SUSTAINABLE SOLID WASTE MANAGEMENT THROUGH ECOLOGICAL FOOTPRINT ANALYSIS – A SOLUTION TO KOCHI CITY, INDIA

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Abstract

Kochi, the commercial capital of Kerala, South India and second most important city next to Mumbai on the Western coast is a land having a wide variety of residential environments. Due to rapid population growth, changing lifestyles, food habits and living standards, institutional weaknesses, improper choice of technology and public apathy, the present pattern of the city can be classified as that of haphazard growth with typical problems characteristics of unplanned urban development especially in the case of solid waste management. To have a better living condition for us and our future generations, we must know where we are now and how far we need to go. We, each individual must calculate how much nature we use and compare it to how much nature we have available. This can be achieved by applying the concept of ecological footprint. Ecological footprint analysis (EFA) is a quantitative tool that represents the ecological load imposed on earth by humans in spatial terms. The aim of applying EFA to Kochi city is to quantify the consumption and waste generation of a population and to compare it with the existing biocapacity. By quantifying the ecological footprint we can formulate strategies to reduce the footprint and there by having a sustainable living. The paper discusses the various footprint components of Kochi city and in detail analyses the waste footprint of the residential areas using waste footprint analyzer. An attempt is also made to suggest some waste foot print reduction strategies thereby making the city sustainable as far as solid waste management is concerned.

Keywords: Ecological Footprint Analysis, Sustainable solid waste management, Kochi City.

1. Introduction

1.1 Kochi City

Kochi, affectionately called the 'Queen of the Arabian Sea', is located on the west coast of India, in the beautiful state of Kerala. This city in the district of Ernakulum can be regarded as the commercial and industrial capital of Kerala. Kochi city is the second most important city next to Mumbai on the western cost of India. Cochin Corporation has an area of 94.88 sq.km. and is divided into 66 wards (administrative division). Kochi is the most urbanized region in Ernakulam district. As per census of India 2001, the population of Kochi Corporation is 5,95,575. Physical, social, political and economic factors have played their decisive role in the formation of land use pattern in Kochi city. Constraints of landforms and lagoon system contributed to the concentration of economic activities to the water front areas. The existing land use pattern has resulted from the complex interactions of varied factors in the urban structures. The characteristic feature of the central city is the predominance of the area under water. The water sheet consists of backwaters, rivers, canals, tanks and ponds and altogether it forms 23.4% of the green land of the city. The net dry land available for urban use amounts to 71.86% of the gross land i.e. 68.18 sq. km. Truly there could be no ideal location than this, with its protected lagoons directly accessible from the sea, for a major terminal port and with its hinterland bountifully blessed by nature for a concentration of urban population and activities. But the present pattern of the city can be classified as that of haphazard growth with typical problems characteristics of unplanned urban development.

1.2 Ecological Footprint Analysis

Ecological footprint analysis is a quantitative tool that represents the ecological load imposed on the earth by humans in spatial terms. Ecological footprint analysis was invented in 1992 by Dr. William Rees and Mathis Wackernagel at the University of British Columbia. The ecological foot print of a defined population is the total area of land and water ecosystems required to produce the resources that the population consumes, and to assimilate the wastes that the population generates, wherever on earth the relevant land / water are located. The footprint is expressed in global hectares. A global hectare is one hectare of biologically productive space with world average productivity.

The important uses of EFA are

• Ecological foot printing is both a technical concept and a metaphor. With its intuitive meaning it says that the human footprint should not exceed the area able to support it.

• EFA is a strategic management tool; strategies that reduce the footprint can then be prioritized.

• EFA is an awareness raising visioning tool that enables us to think about scenarios for the creation of a more sustainable future.

• The footprint can be used to measure any product, activity or impact, at all levels from self to planet. It is therefore possible to use the footprint in Environmental Management Systems (EMS) and as a planning tool.

