

Sustainable Development through the Environment Management Tool Ecological Footprint Analysis – A Study in Kochi City, India

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Abstract— In the past, natural resources were plentiful and people were scarce. But the situation is rapidly reversing. Our challenge is to find a way to balance human consumption and nature's limited productivity in order to ensure that our communities are sustainable locally, regionally and globally. Kochi, the commercial capital of Kerala, South India and the 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. Ecological Footprint Analysis (EFA) is physical accounting method, developed by William Rees and M. Wackernagel, focusing on land appropriation using land as its "currency". It provides a means for measuring and communicating human induced environmental impacts upon the planet. 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. In this paper, an attempt is made to explore the tool Ecological Footprint Analysis and calculate and analyse the ecological footprint of the residential areas of Kochi city. The paper also discusses and analyses the waste footprint of the city. An attempt is also made to suggest strategies to reduce the footprint thereby making the city sustainable.

Index Terms— Biocapacity, Environment Management, Ecological Footprint Analysis, Environmental impact, Kochi City, Sustainable Development, Waste footprint.

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1 INTRODUCTION

EVERYBODY (from a single individual to a whole city or a country) makes an impact on the earth, because they consume the products and services of nature. At sometime in the 1970's humanity as a whole passed the point at which it lived within the global regenerative capacity of the earth, causing depletion of the earth's natural capital as a consequence. Each generation is demanding more from our stocks of natural capital than the last generation did. There are now six billion people, but there is still only one earth. Five years later we will be living in a riskier world with more people, more consumption, more waste and more poverty, but with less forest area, less available fresh water, less soil and less stratospheric ozone layer. The situation will be more crucial and dangerous in the urban areas because they are the major centres of consumption of natural resources and energy.

Kochi, the commercial capital of Kerala and the second most important city next to Mumbai on the Western coast of India, is a land having a wide variety of residential environments. Central city extends to an area of 275.85 sq.km and the area jurisdiction of the city corporation is 94.88sq.km. The population of the corporation area as per 2001 Census is 5, 95,575 and the gross density is about 6277 persons/sq.km. As per 2011

Census the population is 6, 01,574. The present pattern of the city can be classified as that of haphazard growth with typical problems characteristics of unplanned urban development.

Surely we all need our city, to be cleaner and greener, more convenient, less noisy, more like it was in the good old days. 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, especially at the age of IT development, developments in the tourism sector, copying foreign lifestyles etc. We (including a single human being) 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.

In this paper, an attempt is made to explore the tool Ecological Footprint Analysis and calculate and analyse the ecological footprint of the residential areas of Kochi city using the Global Footprint Calculator developed by Redefining Progress and Earth Day Network and to suggest strategies to reduce the footprint of the residential areas of Kochi city. The paper also discusses and analyses the waste footprint using waste footprint analyzer. An attempt is also made to suggest strategies to reduce the footprint of the city thereby making the city sustainable with special emphasis to solid waste management.

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 Uni-

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versity of British Columbia.

The ecological footprint 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.

There are mainly two methods for calculating the ecological footprint of a population.

1. Component based approach
2. Compound footprinting

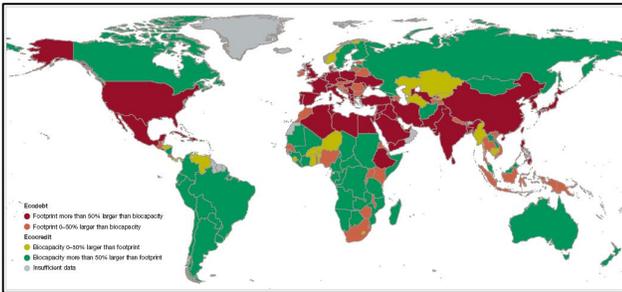


Fig. 1 Ecological debtor and creditor countries, 2003

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.

Limitations of EFA are

The ecological footprint is *one* indication of unsustainability. Because of the limitations below, we can say that "x is unsustainable because it's ecological footprint exceeds the fair share" but you cannot say "x is sustainable because it fits within the fair share"; we would then need to account for pollution, water use, toxicity, health, happiness, and so on. The accuracy of any given footprint analysis is also constrained by the quality of the data. Because of these limitations, ecological foot printing should be used as one tool amongst many.

