ECOLOGICAL FOOTPRINT OF WASTE GENERATION: A SUSTAINABLE TOOL FOR SOLID WASTE MANAGEMENT OF KHULNA CITY CORPORATION OF BANGLADESH

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ABSTRACT

Waste is directly related to the consumption of food and dumping to the land. Ecological footprint makes a relationship between two factors- the amount of land required to dispose per capita generated waste. Alike all municipal corporations around the world, Khulna City Corporation (KCC) face lack of waste dumping area with its increasing urbanized wastes. In this concern, the research has to calculate the ecological footprint to develop a sustainable waste management for waste generation in KCC considering its existing solid waste characteristics. Characteristically, KCC area is a naturally productive zone, because the income level of its population is not up to the mark. Although the city managed by unplanned way, it has potentiality to be developed in planned order through the estimation of ecological footprint for waste generation. The research reveals that the ecological footprint of waste generation in KCC area is significant. Because per capita waste generation in KCC area is 0.5 kg/capita/day or 455 tons/day, of which organic waste is 78%, paper 11.5%, plastic 5%, glass 4.7% and metal 2.8%. To assimilate of these components in its generated waste required 0.088 hector land per capita consisting of 152.85 m^2/ capita for paper, 43.32 m^2/capita for plastic, 19.31 m^2/capita for glass, 46.73 m^2/capita for metal and 624.30 m^2/capita for organic waste composition. Considering the land categories, 775.86 m^2/capita and 96.76 m^2/capita energy accumulative and built up lands required for assimilating the total generated waste in KCC area respectively. These lands requirement are directly related to the recycling rate of wastes. The analysis reveals that the ecological footprint provides on the basis of waste management practices. Finally the research recommends that the ecological footprint could be used as a sustainable waste management tool for KCC and other metropolitan cities of Bangladesh environmentally friendly sustainable waste management.

KEY WORDS: Ecological Footprint (EF), Sustainability, Khulna City Corporation (KCC).

INTRODUCTION

All human activity has an impact on its surroundings unless nature's limits are respected. After originally being developed at the University of British Columbia's School of Community and Regional Planning in the early 1990s by Wackernagel and Rees (1996), the ecological footprint is increasingly being used as an indicator of sustainability. The ecological footprint has recently been calculated for 150 countries in the World Wildlife Fund's report *Living Planet Report 2000* (Loh, 2000). The ecological footprint is the total land area required to support a given population with the resources they consume to absorb all the waste they produce. It provides a valuable insight into the carrying capacity of the Earth and human appropriation of resources. Through the ecological footprint, it is possible to compare 'human demand and nature's supply'. The ecological footprint confirms Ehrlich and Holdren's definition of human impact on the environment. This being:

$$I = PAT$$

Where I is Impact, P is population, A is affluence, and T is technology (Ehrlich, 1971). In the Ehrlich-Holdren formulation the impact (I) corresponds to a population's ecological footprint, which is a function of population size and consumption (converted into a land area) (Rees, 2000).

In developing country like Bangladesh, Ecological Footprint changes in proportion to population size, average consumption per person, and the resource intensity of the technology being used. If population sizes increase then both resource consumption and waste generation will be increased, consequently ecological footprint will also increase. The waste scenarios provide an insight into both efficiency and sufficiency measures to reduce

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the ecological footprint of waste. 'Efficiency measures' include recycling and composting while 'sufficiency measures' include the introduction of waste minimization schemes. Under the 'business-as-usual' waste scenario (World wide assuming that an increase in the tonnage of domestic waste of 3% per year), by 2010 the ecological footprint for solid waste will rise by 67,700 ha. This is an increase from 1.1 ha per person to 1.5 ha per person (Harry *et al*., 2001). This demonstrates that current solid waste management policies will not be able to cope with the increase in waste generation.

Khulna City Corporation (KCC) generates around 455 ton municipal solid waste per day, of which, managed waste is 26.5 tons, KCC collects 240-260 tons and unmanaged waste (mainly organic) is 191.3 tons of total waste (Waste safe, 2005). The 40% – 50% unmanaged waste and its uncontrolled disposal degrade the quality of urban living environment in the KCC area. Different types of management tools such as participatory management, traditional management, scientific management etc. are used in solid waste management. In this paper the ecological footprint of waste generation was evaluated as a management tool for sustainable waste management for KCC and other areas of Bangladesh.