Basically, the aim of ecological footprint analysis is to quantify the consumption and waste generation of a population and to compare it with the existing biocapacity. By quantifying the ecological footprint we can formulate strategies to reduce the ecological footprint and there by having a sustainable living. The ecological footprint of waste generation provides per capita land requirements for waste generation. Thus calculating the footprint for an area, the ecological footprint can be a tool for sustainable environmental management as:

• The calculation of ecological footprint of food can suggest strategies and create awareness to reduce the food consumption, change the food composition, reduce the food waste, increase the efficiency of food production and improve the efficiency of food distribution and delivery.

• The calculation of ecological footprint of waste generation is the primary and basic stage of sustainable waste management

• The calculation of goods and services footprint can suggest strategies to reduce the demand or to shift the demand for goods and services, to prolong the life span of products, to purchase goods that are sourced and manufactured locally.

• The calculation of shelter footprint can formulate strategies to reduce the house area usage, reduce energy demand for housing .

• The calculation of mobility footprint can formulate urban planning measures and to propose a mode shift to reduce the mobility foot print.

• The calculation of waste can determine the land required to assimilate the waste generated in present and future.

• Calculation of footprint is handy for selection of disposal site like land required for disposal, disposal site characteristics determination based on the footprint of waste components, etc.

• The design of landfill site can be supported through the footprint calculation of wastes providing information on land required for different components of wastes.

• Selection of the suitable site for landfill can be supported through footprint calculation as the calculation provides the information on land requirement in the predicted future. Thus many suitable sites can be selected if the requirement can be known.

• To determine the importance of recycling of different waste categories in order to reduce the footprint.

2. Ecological Footprint of Kochi City

The ecological footprint of Kochi city was calculated using the global footprint calculator developed by Redefining Progress and Earth Day Network . These are organizations conducting Ecological Footprint studies and generating environmental awareness around the world, along with WWF. Components for footprint calculation were food, mobility choices, shelter and goods and services. For the purpose of primary studies representative random samples of the residential areas in the city were selected. The criteria for selection were

- Density of population
- Concentration of high rise buildings
- Location

The ecological footprint of the residential areas in the corporation area has been studied in 6 wards in 485 houses (5% from each ward) in the Kochi corporation area. The following inferences were made.

• The average footprint of residents in the city area is above the national average. (2.19 > 0.8).

• Consumption exceeds the available bio productive space per person in the world. (2.19 >1.8).

• According to the Global footprint calculator if everyone like this we would need 1.3 PLANETS to sustain our life.

• Average shelter footprint for

- Flats / high rise buildings - 0.21
- Row housing Units- 0.568
- Independent units- 0.77-1.21

Low land area occupancy when compared to other units reduces the average shelter footprint of high rise buildings.

• The mobility footprint of the population in the wards near to the CBD and major transportation nodes is low because of their dependence on public transportation facilities when compared to the other wards.

• Average dependence on public transportation facilities in the city is about 36.4%.

• Improper waste disposal at the source (house) is contributing to high waste footprint which in turn raises the goods and services footprint of the population.

2.1 Average footprint comparison

The high shelter footprint of (1.21gha) is in Ward No.58, which has the highest average footprint of 2.52gha. This is because of high house area usage. The lowest ecological footprint is in Ward No. 53(1.79gha).

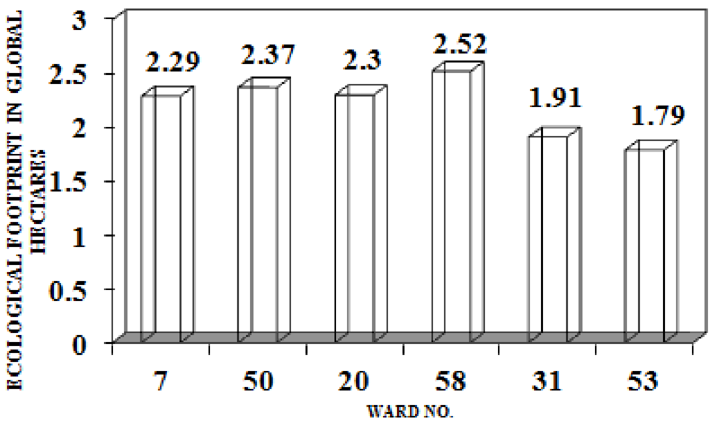

Figure 1. Average Footprint of the Wards

2.2 Footprint components comparison

For all residents, the shelter footprint goes to the maximum followed by goods and services footprint, food footprint & mobility footprint. In most cases the shelter footprint constitutes about 46.37% of the footprint. Average house area usage is 400.45 sqft/person. This is contributing to high shelter footprint.

