paucity of data resources on green growth practices. Data on the land use pattern of Thiruvananthapuram Corporation was only available for the years 1966, 1990 and 2011. Similarly, data for analysis of Pipe composting systems was not available for recent years.

Due to time constraints I could only conduct a primary analysis of two wards of the corporation.

URBANIZATION

Urbanization as measured by share of urban population of the state, has experienced a tremendous increase from 26.39 percent in 1991 to 25.96 in 2001 to 47.72 percent in 2011. Urbanization saw a jump in Kerala after 2001.The corresponding numbers for India was 25.52 percent in 1991, 27.78 percent in 2001 and 31.16 percent in 2011[ii]. The peculiarity of Urbanization patterns in Kerala is that it is not fuelled by population growth in major cities but the growth of census towns.

In 2001, 60 statutory and 99 census towns i.e. 159 total towns were present in Kerala. In 2011, statutory towns reduced to 59 whereas census town rose to 461, which is an increase of 362 towns. Urbanization also picked up due to the re-classification of rural area into urban area which resulted in rural urban continuum.



Source: Kerala Perspective Plan, 2030

Similarly, if we look at national trends, urban centres in India grew at 7935 classified town and 475 agglomerations in 2011 from 5161 classified town and 384 urban agglomeration in 2001. These urban centres house 377 million people and expected to accommodate 590 million by 2030.
Urban areas contribute 60 % of national GDP (47 % in 80-81) and expected to increase by 75 % by 2020.

The NCAER has used the UN methodology of population projection to calculate the rural and urban population of Kerala for the years 2012−31. It shows that for the year 2025, the share of the urban population works out to 63.4 per cent and by 2031 it is likely to increase to 68.87 per. The various estimates indicate that the urban population is projected to grow over the next 20 years and, at the minimum, 70 per cent of the population in Kerala will be living in urban areas.
This sudden explosion of urbanisation has posed challenges in the provision of urban infrastructure. The number of towns increased manifold between 2001 and 2011, resulting in an urban explosion. However, most of these towns were under the jurisdiction of urban agglomerations.

Thiruvananthapuram Corporation is one of these urban agglomerations.
This can be seen by the fact that 94.8 % population of Thiruvananthapuram district reside in Urban Agglomeration to Total Urban Population in the District.
Urban population living in urban agglomerations in Kerala is very high i.e. 94.2 %.
Decadal Growth rate of urban population during 2001-2011 is 63 % in Thiruvananthapuram district.
In Thiruvananthapuram district, decline in rural population between 2001-2011 was 28.69 % mainly because of reclassification of rural areas in urban areas.

POPULATION GROWTH AND DENSITY

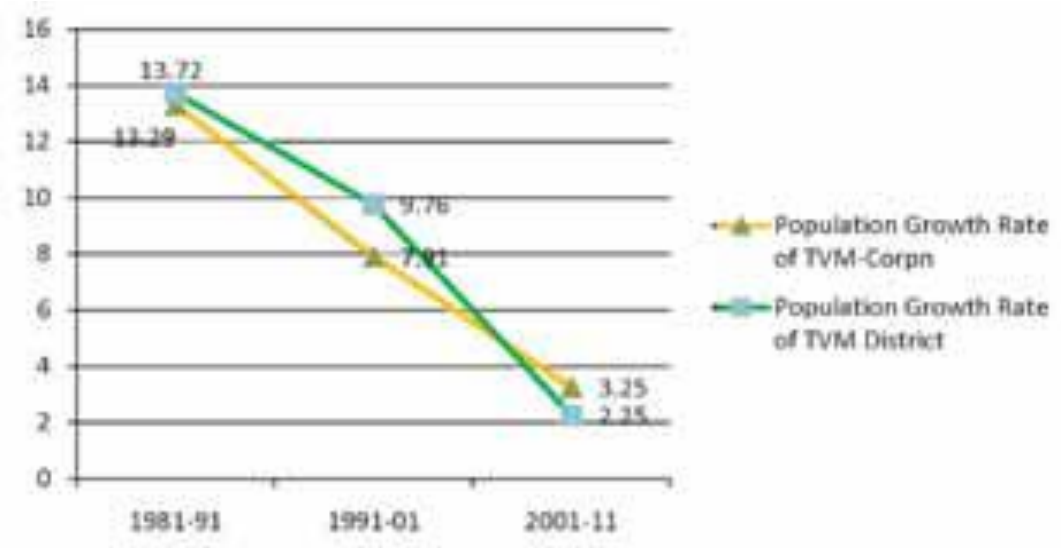
India witnessed a decennial change of 17.64 % from 1.028 billion in 2001 to 1.21 billion in 2011. Population density of India is 382 person per sq.km. Kerala population is currently is 33.4 million, an increase from 31.8 million in 2001. It increased by 1.55 million during 2001-2011. The decadal growth was 4.86 % in 2001-2011.

The population of Thiruvananthapuram district in 2011 was 3,307,284 which increased from 3,234,356 in 2001. There is a change of 2.07 % in population compared to 2001.

Thiruvananthapuram district has 78 grama panchayat, 1 municipal corporation, 4 municipal councils i.e. 83 LSG in 2001. The corporation had 81 wards in 2001 which increased to 100 wards in 2010 after the merging of 5 Panchayats i.e. Kazhokootam, Sreekaryam, Kudappanamkunnu, Vattiyoorkavu and Vizhinjam.

Currently the area of the corporation covers 221 sq. km.
Thiruvananthapuram corporation had a population of 10,32,292 in 2011 which was 10,18,642 in 2001. The table below shows the growth rate of Population of Thiruvanthapuram Corporation in comparison with the District. Corporation Population Growth rate is decreasing but it is slightly greater than that of a district during 2001-

2011.