ECOLOGICAL FOOTPRINT OF WASTE GENERATION

Ecological footprint of waste generation means the measurement of biologically productive land (fossil energy land, forest land, pasture land, built up area etc) to assimilate the generated waste. Two key questions are highlighted by the waste footprint study:

- Reducing the amount of waste that city's residents produce, and
- Deciding what to do with these generated wastes. (Netherwood, 2005)

Ecological footprint of waste generation mainly depends on the inorganic waste rather than organic waste. Because of the high-energy intensity of inorganic waste and energy requiring for it's processing, the waste footprint of inorganic waste is large. On the other hand most of the organic wastes are food waste and these foods are locally grown and consume. So a negligible energy is required for its processing. As a result its energy intensity is low and produce small footprint. But organic waste is the 80% of the total generated waste and because of these large amounts of organic waste, it requires more land to assimilate those organic wastes.

OBJECTIVES OF THE STUDY

The overall objective is "the development of a policy framework of sustainable solid waste management of KCC area by the concept of ecological footprint". The specific objectives are as follow:

i) To know the existing solid waste management characteristics of Khulna city corporation area;
ii) To determine the ecological footprint of waste generation of KCC area by a specified mathematical tool;
iii) To recommend the way by which the ecological footprint of waste generation can be a very effective tool for sustainable waste management in KCC area.

STUDY AREA

Bangladesh is located in Southeast Asia. Khulna is one of its divisional Cities, which is located in south west of Bangladesh. It lies between 22^0 49' north latitude and 89^0 34' east longitudes and its elevation is 2.13 meters above mean sea level (Environmental maps and workbook for Khulna City, 1999). City Corporation area of Khulna is 44.78 sq. km with population around 1.3 million. The Bhairab River and Fultala Thana bound Khulna on the north, by the Rupsha River on the east and south and on the west by Dumuria Thana. The location of the three sample area in Khulna city in context of the South Asian Regional Countries (SAARC), Bangladesh and Khulna district is shown in Map- 1(APPENDIX-A).

METHODOLOGY OF THE STUDY

For calculating the footprint of waste generation, three wards (17, 24 and 30) or area of KCC were selected. The households of those areas were considered as the sampling unit for the study. At first household of those areas were divided into some cluster on the basis of income level of the people of that area. From the sampling area, samples were then randomly selected from each stratum using the random table. The stratified random sampling technique was developed in order to achieve representative samples without biasness and to mach with objectives. For obtaining year round data, samples were collected in different seasons of the year in the same procedure of stratified random sampling technique mentioned before.

Methods for calculating the ecological footprint for waste generation in KCC area

In calculating the ecological footprint for household waste generation, methodology to assess the household ecological footprint, developed by Mathis Warckernagel, Ritik Dholakia, Diana Deumling and Dick Richardson, Redefining Progress v 2.0, March 2000, was used. The methodology utilized the resource consumption and waste generation categories and the land use categories for those consumption and waste generation.

🗁 *Land use categories for estimating ecological footprint:*

The land use categories are summarized as:

1.**Energy Land:** The area of forest that would be required to absorb the CO_2 emissions resulting from that individual 's energy consumption.

2.**Crop Land:** The area of cropland required to produce the crops that the individual consumes.

3.**Pasture Land:** The area of grazing land required to produce the necessary animal products.

4.**Forest Land:** The area of forest required to produce the wood and paper.

5.**Sea Space:** The area of sea required to produce the marine fish and seafood.

6.**Built Area:** The area of land required to accommodate housing and infrastructure.

🗁 *Generalized procedure*

- The sum of the land requirements for the six individual land categories represents the community's ecological footprint.
- The methodology presents all results in per capita figures. Multiplying the per capita data by the selected area's population gives the total footprint of that area.
- The EF is expressed in land "area units" (in hectares) where each area unit corresponds to one hectare of biologically productive space with world-average productivity.
- To calculate the ecological footprint of waste generation, the generated waste is categorized as paper, plastic, glass, metal, aluminum and organic waste.

🗁 *Underlying equations for calculation*

The biologically productive land required for this waste generation are calculated by some equations, which are given below:

Biologically productive land required for paper

Energy land = world energy yield * energy intensity of paper * (amount of per capita paper waste per year / waste factor of paper) * (1 – % of recycling of paper * % of energy saved from recycling)………………(i)

Where,

- The energy yield (assumed to be average fossil fuel = liquid fossil fuel) is 73000 Mj / 10000 m2-year.
- Energy intensity of paper is 35 Mj/kg.
- Waste factor is the percentage of paper consumed.
- Energy saved from recycling is 45% for paper.

Forest land = World average yield of round wood * ratio of round wood needed per unit paper * (amount of per capita paper waste per year / waste factor of paper) * (1 - % of recycling of paper * % energy saved from recycling)……………………………………..(ii)

Where,

- World average yield of round wood is 10000/2.6 m3/hactore.
- Ratio of round wood needed per unit paper is 1.65/1000.
- Waste factor is the percentage of paper consumed.
- Energy saved from recycling is 80%.