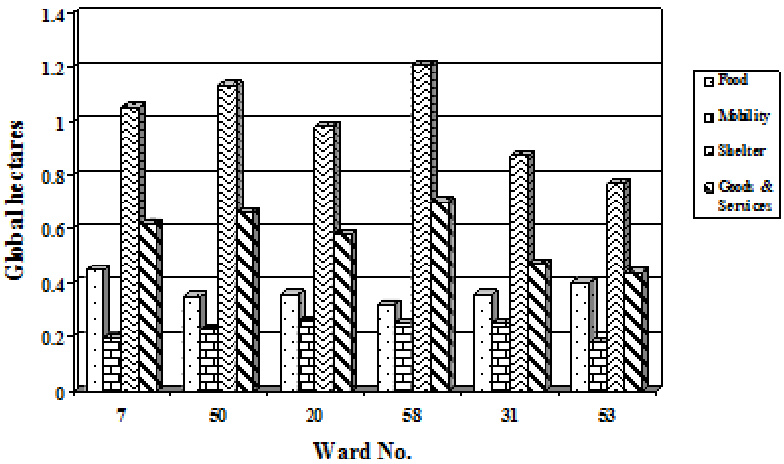

Figure 2. Footprint components comparison

2.3 Gender and footprint comparison

The average male footprint is greater than the female footprint because the male mobility footprint is more than that of female.

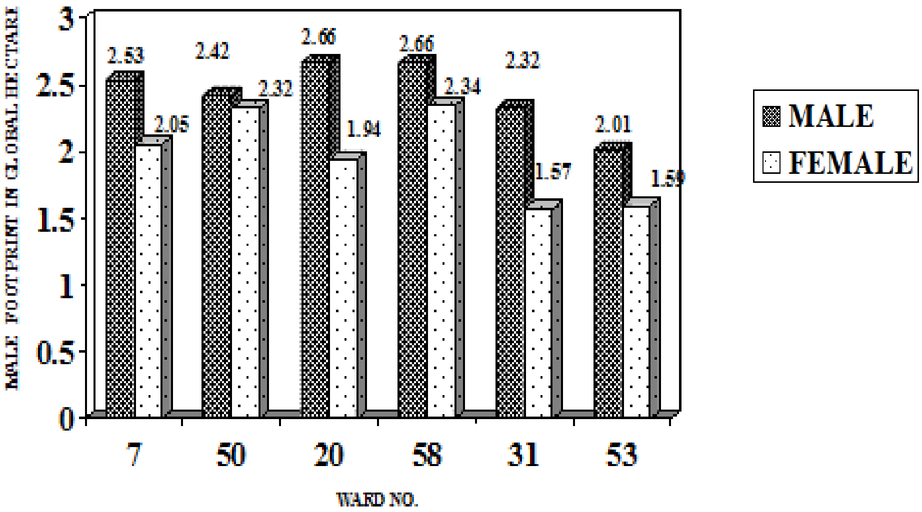

Figure 3.Gender & Footprint

2.4 Family structure and footprint comparison

The average footprint of nuclear family footprint is more than that of joint family which is depicted in Figure 4.