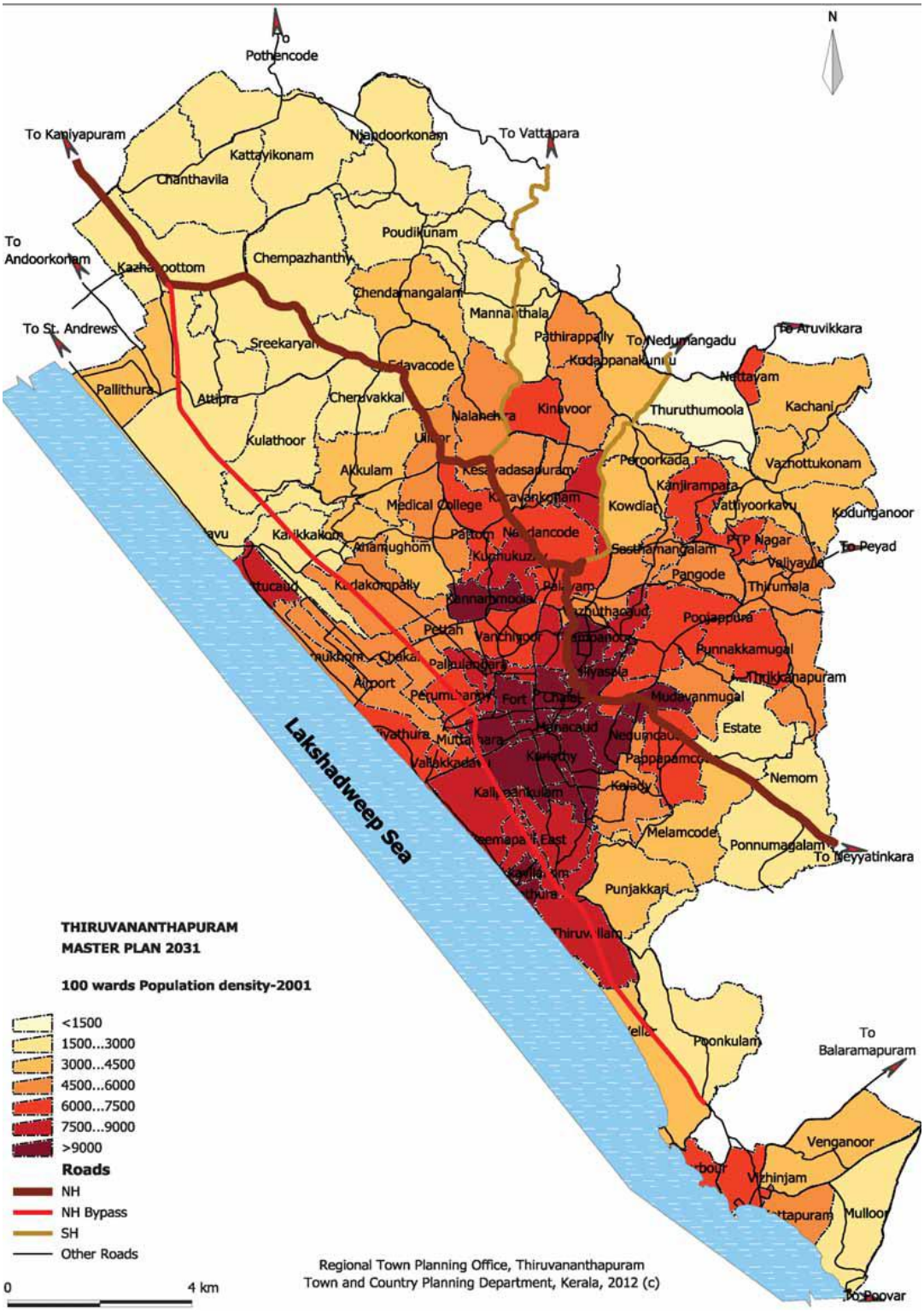
Source: Thiruvananthapuram Master Plan 2011

Population density

The Average population density of the state of Kerala is 859 persons per sq.km, 2.25 times the national average of 382.

Average population density of the district is 1509 i.e. 1.75 times higher than state average.

Currently Population density of the city is 4444 persons/sq.km. The population density is higher in the city's core area and towards the coastal areas. The areas recently merged into the corporation are less dense. The below map shows the population density of the Thiruvananthapuram corporation.



Source: Thiruvananthapuram Master Plan 2031

Population projection

For the city, population is projected by decrease rate method, since there is drastic decrease in growth rate of population in Thiruvananthapuram.

Year	Population	Population Growth Rate	% Decrease in population Growth Rate
1981	781592		
1991	885483	13.29	
2001	955494	7.91	40.48
2011	986578	3.25	58.91
2021	1018642	1.34	
2031	1032292	0.55	

Population projection for city

Inspite of a constant population in city rapid urbanisation has posed daunting challenges due to insufficient services such as water supply, sanitation, transport and power and civic administration, with the resulting environmental problem.

There is the need for green growth by which sustainable growth can happen in which city can absorb increasing population as well as provide daily necessary services without harming the environment.

WHAT IS GREEN GROWTH?

Green growth is a strategy for achieving sustainable development, converging economic growth and environmental protection, building green economy in which investment in resources, saving as well as management of natural resources are drivers of growth.

Green growth was initially defined by the experts from ICLEI, NIUA and GGGI in the 2015 report Urban Green Growth Strategies for Indian Cities as:

"Recognizing that growth is taking place in Indian cities, looking at the current state and trends, moving towards a triple bottom line (social, economic and environment) integrated solutions maximizing potential and addressing the barriers".

Green Growth is a new concept and is not much known in India**.**

COMPONENTS OF GREEN GROWTH

The components of Green Growth comprise the following eight urban sectors, as defined by the report by ICLEI –Urban Green Growth Strategies for Indian Cities -

Land Use and Density, Ecosystem & Biodiversity, Energy, Economy and Business, Housing and Buildings, Transport, Water and Sanitation, Solid Waste Management. These have been selected on the basis of the extent of infrastructure and services they cover - and that drive growth - and on their impacts on the local quality of life.

In this study, I have analysed green growth components for Thiruvananthapuram corporation which I found most relevant. Urban Land Use Pattern, Biodiversity and Solid Waste Management are the three components that I have chosen for this study. I have chosen these components for the following reasons-

- In the light of increasing agglomeration of the district, re-classification of wards and increasing urbanization, it is very important to analyse land use patterns before defining and advocating green growth strategies.
- In the case of solid waste management, Thiruvananthapuram corporation has discontinued solid waste collection since 2011. In the light of increasing population which leads to a rise in waste generation, it is imperative to analyse other systems of waste management at the source itself. Hence I have focused

on the practice of Pipe composting which is installed at the source of waste generation.

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Urban Land use

The Land use pattern in a city is the outcome of natural, socio economic factors and human interactions that take place across time and space.

The study of land use is important not only in agriculturally dominated, over populated developing regions but throughout the world because of its relationship with different human phenomena. Its importance also increased during the population pressure and decreasing man and land ratio, increasing demand for food and raw materials the need for optimum utilization of land in an integrated manner has assumed greater relevance (Lahu, 2012).

It is also useful for planners to evolute the possibilities and limitations of further spatial development to avoid or restrict undesirable trends of land exploitation to adjust the forms of land use to the land capability and to direct the expansion of intensive land utilization into suitable areas (Nageswar Rao and Vaidyanathan, 1990)

Land Use Pattern

The Urban Development Plans Formulations and Implementation(UDPFI) guidelines classify urban land uses into residential, commercial, industrial, public and semi-public, parks/open spaces (recreational),transport and communication, agriculture, water bodies and special activities(tourism and pilgrimage).