Built up land = Energy land required for paper waste * built up land footprint component of waste / (world average fossil fuel area of goods + world average fossil fuel area of waste) / primary biomass equivalence factor for built up area…………………………(iii)

Where,

- Energy land required for paper waste get from equation no. (i)
- Built up land footprint component of waste is 1100m2.
- World average fossil fuel area of goods is 1324 hector.
- World average fossil fuel area of waste is 1196 hector.
- Primary biomass equivalence factor for built up area is 3.5

Biologically productive land required for plastic

Energy land = world energy yield * energy intensity of plastic * per capita amount of plastic waste per year **(**1-% of recycling of plastic waste*energy saved from recycling of glass waste)………..(iv)

Where,

- The energy yield (assumed to be average fossil fuel = liquid fossil fuel) is 73000 Mj / 10000 m^2-year.

- Energy intensity of plastic is 50 Mj/kg
- Energy saved from plastic waste recycling is 70%.

Built up land =Energy land required for plastic waste * built up land footprint component of waste / (world average fossil fuel area of goods + world average fossil fuel area of waste) / primary biomass equivalence factor for built up area………………………(v)

Where,

- Energy land required for plastic waste get from equation no. (iv)
- Built up land footprint component of waste is 1100m^2.
- World average fossil fuel area of goods is 1324 hector.
- World average fossil fuel area of waste is 1196 hector.
- Primary biomass equivalence factor for built up area is 3.5

➢ <u>Biologically productive land required for glass</u>

Energy land = world energy yield * energy intensity of glass* per capita amount of glass waste per year **(**1- % of recycling of glass waste*energy saved from recycling of glass waste)…………………….(vi)

Where,

- The energy yield (assumed to be average fossil fuel = liquid fossil fuel) is 73000 Mj / 10000 m^2-year.
- Energy intensity of glass is 15 Mj/kg
- Energy saved from glass waste recycling is 30%.

Built up land = Energy land required for glass waste * built up land footprint component of waste / (world average fossil fuel area of goods + world average fossil fuel area of waste) / primary biomass equivalence factor for built up area………………………(vii)

Where,

- Energy land required for glass waste get from equation no.(vi)
- Built up land footprint component of waste is 1100m^2.
- World average fossil fuel area of goods is 1324 hector.
- World average fossil fuel area of waste is 1196 hector.
- Primary biomass equivalence factor for built up area is 3.5

➢ <u>Biologically productive land required for metal</u>

Energy land = world energy yield * energy intensity of metal* per capita amount of metal waste per year **(**1- % of recycling of metal waste*energy saved from recycling of metal waste)…………………….(viii)

Where,

- The energy yield (assumed to be average fossil fuel = liquid fossil fuel) is 73000 Mj / 10000 m^2-year.
- Energy intensity of metal is 60 Mj/kg
- Energy saved from glass waste recycling is 95%.

Built up land = Energy land required for metal waste * built up land footprint component of waste / (world average fossil fuel area of goods + world average fossil fuel area of waste) / primary biomass equivalence factor for built up area………………………(ix)

Where,

- Energy land required for metal waste get from equation no. (viii)
- Built up land footprint component of waste is 1100m^2.
- World average fossil fuel area of goods is 1324 hector.
- World average fossil fuel area of waste is 1196 hector.
- Primary biomass equivalence factor for built up area is 3.5

➢ <u>Biologically productive land required for Organic waste (food)</u>

Energy land = world energy yield * energy intensity of organic waste* per capita amount of organic waste per year * **(**1- % of recycling of organic waste*energy saved from recycling of organic waste)…………………….(x)

Where,

- The energy yield (assumed to be average fossil fuel = liquid fossil fuel) is 73000 Mj / 10000 m^2-year.
- Energy intensity of organic waste is 30 Mj/kg
- The amount of recycling of organic waste is equal to the amount of composting, on the basis of this organic waste are recycled only 1.01%.
- Energy saved from the recycling of organic waste is 58% that is determine by the following way:

- Calculating the amount of biogas from the organic waste.
- Calculating the energy production from that biogas.
- Calculating the percentage of energy getting from organic waste.

I) Biogas production

The amount of biogas (**X**) generated from total areas is calculated from the relation: (Biswas and Lucas, 1996).

X (m^3) =Raw material (solid waste, kg) x TSC x Gas generation rate per unit of solid (m^3/kg).