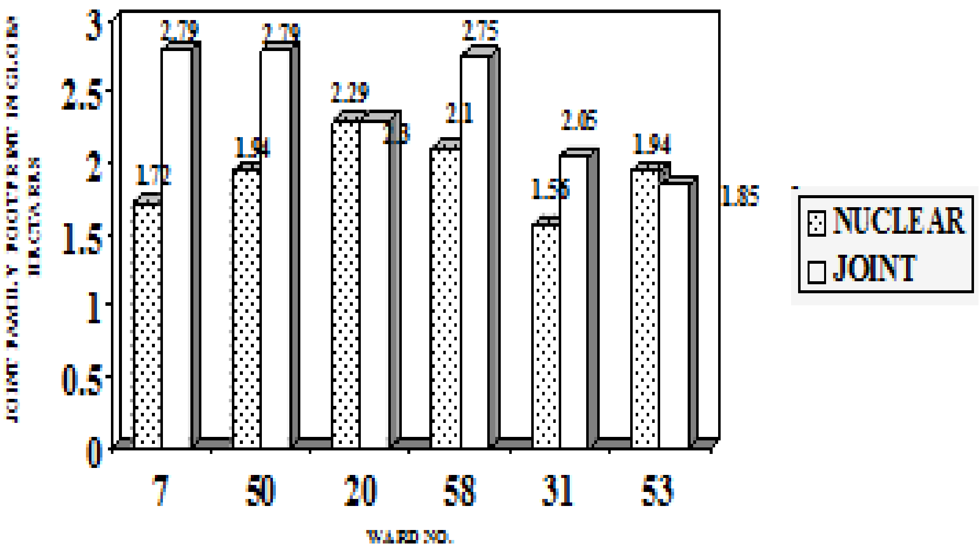

Figure 4.Family structure & Footprint

2.5 Age & footprint comparison

The age wise footprint comparison of the city's population is shown in Figure 5.

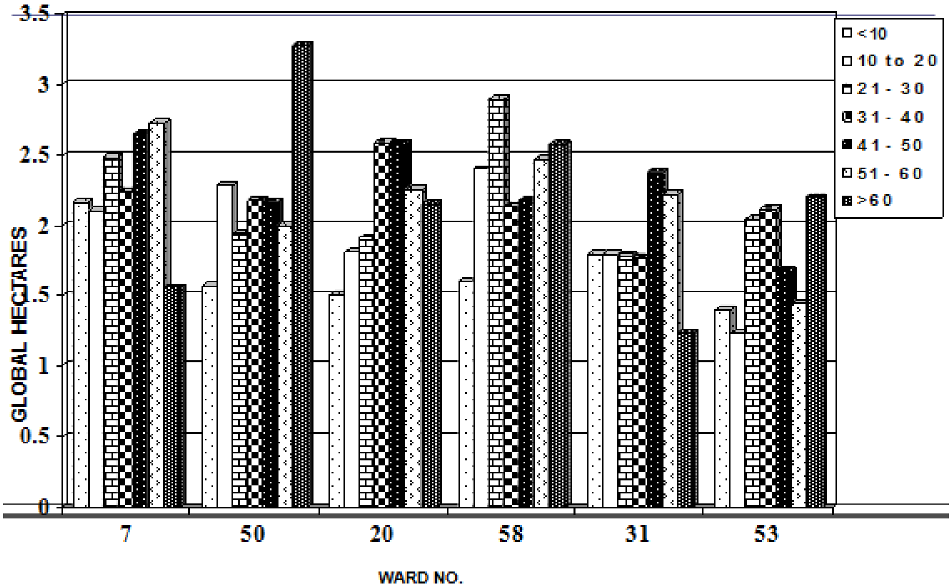

Figure 5. Age & Footprint

2.6 Income & footprint comparison

The income wise footprint comparison of the city's population is shown in Figure 5.