Land Use Pattern in Thiruvananthapuram Corporation
In 1966, the corporation had 74.86 sq. km. which increased to 141.74 sq.km in 1990. Currently, the total area of corporation is 215.86 sq.km among 100 wards. The land use pattern has been illustrated below.

Land use category	Percentage of Land use		
	1966	1990	2011
Residential	65	59	56
Agriculture	11	10	22
Public/Semi public	6	9	12
Industrial	.5	2	1
Commercial	1	1	1
Parks and open spaces	1	8	2
Transport	6.5	7	3
Waterbodies	1	2	2

Source: Thiruvananthapuram Master Plan 2011

Note: Agricultural Land includes only paddy land for 1966 and 1990

Residential

Over time with increase in area of corporation, the actual area of residential has increased but the percent of residential area with total area has been decreasing.

Public and Semi-Public

The area in 1966 was 6 % of total area which increased to 9% in 1990. Currently, total area under public and semi-public is 27.86 Sq.km which is 12 % of the total area of corporation.

The area has been increasing mainly because city acts as administrative head of the state.

Commercial

The commercial land use was 1 sq.km in 1966 which has increased to 2.53 sq.km currently. It occupies 1 % area of corporation as the city acts as collection and distribution centre of agricultural products and consumer goods. The commercial land use is found mainly along the road network of the city.

Industrial

Industrial land use had an area of 0.43 (0.5%) sq.km in 1966 which is currently 1.82 sq.km .The industrial area is mainly seen in Pappanamcoode, Veli and Kazhakootam area.

At a city level, there are a few manufacturing enterprises, information technology parks and traditional industries.

Registered working factories in the city include oil mills, cashew factories, cotton textile, rubber industrial units, chemical units.
Thiruvananthapuram Corporation has one information park Techno Park at Kazhakootam and 2 KINFRA industrial parks.

The industrial area remained the same for the last 20 years. With a rise in population, tremendous pressure on available land diminished the prospects of large scale industries in the city area. (The extension of corporation area in recent years has increased the scope for setting up new enterprises in the newly added areas)

Agriculture
In 1966, the total area under paddy was 8.34 sq.km and had a total coverage of 11%. It decreased by 1 % in 1990 but in 2012, total 0.67 (0.2%) sq.km of area is left for paddy in corporation limit.
Rapid urbanization has resulted in paddy land being filled and used mainly for residential purposes. There is very little active paddy cultivation. The outskirts of the city is still agriculture oriented; mainly the newly added Gram panchayats. 22 % of agriculture land use is mainly dry agriculture.

Green cover
Green cover of Thiruvananthapuram corporation comprises of paddy and low lying areas, dry agriculture, parks and open spaces. Green areas are mostly located in close vicinity of water bodies and in the newly added panchayats as compared to the other parts of city.

Existing Green Cover in the City

Source: Thiruvananthapuram Master Plan 2011

As per the above definition, the Green cover of the Thiruvananthapuram corporation is 26 %. This is an increase from 20% in 1990.

In state of Kerala, most of the department and boards uses GIS for planning and mapping of inhabited and uninhabited areas. This is unlike most of the other Indian states.

The table below provides an insight into the activities of Thiruvananthapuram corporation in mapping total area and green cover of the city.

EXISTING MASTER PLAN	YES
% OF GREEN COVER TO TOTAL LAND USE	26 %
TOTAL CORPORATION AREA(2011)	215.86
TOTAL CORPORATION AREA 1990	141.74
POPULATION DENSITY OF THE CORPORATION AREA (2001)	4444 persons/sq.km
ATTEMPT OF GIS MAPPING OF THE CORPORATION	Yes

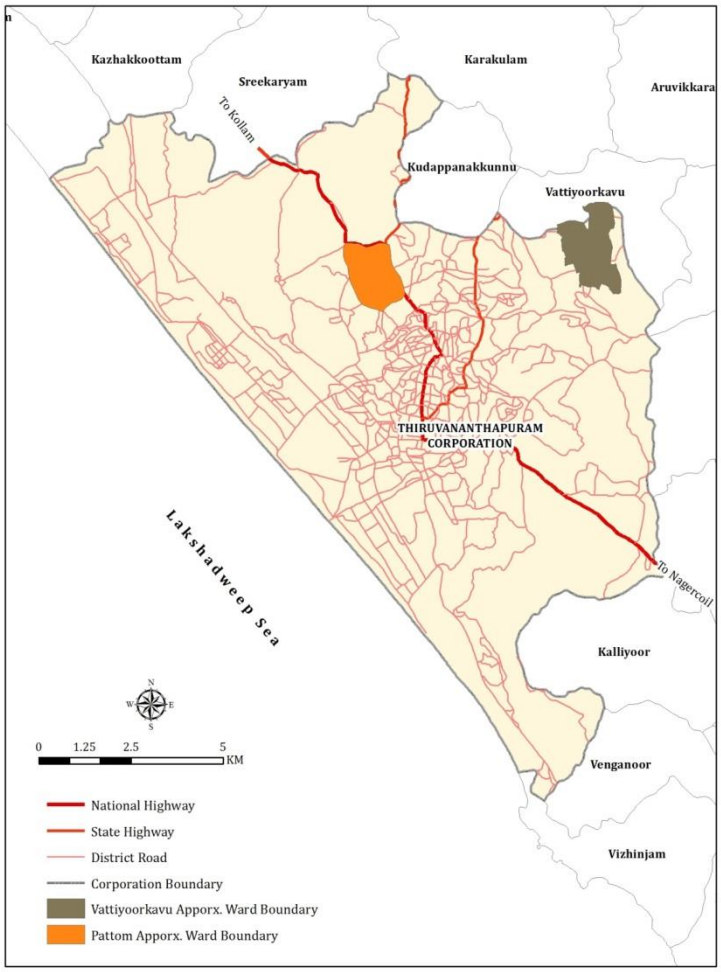
APPLICATION OF GIS PLANNING IN EXISTING MASTER PLAN	Yes

There exist several issues in the computation of green cover in the corporation area. One of the issues in making comparative statements is the fact that Thiruvananthapuram corporation area has increased over the last few years. Secondly, micro computational issues are also created due to the definition of agricultural land, which previously included only paddy land, but now also includes mixed crop land (which was previously added to residential land). Hence whether the green cover figures of 1990 was 20 % cannot be verified.

CASE STUDY OF TWO WARDS

For my case study on land use patterns, I have chosen two wards- Pattom and Vattiyoorkavu, located in Thiruvananthapuram corporation. In the light of increasing agglomeration of the district, re-classification of wards and increasing urbanization, it is very important to analyse land use patterns at micro level before defining and advocating green growth strategies.