Where,

- Raw material = 9.4 kg
- Total solid content (TSC) =18-20% (Average 19%) (Source: BCSIR)
- Gas generation rate per unit of solid=0.25 m^3/kg.
- Biogas production, **X** = 0.44 m3

II) Energy production

The expected amount of energy from biogas in total areas is

E_1 (kJ) = **X** (m^3) x (%) of methane x LHV (kJ/m^3)

Where,

- **X** = 0.44 m3
- Methane content = 60%
- Lower heating value (LHV) =20,580 kJ/m^3

So, E_1 = 5.513MJ

III) Percentage of energy saved from organic waste

$$\frac{5.513 \times 100}{9.4}$$

$$= 58\%$$

Built up land = Energy land required for organic waste * built up land footprint component of waste / (world average fossil fuel area of goods + world average fossil fuel area of waste) / primary biomass equivalence factor for built up area………………………(xi)

Where,

- Energy land required for metal waste get from equation no. (x)
- Built up land footprint component of waste is 1100m^2.
- World average fossil fuel area of goods is 1324 hector.
- World average fossil fuel area of waste is 1196 hector.
- Primary biomass equivalence factor for built up area is 3.5

➷ Obtaining the total footprint for waste generation

The sum of the total land required for different waste categories the biologically productive land required for waste assimilation can be obtained, which means the ecological footprint of waste generation.

RESULTS AND DISCUSSION

To present the ecological footprint of waste generation, the calculations employed for waste generation and recycling are required along with some assumptions. It was remarked before that the accuracy of the eco-footprint is totally dependent on the availability of data and different assumptions are needed to be considered.

Composition of Household Waste: Breakdown of a Study Area Household Bin

It is essential to understand the components that make up domestic waste so as to explore the possibilities for reducing the waste and for an accurate footprint calculation. This provided the necessary baseline data to calculate waste amount and convert these figures into biologically productive land to assimilate the produced waste that means the waste footprint. Figure 1 below highlights the breakdown of average study area household bin.

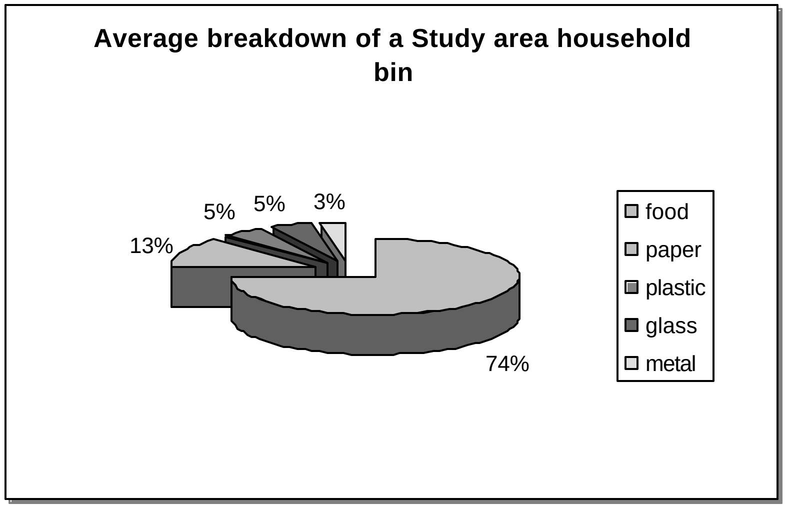

Fig 1: The Average breakdown of household bin in KCC area of Bangladesh, 2005

Fig 1 reveals that breaking down a household bin in the study area, in an average about 74% of the total waste is food waste, while paper 13%, plastic and glass 5% and metal is about 3% of the total waste. The composition of the waste is necessary in order to calculate the ecological footprint for waste generation in the study area.

Waste Footprint of Three-Sample Area Containing Different Income Group of KCC

To fulfill the objectives, the footprint for waste generation need to be calculated for different income groups of the study area. Table1 shows the ecological footprint for three different income groups indicated by ward no 17 as higher income group; ward no 24 as moderate income group and ward no 30 as lower income group. The land use categories considered are listed across the top of the table and waste components are listed down the left side.

The result shown in Table 1 indicates that for the ward no.17 in an average 309.01 m^2 /capita energy land, 6.64 m^2/capita of forest land and 38.51 m^2/capita of built up land is required for the assimilation of generated waste. In total, almost 345.27 m^2 /capita or 0.0354 hector/capita biologically productive land is required for the generated waste assimilation, i.e. the ecological footprint for the area. For the ward no. 24 in an average 236.82 m^2 /capita energy land, 3.32 m^2/capita of forest land and 29.50 m^2/capita of built up land is required for the assimilation of generated waste. In total, almost 269.52 m^2 /capita or 0.027 hector/capita biologically productive land is required for the generated waste assimilation, i.e. the ecological footprint for the area. And for the ward no. 30 area in an average 111.37 m^2 /capita energy land, 1.75 m^2/capita of forestland and 13.87 m^2/capita of built up land is required for the assimilation of generated waste. In total, almost 127 m^2 /capita or 0.0127 hector/capita biologically productive land is required for the generated waste assimilation, i.e. the ecological footprint for the area.