3 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 con-

ducting 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

Table 1. Selection of wards for primary study

Density		High rise buildings conc. (Nos.)		Location (w.r.t to CBD & MTN)		Ward No.	Ward Name
Hig h	Lo w	>14	<14	Near	Away		
•		•		•		---	
•		•			•	---	
•			•	•		50	PanampillyNagar
•			•		•	7	Pandykudi
	•	•		•		58	Ernakulam North
	•	•			•	20	Mundamveli
	•		•	•		53	Thevara
	•		•		•	31	Ponnekara

Results and Findings from the primary studies

- The average footprint of residents in the city area is above the national average. (2.19 > 0.8).
- Also it 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 footprint comparison

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

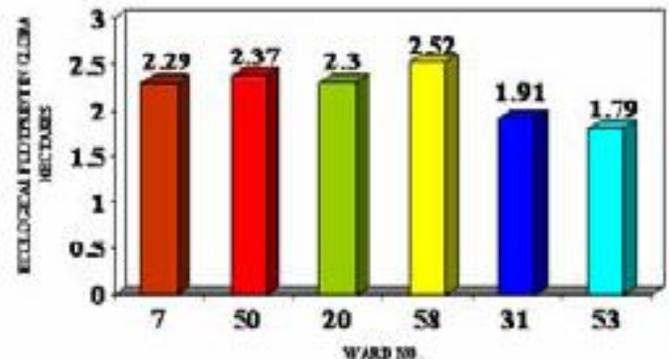


Fig.2. Average Footprint of the Wards

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 consti-

tutes about 46.37% of the footprint. Average house area usage is 400.45 sqft/person. This is contributing to high shelter footprint.

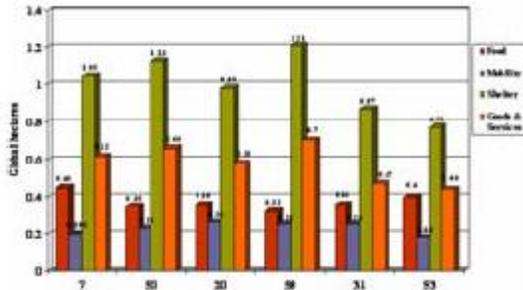


Fig.3. Footprint components comparison

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.

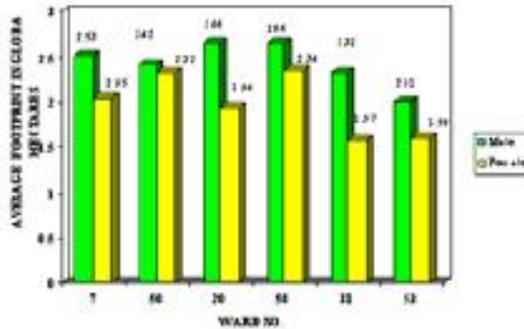


Fig.4. Gender & Footprint

Family structure and footprint comparison

The average footprint of nuclear family footprint is more than that of joint family.