THE TWO WARDS OF STUDY



The main objective is to highlight the spatiotemporal pattern of land use in the study region. The ward are considered as a study units. The present section deals with the pattern of general land use as defined by The Urban Development Plans Formulations and Implementation (UDPFI) guidelines. The years for which the analysis is done is 2003 and 2015 because data for these years was created by CESS for the purpose of

this study.

Classification of Land Use

On the basis of data gathered from National Centre for earth sciences(CESS) , the present study have been grouped into six major land use categories.

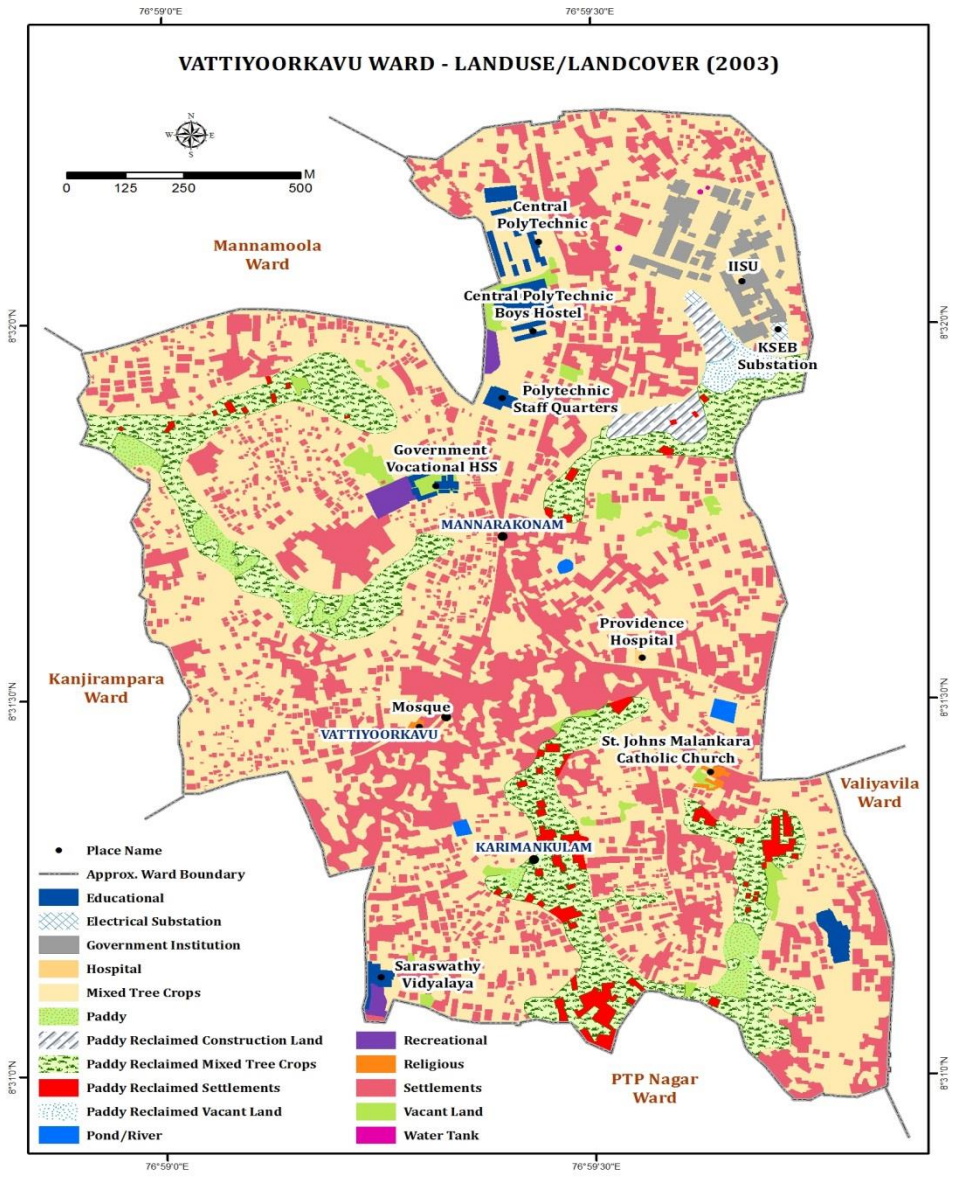
1. Residential
2. Agricultural
3. Public/Semi-public
4. Commercial
5. Parks and open spaces
6. Waterbodies

Ward Wise Trend in General Land use pattern

This chapter examines the general land use pattern of Pattom and Vattiyoorkavu wards. Land use statistics for the period 2003 and 2015 have been used. Ward level statistics is used for analyzing the distributional pattern of general land use and changes within. The general land use pattern of the region under study differs from ward to ward due to the locality.

The study of land utilization is of immense value in tracing out the past use of land to predict its future trend. Only through the study of past land utilization one can be able to predict its future use and evolve land use planning of a particular region.

LAND USE OF VATTIYOORKAVU WARD



Source: National Centre for Earth Sciences (CESS)

In the above map the studied area of the panchayat i.e Vattiyoorkavu ward is approximately 255 hectare.

Change in Land Use in Vattiyoorkavu

1.**Residential Area**

This category includes

1) Settlements
2) Paddy Reclaimed Settlements

It is clear from figure that 32.89 hectares i.e. 12.9 % of total area of Vattiyoorkavu ward was under residential use in 2003. Settlements increased from 32.89 Hectare to 70.75 hectares in 2015 i.e 115 % during the period. Currently, the Residential use of the area is 27.74 % of the total geographical area.

Paddy Reclaimed settlements
This includes land which was earlier under paddy cultivation but has now been reclaimed for residential use. Such transfer activity reduces the total cultivable land available for paddy use. Paddy Reclaimed Settlements was 0.65 hectares in 2003. This drastically increased to 3.44 Hectares in 2015.

2. **Public/Semi-public**
This category include
1) Educational Institutions
2) Electrical Substation
3) Govt. Institutions
4) Hospitals
5) Religious Sites

The public/semi-public areas held a small proportion of 4.76 hectares in 2003 which increased to 7.93 hectare in 2015. Volume of change is 0.88 % of total area.

3.**Vacant land & open spaces**
This category include
1) Vacant land
2) Paddy reclaimed vacant land
3) Recreational areas

4 % of the ward area was vacant in 2003 which has decreased to 2.3 % currently. Vacant land decreased from 8.38 hectare in 2003 to 3.43 hectare in 2015. There was no
Paddy reclaimed vacant land in 2003. But by 2015, this land had a share of 1.26 hectares. These lands are potential agricultural land which can be available for extension of paddy cultivation but have not been cultivated currently.

4. **Water bodies**
Area under water bodies in the ward was just 0.38 hectare in 2003 which increased to 0.49 hectare in 2015.