Comparing the ecological footprint of generated waste for the different income group it is found that the footprint varies according to the waste generation characteristics of the people living in those three areas as different income level people generate different categories of wastes in different quantities. The comparison of differences of ecological footprint for waste generation based on income group is shown in the following Fig 2.

In Fig 2 it is shown that whatever types of waste, the ecological footprint of waste generation for ward no.17 is always higher than other two wards, because this area contain higher income people which produced highest amount of solid waste other than ward no. 24 containing mix income group and ward no.30 containing lower income group of people.

Ecological Footprint of Waste Generation for KCC Area

- In KCC area the ecological footprint for waste generation is 0.088 hector per capita.
- Per capita waste generation in KCC area is 0.5 kg /capita /day or 455 tons / day, of which organic waste is 78%, paper 11.5%, plastic %, glass 4.7% and metal 2.8%. To assimilate of these generated wastes required 0.088 hector land per capita. Table: 5.4 shows the ecological footprint of waste generation for KCC area

Table 1: Ecological footprint of solid waste generation for three selected wards (no. 17,24 & 30) of Khulna City, Bangladesh in 2005																		
Waste component	**Land category**									**Sub Total (m^2/capita)**			**Total footprint (Ha/capita)**			**Percentage (%)**		
	Energy land (m^2/capita)			**Forest land (m^2/capita)**			Built up land **(m^2/capita)**											
	Ward 17	**Ward 24**	**Ward 30**	**Ward 17**	**Ward 24**	**Ward 30**	**Ward 17**	**Ward 24**	**Ward 30**	**Ward 17**	**Ward 24**	**Ward 30**	**Ward 17**	**Ward 24**	**Ward 30**	**Ward 17**	**Ward 24**	**Ward 30**
Paper	56.56	9.77	14.77	6.64	3.32	1.75	7.05	3.53	1.84	70.25	35.23	18.36	0.0354	0.027	0.0127	20	13	14
Plastic	19.80	5.23	2.94	-	-	-	2.46	1.21	0.36	22.25	10.98	3.30				6	4	3
Glass	8.25	12.61	1.03	-	-	-	1.02	0.65	0.13	9.27	5.88	1.16				3	2	1
Metal	20.57	180.72	2.273	-	-	-	2.56	1.57	0.28	23.25	14.18	2.55				7	5	2
Organic Waste	203.83	236.82	90.36	-	-		25.42	22.53	11.26	229.25	203.25	101.62				64	76	80
Total	309.01	9.77	111.37	6.64	3.32	1.75	38.51	29.50	13.87	354.27	269.52	127.00				100	100	100

Note: Calculation done based on the methodology provided in methodology section.

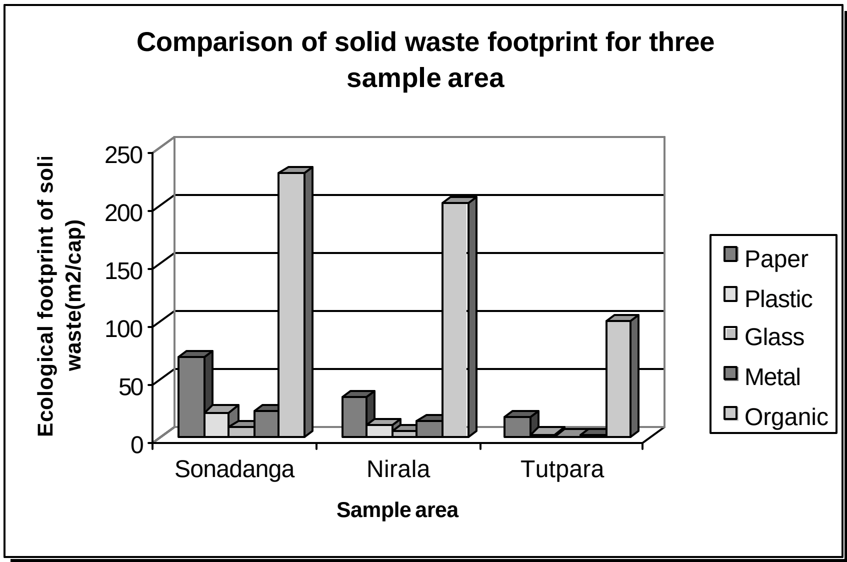

Fig 2: Comparison of ecological footprint of solid waste generation for three-sample area (residential area of ward no 17, Ward no 24 and ward no 30) Khulna, Bangladesh in 2005.