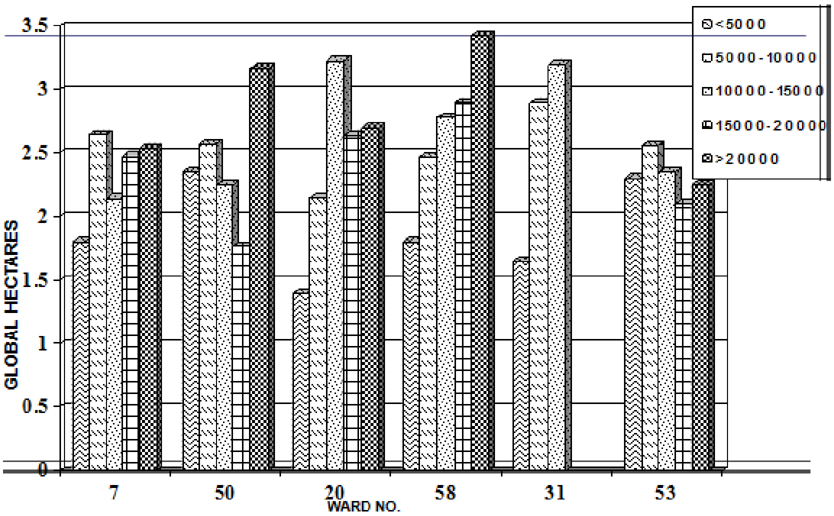

Figure 6. Income & Footprint

2.7 Distance to place of work and mobility footprint

Mobility footprint is directly proportional to the distance to the place of work or education.

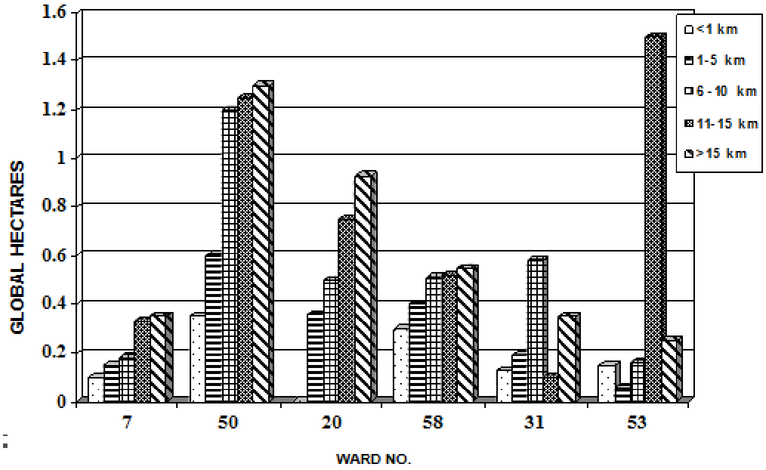

Figure 7. Distance to place of work and mobility footprint

3. Waste footprint of Kochi City

For the detailed study of waste footprint of the city, a questionnaire survey was conducted for 500 samples in three different seasons i.e dry(April 2010 and December 2010-January 2011),wet (July 2010) and festival season (August 2010), inside the Corporation boundary and random samples in the outskirts. For calculating the waste foot print , the waste generated in the city was categorised into paper, glass, plastic, metal and organic waste. Analysis of the data was done using waste footprint analyser, which is a program developed for inputting the survey data and estimating the footprint values in a visual basic platform. The analyser generated the footprint value in hectares per capita. Following are the results obtained.

- In all the seasons the organic waste constitutes more than 70%.
- Paper waste constitutes more than 10%.
- Plastic waste consitutes more than 5%.

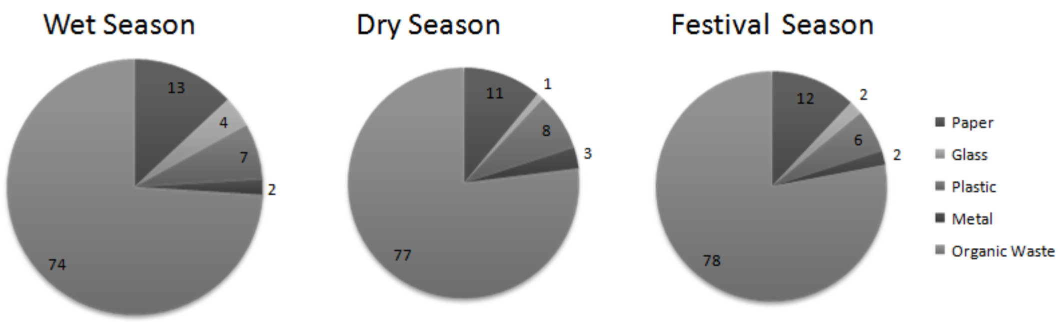

Figure 8. Category wise waste comparison in three different seasons

3.1 Waste footprint of categories of waste & seasonal variation

The total waste footprint value is low in the dry season and increases in the wet season and higher in the festival season. For glass and metal waste the trend is reversing.