5. **Agricultural Land**

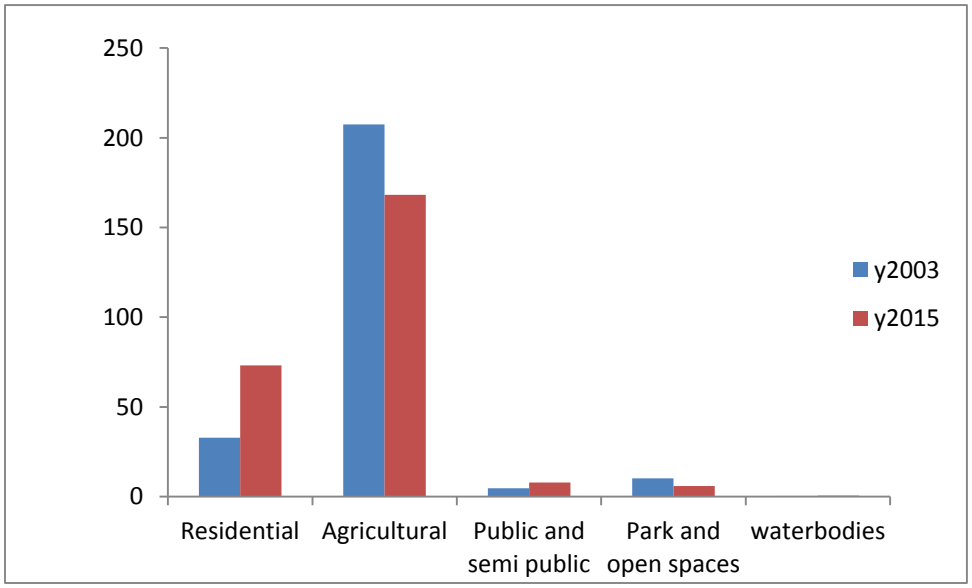
This category include land under-
1) Paddy
2) Mixed tree crops
3) Paddy Reclaimed Mixed Tree Crop

These 3 constitute the extent of agricultural land in the region. Vattiyoorkavu ward has a substantial proportion of agricultural land use i.e. currently 65 % cent of the total geographical area. In 2003, it was 81 %. Hence there has been a substantial decrease in agricultural land from

207.35 hectare in 2003 to 168.18 hectares in 2015. Total Volume of change in agricultural area is -15.27 % of total area.

The general Paddy cultivation in 2003 was only 12.56 hectare which was 6 % of total agricultural land which decreased to only 3.26 hectare in 2015 i.e. just 1.8 % of total agricultural land. Paddy cultivation has diminished due to conversion of wetlands in mixed tree crops, construction land and settlements.

Land Use in Vattiyoorkavu



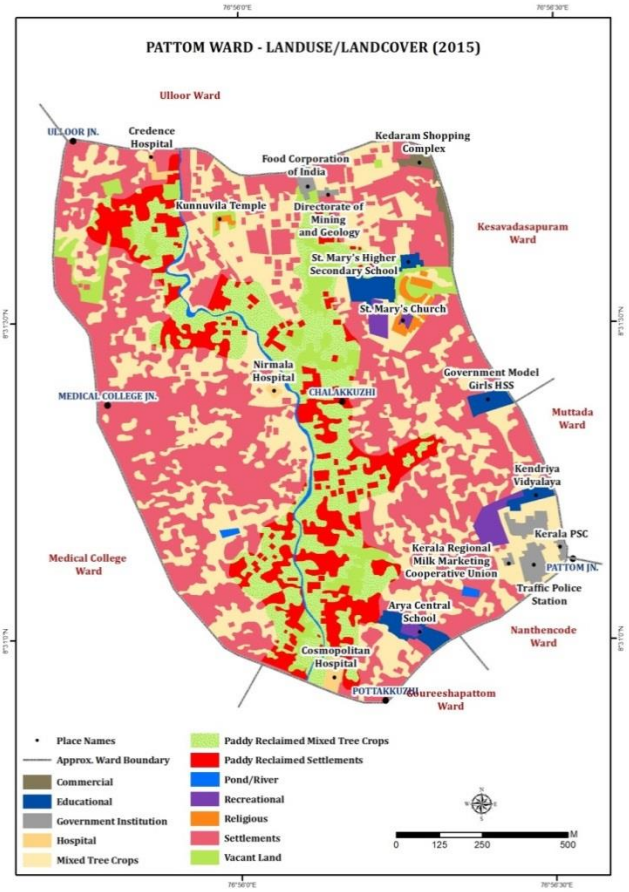
Green cover

Green cover comprises of paddy and low lying area, dry agriculture as well as park and

open spaces. The green cover of the ward was 216.11 hectare i.e. 84 % in 2003 which decreased to 173.32 hectare in 2015 i.e. 68 %.

Land Use in Pattom

The studied area of the Pattom ward is approximately 169.27 hectare. The work below shows the change in land use from 2003 to 2015.



Source: CESS

1. **Residential Use**

This Category include

1) settlements
2) paddy reclaimed settlements.

Residential area increased from 34.65 hectares in 2003 to 81.3 hectares in 2015. The volume of change is 20.5 % in 2003 to 48 % of total geographical area of the ward

in 2015.

2. **Agricultural Use**
This Category Include
1) Mixed tree crops
2) Paddy reclaimed mixed tree

Agricultural land use decreased from 123.07 hectare in 2003 to 69 hectare in 2015. Total volume of change was -31.88 %. Earlier, area under agricultural land use was 72.78 % of the entire geographical area of the ward which reduced to 40.83 % in 2015.

3.**Public/Semi-public**
This Category Include
1) Educational
2) Govt. institutions
3) Hospitals
4) Religious Areas

Public/Semi-public land use increased from 5.79 hectare in 2013 to 7.41 hectare in 2015.

4. **Commercial**
Area under Commercial activity was 0.37 hectare in 2003 which increased to 0.87 hectare in 2015.