Table 2: Ecological footprint for solid waste generation of KCC area, Khulna Bangladesh in 2005

Waste component	Land category			Sub Total (m^2/capita)	Total (ha/capita)	Percentage (%)
	Energy land (m^2/capita)	Forest land (m^2/capita)	Built up land (m^2/capita)			
Paper	123.05	14.46	15.34	152.85		17
Plastic	38.42	-	4.80	43.32		5
Glass	17.17	-	2.14	19.31		2
Metal	41.56	-	5.18	46.73		5
Organic Waste	555.66	-	69.30	624.30		71
Total	775.86		96.76	886.50	0.088	100

Note: Calculation done based on the methodology provided in the methodology section.

Ecological Footprint of Solid Waste Generation versus Recycling

Increasing the recycling of solid waste can reduce ecological footprint of Solid waste generation. In solid waste, the inorganic wastes are mainly recycled. So they contribute small ecological footprint of waste. On the other hand the organic wastes are recycled a very small amount compare to its generation, as a result it produced a large footprint and imposed a great impact on the environment. In the following table 3 the recycling rate and ecological footprint for different types of solid waste are given.

Table 3: **Recycling rate and ecological footprint for different types of solid waste in KCC area, Bangladesh in 2005**

	Component	**Recycling (%)***	Ecological footprint **(m^2/capita)**
Inorganic waste	Paper	28	152.85
	Plastic	55	43.21
	Glass	8	19.31
	Metal	7	46.73
Organic Waste	Food waste	1.09	624

Note: *Data collected through field survey, Calculation done based on the methodology provided in methodology section.

Table 3 reveals that, food waste is recycled in the lowest amount in KCC area while for food waste the ecological footprint is highest (about 624 m^2/capita). At the same time for paper recycling of paper is 28% and footprint is 152.85 m^2/capita, which indicates that recycling has reduced its ecological footprint in comparison to the organic food waste. For 7% metal recycling, ecological footprint is 46.73 m^2/capita; for 55% plastic recycling, ecological footprint is 43.21 m^2/capita; and for 8% glass recycling, ecological footprint is 19.31 m^2/capita. The figures are represented graphically in Fig 3 below.

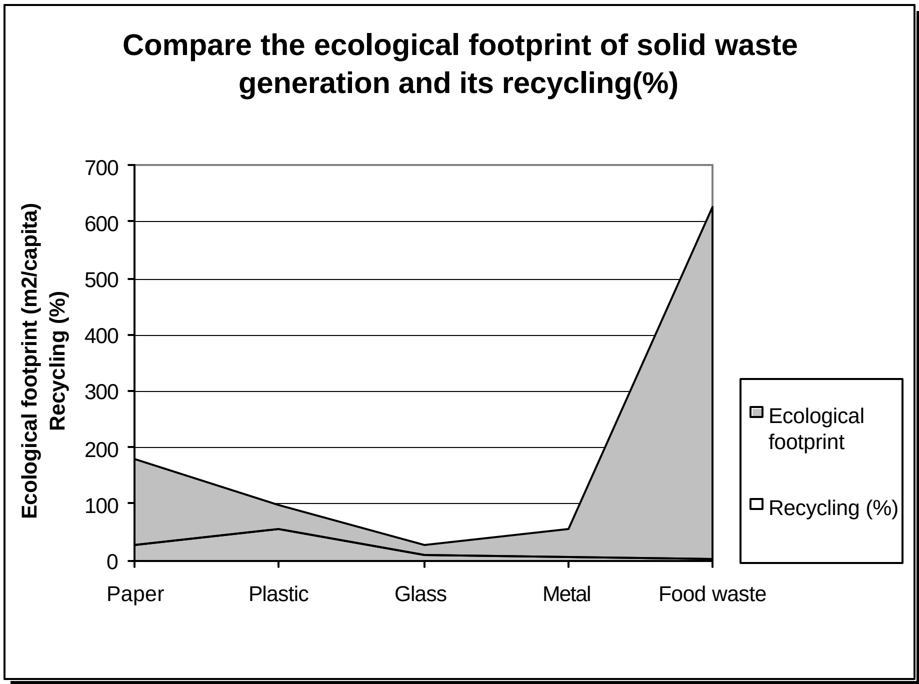

Fig 3: Comparison of ecological footprint and recycling (%) of solid waste in KCC area, Khulna, Bangladesh in 2005

The Ecological Footprint and Sustainable Environmental Management

The ecological footprint could easily be incorporated into either system or be employed independently. Both EMAS and ISO 14001 require that significant aspects or effects, which an organization or KCC may have on the environment, should be identified and be subjected to control and improvement where practicable. Basically, the aim of ecological footprint of waste in sustainable management system is to achieve regulatory compliance and potentially improve performance.

However, the ecological footprint of waste generation provides per capita land requirements for waste generation. Thus calculating the footprint for an area like KCC, the ecological footprint can be a tool for sustainable environmental management as:

- The calculation of ecological footprint of waste generation is the primary and basic stage of sustainable waste management to 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.
- Determining the importance of recycling of different waste categories in order to reduce the footprint.