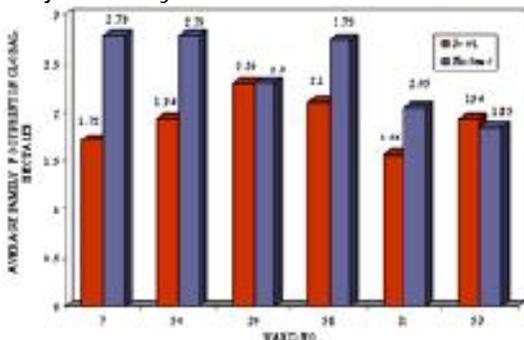


Fig.5. Family structure & Footprint

Age & footprint comparison

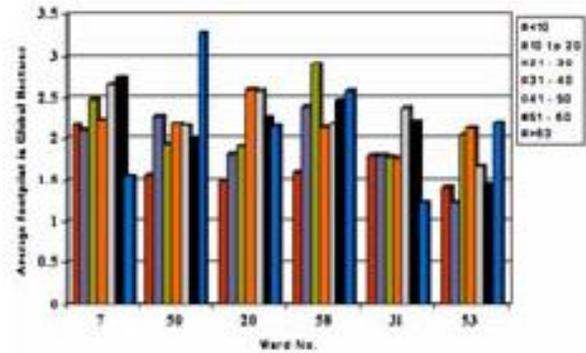


Fig.6. Age & Footprint

Income & footprint comparison

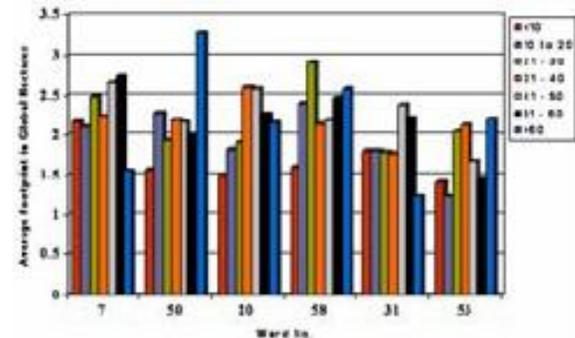


Fig.7. Income & Footprint

Distance to place of work and mobility footprint

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

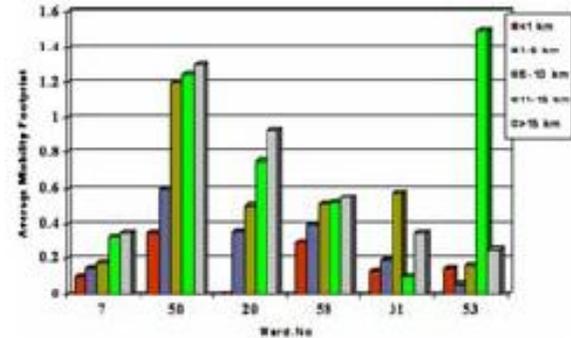


Fig.8. Distance to place of work and mobility footprint

• Average shelter footprint for

- Flats- 0.21
- Row housing Units- 0.568
- Independent units- 0.77-1.21

Low land area occupancy when compared to other units is reducing the average shelter footprint of high rise buildings. Therefore promoting well planned high density buildings will help us to conserve our bioproductive space.

• 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.

4 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 (organic wastes other than paper). Analysis of the data was done using waste footprint analyser, which is a program developed on the basis of equations developed by W.E Rees, 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 constitutes more than 5%.

3.1 Waste footprint of categories of waste & seasonal variation

As shown in Table 2 below it is clear that 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.

Table3. 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 Waste	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 3 shown below 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 3: 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. This is shown in Table 4.

Table 4: 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

Table 5 shows that the waste footprint increases up to 10000 to 15000 income group and is highest in that group.

Table 5: 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 as shown in Table 6. This may be due to defects in sample.

Table 6: 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

as shown in Table 7 indicate the importance of waste disposal at the source.

Table 7: 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 8.

Table 8: Biological Productive Land Requirement and type of housing unit

Housing Unit Type	Biological Productive Land Requirement (in Sqm)					Total
	Paper	Glass	Metal	Organic Waste	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 STRATEGIES TO REDUCE THE ECOLOGICAL FOOTPRINT OF POPULATION OF THE CITY

4.1 Food footprint

- 1) Reduction of food consumption by
 - a) Reduce household food waste
 - Reduce quantity of food purchases- encourage local stores rather than large out-of town supermarkets to reduce the over purchasing of foodstuffs
 - b) Awareness
 - Education campaign to close the gap between current consumption and local production.
- 2) Change of food composition (eating lower on the food chain)
 - a) Promote healthy eating habits and diet awareness
 - b) Education of the public

- Raise awareness of the environmental impacts of different food products making people aware of the effects of their choices.
- Increase media awareness of positive food messages
- Undertaking a comparative study of the footprint of what an average Keralite eats for lunch.
- Increase public awareness of local and regional food markets by providing information.

c) Food labelling

- Encourage retailers and processors to introduce labelling schemes for fresh and processed products showing food miles, country/countries of origin and the environmental impact of production and distribution.

3) Increase the efficiency of food production

a) Production

- Promote R&D into energy and space saving agriculture options

4) Improve the efficiency of food distribution and delivery: Reduce food miles

a) Encourage a hierarchy of purchasing policies

- i) Buy locally produced, seasonally fresh produce
- ii) Buy nationally
- iii) Buy from the region
 - Purchase food from farmer markets, community supported agriculture schemes etc
 - Introduce a transportation taxation based on the distance produce has travelled to reach a retailer
- b) More food growing on the urban fringe using sustainable methods
 - Integrate urban agriculture into policies, forthcoming community strategies etc
 - Encourage people to grow their own food in gardens or allotments or support local food growing initiatives e.g. community gardens or city farms.

5) Reduce waste associated with food

4.2 Goods and services footprint

- 1) Reduce Demand and shift demand for goods and services
 - a) Restrict use of disposable goods
 - b) Economic Incentives: Transfer taxes away from labour and onto the use of resources
 - Tax products on the basis of their embodied energy.
 - c) Increase purchaser awareness
 - Policies to promote recycled/low footprint goods.
 - A reduced VAT on all products containing a high recycled content to encourage use
 - d) Increase consumer awareness
 - Label for products that shows the ecological footprint value of the product.
- 2) Longevity of Use: Prolong the life span of products
 - a) Reuse materials at end-of-life
 - Introduce a recycling department for the state