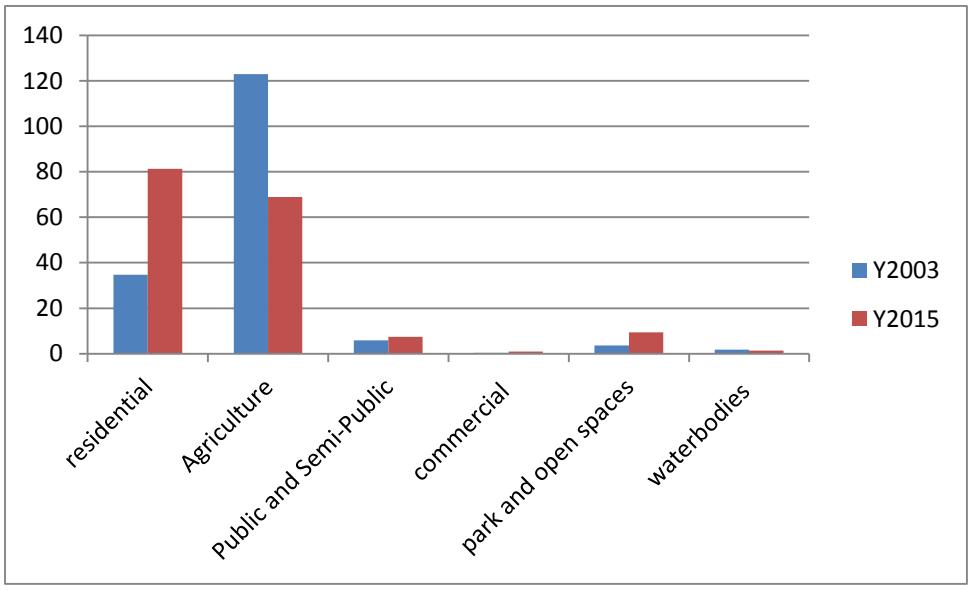
5. **Park and open spaces**
This Category Include
1) Recreational
2) Vacant land

Parks and open spaces showed a positive increase from 3.65 hectare in 2003 to 9.31 hectares in 2015.

6. **Water bodies**
This Category Include
1) Ponds
2) water bodies

Area Under water bodies decreased marginally from 1.73 hectares in 2003 to 1.31 hectares in 2015.

Land Use in Pattom



A COMPARISON OF LAND USE PATTERNS IN PATTOM AND VATTIYOORKAVU WARDS

Land use	Year	Pattom ward	Vattiyoorkavu ward
Residential	2003	34.65	32.89
	%	20.47	12.87
	2015	81.3	73.09
	%	48.03	28.62
	Volume of change	**27.56**	**15.75**
Agricultural	2003	123.07	207.35
	%	72.71	81
	2015	69	168.18
	%	40.83	65.73
	Volume of change	**-31.88**	**-15.27**
Public/Semi public	2003	5.79	4.76
	%	3.42	1.86
	2015	7.41	7.93
	%	4.3	3.11
	Volume of change	**.88**	**1.25**
Commercial	2003	.37	
	%	.21	
	2015	.87	
	%	.51	
	Volume of change	**.30**	
.Parks and open spaces	2003	3.65	10.2
	%	2.16	4
	2015	9.31	5.89
	%	5.5	2.30
	Volume of change	**3.34**	**-1.7**
Waterbodies	2003	1.73	.38
	%	1.02	.14
	2015	1.31	.49
	%	.77	.19
	Volume of change	**-.25**	**.05**
Total geographical area	2003	169.25	255.58
	%	100	100
	2015	169.25	255.58
	%	100	100

SOLID WASTE MANAGEMENT

One of the major problems of growing urbanization is constant change in consumption pattern which bring along the problem of Solid waste management. The study tries to examine the present status of solid waste management in Thiruvananthapuram.

Till 2011, there was system of segregation of waste at source, door to door collection of waste, followed by transportation of waste to the garbage treatment plant at Vilappilsala. The waste collected from various wards is then transported to the processing centre for treatment at Vilappilsala, located about 16km from the Corporation. There was a mechanical compost treatment plant having a capacity of maximum 300 tons per day which used to process 90 ton per day.
But, gradually the plant turned into a dumping site due to gap between generated solid waste and processing quantity. The plant is now closed due to social unrest caused by leaching problem and air pollution. The leachate flowing from landfill inside the plant reached Karamana river through Meenabally canal causing water pollution.
There is however no secondary storage in city .So, after the shutting down of the plant,collection and transportation service given by the corporation stopped.

The per capita waste generation is estimated to be 350 grams per day[iii].

COMPOSITION

The composition of waste generation indicate that maximum waste generated in the city is domestic waste (53%) followed by commercial waste (app. 20%) and street sweeping (18 %).

PROBLEMS

-No collection and transportation of solid waste
-Open littering
-Absence of sanitary engineered landfill and recycling plant

To solve the excess waste management problem in the city, the corporation began to give subsidies to encourage private solid waste management at source level treatment in households and organisations.

Due to unfeasibility of centralized treatment plant, decentralized methods are adopted to cater to the solid waste management. Decentralized treatment plants like aerobic composting; vermi-composting, bio-gas plants, pipe composting etc. should be given priority to save cost and to mitigate the ill effects.. These should be supported by massive awareness campaigns to bring about a change in behavior of the public.

BIODEGRADABLE WASTE

1. **Aerobins**

This is for public use at a very small level. Dry leaves are first placed and then organic garbage is dumped into rectangular bins. Rather than enzymes made from cow dung enoculum is sprayed which increase the composting process. Such 127 Aerobins are installed into the city. Highest number of bins(33) are in Chalai area.

2. Pipe composting systems

As 57 % of the waste come from household in the corporation, it is most necessary to work on household level. Currently 76,000 households use pipe composting method. 90 % subsidy (75% by Suchitwa mission and 15% by corporation) is given for each plant. Pipe composting is a waste to manure method. Each system costs Rs. 900 for which a subsidy of Rs. 820 is given to each household.

3. Biogas plants

Biogas plants convert waste into electrical energy. Biogas plants are created in markets to handle generated garbage at market level itself. 30 biogas plants at main market, local market, sub market Level of capacity of 2 ton/day, 1t on/day constructed by KSUDP and the corporation.

Biogas plants are set up at household level Of Capacity 0.5 m^3, 0.75 m^3, 1 m^3. Corporation provides 75 % subsidy of entire amount on each unit whereas 25 % is incurred by private user. So far subsidy has been given on 1160 biogas plants. These biogas plants can be used for kitchen purpose and it can reduce the use of fuel like LPG & wood for cooking.

4. Bio-bins

This system is used in flats in vertical buildings. Waste is segregrated at source level and biodegradable waste of entire buildings is stored at one place to create compost. Corporation provides 50 % subsidy of each plant in association with CREDAI.
In 150-170 flat bio-bins system is used.

NON BIODEGRADABLE WASTE

1. Plastic waste

These are the non-biodegradable component of the waste. These should be segregated from bio degradable waste at source itself. In the first half of 2015, corporation collected around 14710 kg of plastic waste under Clean Kerala Company(CKC). CKC is a public private partnership to collect plastic waste.

2. E waste

These are Electronic and electrical appliances which have reached their end and are no longer fit for their original intended use. It is collected separately by health inspector office because they are hazardous in nature and leach toxic chemicals. Hence they should not be mixed up with general waste.