The ecological footprint and other uses

To ensure that the message of what needs to be done gets across to a wider audience, the methodology of the ecological footprint can be put to further use. For example, it can be used as an educational tool for local communities and schools, it can assist in identifying potential solutions to sustainable living within the planning system, local industries and the service sector could use the ecological footprint as a 'stand alone' environmental management system or in conjunction with environmental management systems such as the

Regional or Local Eco-management Scheme and the International Organization for Standards environmental management system (ISO 14001: 1996).

The ecological footprint and planning

In addition, the ecological footprint could be used to measure the impact of new developments from the extraction of resources and aggregates, processing, manufacture and transportation of materials and consumable goods and finally the environmental impact of the location. In order to create a sustainable environment, existing solid waste management should be considered first and adapted to meet changing needs.

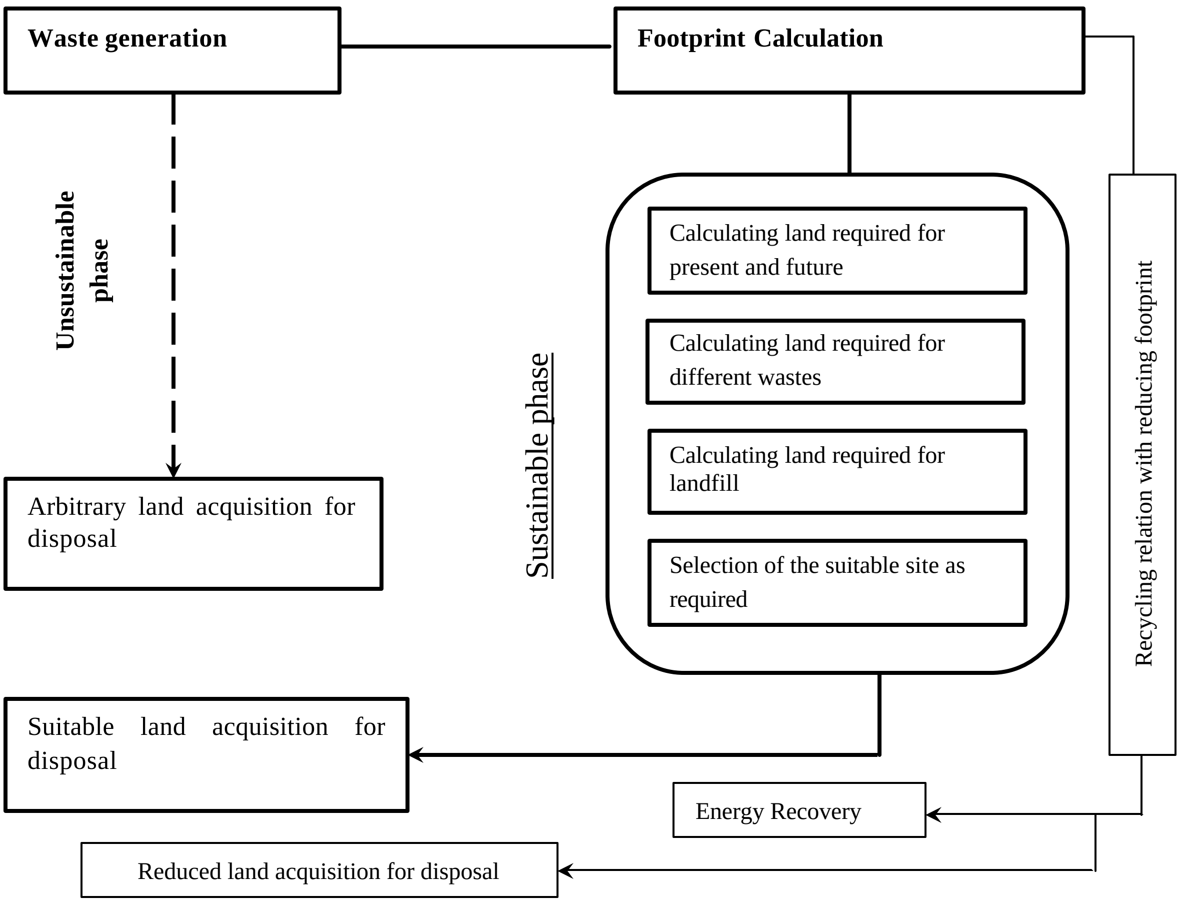

Fig 4: Flow chart showing ecological footprint calculation as a sustainable waste management tool

According to Rees (1996), Cumulative Environmental Effects (CEA) will be the next step in the Impact Assessment (IA) process. In the near future planners will need to address local or regional cumulative effects of environmental activities and assess the impact from a global perspective. Fundamentally, any development will need to take into consideration no net loss of essential natural capital and advocate zero-impact growth for new developments. The ecological footprint approach taken in this study clearly demonstrates the cumulative effect of development and growth. On the other hand, the ecological footprint could also be used to assist in a reversal of the present trend of expansion.