Table 1: Biological Productive Land Requirement of different categories of waste

Season	*Biological Productive Land Requirement -Waste footprint (in Sqm per capita per year)*					*Total*
	Paper	*Glass*	*Metal*	*Organic*	*Plastic*	
Dry	*2.96*	*3.03*	*24.67*	*82.54*	*10.70*	*123.90*
Wet	*3.11*	*2.87*	*22.86*	*102.31*	*14.00*	*145.15*
Festival	*3.22*	*2.59*	*22.10*	*105.33*	*14.55*	*147.79*

3.2 Waste footprint of categories of waste & density of population

From Table 2 we can infer that as the density increases the waste footprint value also increases. Organic waste foot print constitutes highest followed by Metal waste and Plastic waste. Paper waste footprint is low in the high density areas.

Table 2: Biological Productive Land Requirement for different density of population

Density	*Biological Productive Land Requirement (in Sqm)*					*Total*
	Paper	*Glass*	*Metal*	*Organic Waste*	*Plastic*	
High	*3.05*	*2.99*	*26.05*	*101.77*	*13.30*	*147.16*
Low	*3.15*	*2.68*	*20.10*	*91.12*	*12.84*	*129.89*

3.3 Waste footprint of categories of waste & location

The waste footprint value is higher in areas near to CBD/MTN.But organic waste footprint is low in areas away from CBD/MTN.Metal and plastic footprint shows nearly double values in areas near to CBD/MTN.

Table 3: Biological Productive Land Requirement for different location of the residence

Location	*Biological Productive Land Requirement (in Sqm)*					*Total*
	Paper	*Glass*	*Metal*	*Organic Waste*	*Plastic*	
Away from CBD/MTN	*2.85*	*2.32*	*17.27*	*96.52*	*10.36*	*129.32*
Near to CBD/MTN	*3.32*	*3.28*	*28.36*	*95.37*	*16.72*	*147.05*

3.4 Waste footprint of categories of waste & income of population

The waste footprint increases up to 10000 to 15000 income group and is highest in that group.

Table 4: Biological Productive Land Requirement of different categories of income

Household Income	*Biological Productive Land Requirement (in Sqm)*					*Total*
	Paper	*Glass*	*Metal*	*Organic Waste*	*Plastic*	
Less than 5000	*1.56*	*0.77*	*11.23*	*90.84*	*13.01*	*117.41*
5000 to 10000	*3.18*	*2.58*	*20.29*	*97.80*	*12.51*	*136.36*
10000 to 15000	*3.17*	*3.64*	*33.54*	*121.84*	*16.52*	*178.71*
15000 to 20000	*3.24*	*2.72*	*20.54*	*90.55*	*12.65*	*129.70*
above 20000	*3.20*	*3.25*	*27.60*	*96.15*	*13.00*	*143.20*

3.5 Waste footprint of categories of waste & family size

Waste footprint versus family size shows vague results. This may be due to defects in sample.

Table 5: Biological Productive Land Requirement and family size

Household Size	*Biological Productive Land Requirement (in Sqm)*					*Total*
	Paper	*Glass*	*Metal*	*Organic Waste*	*Plastic*	
2	*4.10*	*3.00*	*31.00*	*136.00*	*18.00*	*192.10*
3	*3.43*	*2.82*	*25.80*	*106.80*	*14.29*	*153.14*
4	*2.90*	*2.91*	*21.57*	*83.29*	*11.10*	*121.77*
5	*2.38*	*2.87*	*17.23*	*78.78*	*10.68*	*111.94*
>5	*1.38*	*1.79*	*11.77*	*77.18*	*11.25*	*103.37*

3.6 Waste footprint of categories of waste & mode of waste disposal

The low footprint values at the household level disposal indicate the importance of waste disposal at the source.