- Exchange or donate unwanted office equipment, furniture and other materials rather than disposal to land fill.
 - Increase media awareness
 - Sponsor organized markets of second hand goods.
 - Establish informal exchange centres at civic amenity sites and other suitable locations within the city
 - b) Promote services and schemes that extend the life of goods purchased
 - Encourage the use of hire and lease schemes that result in more efficient use of products by consumers.
 - Provide support for refurbishment, recycling and repair services and shops through promotion, funding and or tax incentives.
 - c) Provide information on longevity of products at point of purchase
 - d) Develop markets for used materials
- 3) Distribution: Purchase goods that are sourced and manufactured locally.
- a) Policies to promote locally sourced goods.
 - Encourage retailers to source local goods or goods that contain a high proportion of locally sourced materials through tax, education etc.
- 4) Reduction of Waste
- a) Household waste
 - Charge people on the basis of volume of waste and on the basis of frequency of collection of waste
- 5) Reuse of waste
- a) Reuse and recycling centres
 - Enable reuse and recycling centres to reuse waste materials disposed of at these sites through the resale of reusable items
- 6) Recovery: Recycling, Re engineering and composting of waste materials
- a) 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.
 - Home and community composting may be promoted through the provision of biogas plants at low cost or with subsidies.
 - b) Construction waste
 - Segregate and reuse/ recycle all wastes by type on construction sites

4.3 Shelter footprint

- 1) Reduce house area usage
- a) Increase density of residential living
 - Require increased density of new housing developments promote apartment style developments.
 - Apply building regulations on house area usage and house occupancy rate.

- Give tax reduction/incentives to joint families
 - Tax residents based on their shelter footprint
- 2) Reduce energy demand of housing
- a) Increased energy efficiency standards for new housing
 - b) Awareness raising
 - Include energy efficiency rating in the sale of domestic properties
 - Undertake an awareness campaign that links climate change and household energy use, stressing the importance of action in households.
 - c) Increase use of renewable energy sources

4.4 Mobility footprint

- 1) Infrastructure/Urban design/ Planning
- Increased mixed use
 - Promote high density mixed use developments
 - Promote and deliver through the planning system the concept of all major centres of education, retail, employment and health being located near to transport exchanges.
- 2) Facilitate a mode shift
- Promote public transport
 - Disincentivise car travel
 - Promote fuel efficient vehicles
 - Encourage use of electric cars, motorbikes etc.
 - Promote walking and cycling
 - Raise the awareness of the travelling public.
 - Promote health benefits of walking and cycling.

4.5 Strategies to reduce solid waste footprint

To reduce the waste footprint following strategies may be adopted.

- 1) State level
- Introduce a recycling department for the state
 - Identify local bodies which offer less economic development and give offer to them to act as 'kidneys' of the rest of the population, without affecting the social life of the people but enhancing the economic development by processing the population's waste into valuable products like manure, recycled products etc.
 - 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.
 - Make use of the waste footprint analyser to assess the waste footprint of the population at individual level.
- 2) City level
- Create awareness among the population
 - Enable reuse and recycling centres to reuse waste materials disposed of at these sites through the resale of reusable items
 - Sustain a give and take relationship with suburban local bodies
 - 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.

3) Community level

- 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.
- Communicate through residential associations the various effects of solid waste management problems.
- Share new ideas and techniques of effective solid waste reduction and disposal methods

4) Household level

- 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.

5) Individual level

- Change mind set of the people regarding waste disposal and other issues. The individual should be aware that they are generating source and only they can
- Observe and compare the individual waste footprint regularly so that the individual can stick on to the techniques of waste reduction and disposal techniques which offer low footprint values thereby less harming the environment.

5 CONCLUSION

The Ecological footprint has a higher flexibility as it can be used for many different purposes. From the studies, it is revealed that the consumption rate (EF=2.19gha) of the population in the city is very high and it is far exceeding the national average (0.8gha) and the nations biocapacity (0.4gha) and the available bio capacity per person in the world (1.8gha). The study also revealed that shelter footprint, which mainly depends on the house area usage and number of occupants, is very high in the city. The improper waste disposal at the source (residential units) is increasing the waste footprint of the population which results in the high goods and services footprint. 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. Consumption rate can be reduced by prioritizing strategies based on the component footprint values starting from the individual level. By measuring consumption rather than pollution, EFA brings sustainable development home, and implicates each of us by the individual and collective decisions we take. For effective footprint reduction through strategies, regions should develop their own ecological footprint calculators based on their consumption pattern and life style of the population. This calculator should be made available to the public through media. Provision should also be given in the calculator so that they can compare their current profile of consumption to a profile which reduces their ecological footprint. This will make the Ecological Footprint Analysis a public awareness tool in addition to a technical tool. This will make Kochi greener, cleaner, safer and self sustainable as in our good old days.

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