3. Bio medical Waste
Indian Medical Association under IMAGE handles all bio medical waste. Source level treatment is done at around 300 hospitals in Corporation.

The success of adopting decentralized planning is unknown as data regarding how much solid waste is treated via decentralized planning is unavailable.

CASE STUDY OF TWO WARDS

In the light of the failure of public waste collection, private waste management gains increasing importance. Hence I decided to analyse Pipe Composting systems in the households of my two chosen wards of study, Pattom, Vattiyoorkavu.
The success of installation of pipe composting can be measured by Pipe Composting Intensity. Pipe Composting Intensity is defined as number of pipe composting units in a particular area divided by total number of households in that area.

For computing Pipe Composting Intensity I used latest household data for 2013 from Thiruvanathapuram Corporation for 55 wards. Number of pipe composting units was derived from Corporation data for 55 wards for the year 2012.

PIPE COMPOSTING INTENSITY

Area	No: of Households	Pipe Composting Units	Pipe Composting Intensity
Thiruvanathapuram Corporation	193605 (55 wards)	22429	0.12
Pattom	7222	1025	0.14
Vattiyoorkavu	6865	491	0.07

Note: Latest estimates of the ward wise pipe composting units not available.

ECOSYSTEM AND BIODIVERSITY

Ecosystem means biological community such as plants ,animals, organisms, people in a given area interacting with each other whereas biodiversity is a term used to describe variety of life found on earth within and between all species of plants, animals and micro-organisms and the ecosystem within which they live. Urban ecosystem and biodiversity are important as measure of quality of life.[iv]

India is one of the 17 identified mega diverse countries of the world with 7-8 % of recorded species including 45,000 species of plants and 91,000 species of animals. Biodiversity is measured as number of plants and vertebrate species.

Kerala has a very high level of biodiversity in the state. It is home to 10035 plant species which is 22 % of total number of plant species found in India. A high number of plants and animal species are endemic to the state. Out of the 3872 flowering plants found in Kerala, 1272 are endemic, 56 out of 102 mammals,139 out of 169 reptiles and 86 out of 89 amphibians are endemic to the state.

No data is available at a corporation level but preparation of People's biodiversity register (PBR) is undertaken by Kerala State Biodiversity Board to identify biological resources in the 100 wards and document it.
These registers are meant to serve as a repository of natural resources found locally, compiles by people living there. It lists plants, animal, resources and traditional knowledge associated with them. It is based on local level PBRs and supposed to be executed by the biodiversity management committee (BMCs) that has already been constituted in all the local bodies in state.

National Biodiversity Authority (NBA)was established in 2003 to implement India's biological Diversity act (2002).State biodiversity boards and biodiversity management committees (BMCs) were formed under NBA to guide state governments and urban local bodies on matters relating to conservation of biodiversity.
Kerala has a strong institutional mechanism for implementing biological Diversity act 2002 by establishing state wise network of BMC in all the 978 Panchayats,60 municipalities and 5 Corporations i.e 1043.

ENVIRONMENT QUALITY OF LIFE

Environment outcomes are very important determinants of human health and well-being. Environmental conditions affect the quality of people life in various ways.
they affect human health through air and water pollution, biodiversity loss and well as affect the health of ecosystem. People benefit from access to clean water and nature.

India ranks 155 out of 178 nation in Environment Performance Index which is ranked out of 9 indicators. In Air quality indicator, India ranks 174 out of 178 nations.

In this study I have examined the Air Quality Thiruvananthapuram corporation. It is important to focus on air quality because the environment outlook (2012) projects that if no new policies are implemented, urban air quality will continue to deteriorate globally, that with increasing urbanization, outdoor air pollution will become top cause of environment related death by 2050.

AIR QUALITY

The Kerala State Pollution Control Board maintains ambient air quality stations at Veli (industrial), SMV school, Over-bridge (sensitive), murinjapalam (sensitive) and Pettah (residential and others) as per CPCB norms to monitor air parameters of SO2, NOX (Nitrogen oxide), RSPM (respirable suspended particular matter).

Parameter	**Limit µg/m3**	**Observed annual average ,µg/m3**	
		2012	2013
Veli (category :industrial)			
Sulphur dioxide (SO2)	50	15.49	16.79
Oxides of nitogen(NOx)	40	18.48	19.81
Respirable Suspendable Particular Matter(RSPM)	60	60.2	57.59
SMV School,Over Bridge(Category:Sensitive)			
Sulphur dioxide (SO2)	20	6.96	7.06
Oxides of nitogen(NOx)	30	23.6	24.18
Respirable Suspendable Particular Matter(RSPM)	60	54.03	53.53
Cosmopolitan Hospital ,Murinjapalam(Category:Sensitive)			
Sulphur dioxide (SO2)	20	7.33	6.92
Oxides of nitogen(NOx)	30	22.38	22.64
Respirable Suspendable Particular Matter(RSPM)	60	52.66	52.08
Pettah(Category:Sensitive)			
Sulphur dioxide (SO2)	30	6.56	6.78
Oxides of nitogen(NOx)	40	22.27	22.96
Respirable Suspendable Particular Matter(RSPM)	60	50.93	51.26

Source: Water and Air Quality Directory 2013, KSPCB, Thiruvananthapuram

According to National Air quality index, the following ratings are to be followed:

Air quality index	Remark	Possible health impact
0-50	Good	Minimal impact
51-100	Satisfactory	Minor breathing discomfort for sensitive people
101-200	Moderate	Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor	Breathing discomfort to most people on prolonged exposure
301-400	Very poor	Respiratory illness on prolonged exposure
401-500	Severe	Affects healthy people and seriously impacts those with existing diseases

According to these ratings, the air quality parameters of Thiruvananthapuram Corporation are within the stated limits and ranging from ‘Good’ to ‘Satisfactory’.

ECO-RESTORATION OF PONDS

Ponds restoration work is done to prevent further degradation and create a space for natural greenery arounds ponds. this conserves aquatic flora and fauna.
KSBB follows low cost pond rehabilitation programme through which assistance limited to one time grant of 3 lakh/per pond is given to residents association/peoples representatives.
Criteria: Priority ponds are selected if it is highly degraded and cannot be used because of pollution and if the pond was an important source of drinking source and is no longer usable.
Conservation of ponds, maintenance of cleanliness is carried by concerned party with technical advice from Kerala State Biodiversity Board (KSBB).

BIODIVERSITY CONSERVATION OF PONDS

After cleaning of the pond i.e. draining out the polluted waste, removal of weeds and other waste material based on the ecological conditions of the pond, water plants, native fishes are provided and medical plants in the surrounding area are planted according to land availability. They try to create sloped boundaries so that natural rainwater comes into ponds. Water weeds can be controlled using herbivorous fishes.
Monitoring of the project is done by BMC of the LSG.
KSBB has so far conserved 14 ponds in the Thiruvananthapuram Corporation.