Table 6: Biological Productive Land Requirement and mode of waste disposal

Mode of Waste Disposal	*Biological Productive Land Requirement (in Sqm)*					*Total*
	Paper	*Glass*	*Metal*	*Organic Waste*	*Plastic*	
Household Level	*3.04*	*2.68*	*17.90*	*82.30*	*11.04*	*116.96*
Community Level	*3.14*	*2.97*	*27.78*	*109.25*	*14.84*	*157.98*

3.7 Waste footprint of categories of waste & type of housing unit

Waste footprint is highest for row housing units and low rise buildings as shown in Table 7.

Table 7: Biological Productive Land Requirement and type of housing unit

Housing Unit Type	*Biological Productive Land Requirement (in Sqm)*					*Total*
	Paper	*Glass*	*Metal*	*Organic*	*Plastic*	
Individual Plot	*3.35*	*2.40*	*19.71*	*85.00*	*11.64*	*122.10*
Row Housing Unit	*2.92*	*4.01*	*32.12*	*116.47*	*15.30*	*170.82*
Low Rise Building	*2.90*	*4.01*	*32.00*	*116.00*	*15.30*	*170.21*
High Rise Building	*2.47*	*3.87*	*19.80*	*89.40*	*12.38*	*127.92*

3.8 Waste footprint of categories of waste & effect of recycling

Except for paper no active recycling methods inside the city and outskirts. Only 42 Organic waste recycling samples were surveyed. Samples having recycling methods show 58% footprint reduction.

4. Solid waste footprint reduction

Waste footprint of the Kochi city population is 0.0139 hectares per capita per year. By 2033 the population will need about the full area of the city to assimilate the generated waste if this trend exists. Recycling reduces about 58% of the waste footprint. To reduce the waste footprint following strategies may be adopted.

Table 8: Strategies to reduce waste footprint of the city

	STRATEGY	*IMPLEMENTATION OPTIONS*
1. Reduction of Waste		
1.1	*Household waste*	*Apply variable charging scheme to the collection and disposal of household waste*
		Charge people on the basis of volume of waste and frequency of collection.
		Charge people on the basis of weight of the waste collected
		Offer incentives to households to produce less waste.
		Introduce deposit refund systems for a range of products including food and beverage containers, which aim to encourage the use of reusable containers and reduce waste at source.
2. Reuse of waste		
2.1	*Reuse and recycling centres*	*Enable reuse and recycling centres to reuse waste materials disposed of at these sites through the resale of reusable items*

3. Recovery: Recycling, Re engineering and composting of waste materials		
3.1	*Household waste*	*Introduce a kerbside collection scheme for recyclables from all homes in the city, supported by a network of recycling centres for residents to ' drop off' recyclable materials.*
		Invest in R& D to identify new uses for waste products(for e.g. clothing from PET plastic etc.) and through market intervention to reduce the prices of recycled products.
		Promote home and community composting in the city.
		Home and community composting may be promoted through the provision of biogas plants at low cost or with subsidies.
3.2	*Construction waste*	*Segregate and reuse/ recycle all wastes by type on construction sites.*

5. Conclusion

The Ecological footprint has a higher flexibility as it can be used for many different purposes. For Kochi city the ecological footprint can be a valuable tool for education at all ages, for businesses to understand their all impacts and as a comparative tool with other cities and local authorities. The waste footprint analyzer developed will allow the public to compare their current profile of consumption and waste generation to a profile which reduces their ecological footprint. For effective footprint reduction through strategies, this analyzer should be made available to the public through media. By doing this, the Ecological Footprint Analysis helps in creating public awareness apart from a technical tool. This will make Kochi greener, cleaner, safer and self sustainable as in our good old days.

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