The ecological footprint: an environmental education and awareness-raising tool

The Ecological footprint has a higher flexibility as it can be used for many different purposes. Within KCC, 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. In a recent study into public perceptions of sustainable development (Barrett and Scott, 2000), it was found that people were generally aware of environmental problems (mainly through the media) but little was known or understood of the concept of sustainable development. Aaland and Caplan (1999) suggested that educating children about their environment through lessons in school is an effective way of making sure that the message about sustainability reaches them.

CONCLUSION

The ecological footprint of waste provides a robust measurement of KCC's demand of nature. This is not the only aspect of the sustainable development debate. It is also important to consider social sustainability issues, such as poverty, exclusion, health and education do. When any decision is made the ecological footprint should never be the sole indicator employed to make that decision. However, what the ecological footprint does do is frame the debate. What is the highest quality of life that can be achieved within our fair earthshare? This is the key question concerning sustainability and the ecological footprint has provided a valuable contribution to answering this question. In this study thus the ecological footprint has shown to be an excellent tool for demonstrating whether a city and its citizens are near to the objective of sustainability. Clearly, those charged with the management of KCC have some important decisions to make in relation to its ecological performance if they want their city to achieve the goal of sustainability in the future. The results show that KCC requires an area many times greater than itself in order to provide it with all its present consumption needs and to absorb the resulting waste that is produced. In essence, this additional land acquisition has accumulated over the years, but in effect, it belongs to other inhabitants elsewhere on the planet. Therefore, KCC should consider ways in which appropriated land could be returned to the community. The scenarios within this study have shown that this can be done to good effect.

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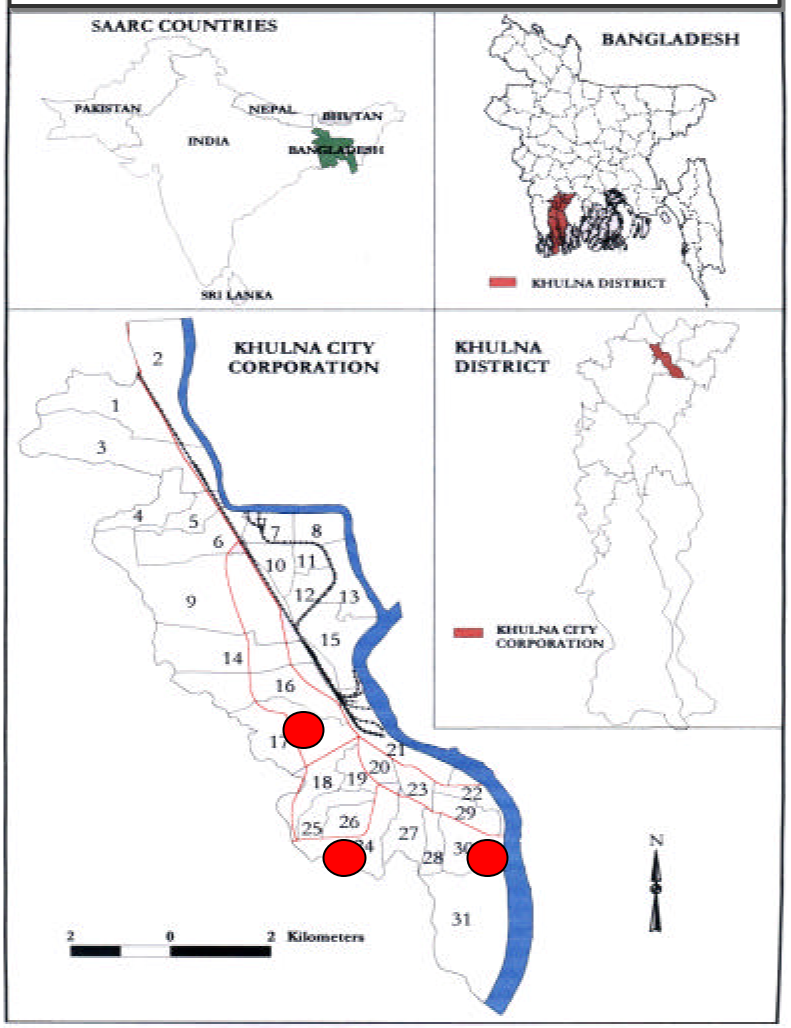
APPENDIX A

Map-1*: Three wards of Khulna city in context of SAARC countries, Banaladesh and Khulna district*



Selected Ward