CASE STUDY BIODIVERSITY CONSERVATION OF TWO WARDS

In the primary survey on Biodiversity conservation I chose two ponds, located in Pattom and Peroorkada Village (Vattiyoorkavu). Both these ponds have undergone eco-restoration by the Kerala State Biodiversity Board. The purpose of my visit was to ascertain the success of the Eco-Restoration done for the purpose of preventing degradation of the aquatic sites.

Site Details

The 1st pond is in a Pattom Residential area. It is located behind Milma bhawan, Pattom.
It is a well maintained fenced pond and is visibly clean. It is surrounded by constructed households.

The 2nd pond is in Peroorkada village, near Vattiyoorkavu. Characteristic of this area is the slum settlement surrounding the entire water body

Observations

The pond located in Pattom has been successfully maintained since the Eco-restoration by the Kerala State Biodiversity Board (KSBB). In stark contrast the Vattiyoorkavu pond has become a waste dumping site and is extremely dirty despite the eco-restoration.

Primary Survey

The door to door survey conducted in the neighbouring residential areas of the pond revealed an interesting difference between the two areas. Eight out of ten households interviewed in Pattom were using some form of private solid waste management in their house; pipe composting, biogas or converting wet waste into manure while the solid waste was burnt. Comparatively, in Vattiyoorkavu the slum areas had no formal system of waste management.

Conclusion

There emerged an interesting linkage between the success of the Eco-restoration and waste management practices of the surrounding areas. The success of Pattom pond restoration can be attributed partly to the formal solid waste management system in the surrounding households. The opposite result could be seen in Vattiyoorkavu (Peroorkada Pond).

This has an important implication for eco-restoration policies considering the expenditure of Rs. 3 Lakhs on the restoration of each pond. This shows that any single green growth policy cannot be viewed in isolation. It must be implemented in tandem with other components.

[i] ICLEI-South Asia (2015) "Urban Green Growth Strategies for Indian Cities", Vol. 1, Delhi, India
[ii] Kerala Perspective Plan, 2030
[iii] STATUS OF MUNICIPAL SOLID WASTE GENERATION IN KERALA AND THEIR CHARACTERISTICS-*Dr. R. Ajaykumar Varma*
[iv] ICLEI-South Asia (2015) "Urban Green Growth Strategies for Indian Cities", Vol. 1, Delhi, India

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APPENDIX

Table 1

	Pipe composting intensity Computation			
Ward No	**Ward Name**	**No of Houses/Flats**	**Pipe Composting**	**Intensity**
1	Medical College	2824	868	0.31
2	Pattom	7222	1025	0.14
3	Kesavadasapuram	5539	629	0.11
4	Kuravankonam	5555	500	0.09
5	Kawdiar	4321	580	0.13
6	Vattiyoorcavu	6865	491	0.07
7	Pangodu	4252	253	0.06
8	Thirumala	4377	475	0.11
9	Sasthamangalam	5539	756	0.14
10	Kanjirampara	5035	500	0.10
11	Nanthencode	3740	300	0.08
12	Kunnukuzhi	2432	310	0.13
13	Kannammula	4724	980	0.21
14	Palayam	2405	503	0.21
15	vazhuthacadu	3359	450	0.13
16	Jagathi	3285	354	0.11
17	Poojappura	4440	515	0.12
18	Thrikkannapuram	6255	445	0.07
19	Mudavanmughal	5201	400	0.08
20	Karamana	4313	489	0.11
21	Nedumkadu	3550	652	0.18
23	Valiyasala	2062	no	
24	Thycadu	2659	325	0.12

25	Thampanoor	4212	212	0.05
26	Secretariate	2448		
27	Rushimangalam	3464		
28	Sreekanteswaram	3646	440	0.12
29	Palkulangara	2905	400	0.14
30	Petha	3183	700	0.22
31	Chakai	3235	500	0.15
32	Titanium	2527		
33	Veli	1339		
34	Sanghumugham	2843	300	0.11
36	Perunthanni	3936	670	0.17
38	Chenthitta	2245		
22	Attukal	1974	424	0.21
35	Vallakadavu	1460	250	0.17
37	Fort	2611	50	0.02
39	Chalai	3349	285	0.09
40	Puthenstreet	2457		
41	Manacadu	4042	153	0.04
42	Sreevaraham	3100	600	0.19
43	Kamaleswaram	4031	1086	0.27
44	Valiyathura	1415	1200	0.85
45	Beemapalli	1713	12	0.01
46	Manikyavilakom	2294	20	0.01
47	Poonthura	1787	no	
48	Amblathara	3466	570	0.16
49	Kalippankulam	2414	763	0.32
50	Kaladi	4121	640	0.16
51	Estate	3935	no	
52	Nemom	3289	268	0.08
53	Ponnumangalam	3431	96	0.03
54	Melamcode	3355	515	0.15
55	Pappanamcode	3424	475	0.14
		193605	22429	0.12

Table 2 : **PATTOM WARD LANDUSE/LANDCOVER CHANGES (2003-2015)**

Types	Area (in Hectare)	
	2003	2015
Commercial	0.37	0.87
Educational	2.94	3.45
Government Institution	1.83	2.14
Hospital	0.33	0.86
Mixed Tree Crops	83.68	45.80
Paddy Reclaimed Mixed Tree Crops	39.39	23.26
Paddy Reclaimed Settlements	3.32	15.21
Pond	0.22	0.23
Recreational	1.54	1.92
Religious	0.69	0.97
Settlements	31.33	66.09
Vacant Land	2.11	7.39
Water Body	1.50	1.08

Table 3: **VATTIYOORKAVU WARD LANDUSE/LANDCOVER CHANGES (2003-2015)**

Types	Area (in Hectare)	
	2003	2015
Educational	1.92	3.47
Electrical Substation	0.29	0.34
Government Institution	2.32	3.77
Hospital	0.04	0.06
Mixed Tree Crops	168.91	136.37
Paddy	12.56	3.26
Paddy Reclaimed Construction Land	0.00	2.34
Paddy Reclaimed Mixed Tree Crops	25.88	28.55
Paddy Reclaimed Settlements	0.65	3.44
Paddy Reclaimed Vacant Land	0.00	1.26
Pond	0.38	0.45
Recreational	1.82	1.20
Religious	0.19	0.29

Settlements	32.24	67.31
Vacant Land	8.38	3.43
Water Tank	0.00	0.04

Site Visits of Eco-Restoration Pond

Picture 1. Pattom Pond

Picture 2. Peroorkada Pond (Vattiyoorkavu)