ASSESSMENT OF ECOLOGICAL FOOTPRINT AND SUSTAINABILITY ANALYSIS OF DEBRE BERHAN UNIVERSITY IN ETHIOPIA

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Abstract

Ecological footprint is an environmental tool to assess the environmental impacts and resource consumption by the operations and activities in a given area. This approach, to make university campus area eco-friendly, is the first step towards the achievement of these goals, which is elucidated in this paper offering the technique of calculating Ecological Footprint and Analysis (EFA) of campus area of the university. This ecological footprint is used to derive the sustainability of the University with the help of criteria formulated on different approaches followed in the paper. Ecological footprint is used to calculate the demand (both production and consumption) of ecological resources and this demand is presented in the form of global average area in units of global hectare. The main focus of this study is to evaluate the ecological footprint analysis of Debre Berhan University, Ethiopia.

Introduction

Ecological footprint [1] is a sustainability analysis application to evaluate and measure the resource consumption and environmental impact [2] of various energy intensive activities on the university environment. Sustainability of any university [3] describes the process adoption methodologies for creating a clean university environment by addressing the social, ecological or economic issues [4].The concept of Ecological footprint analysis was given by Mathis Wackernagel and William Rees [5] at the School for Community and Regional Planning in the University of British Columbia in the year 1996.So, this technique has evolved gradually from its infancy stage to a developing stage for the past two decades when it is regularly modified and updated. It is a management and environmental awareness resource tool.

Ecological footprint is used to calculate the demand (both production and consumption) of ecological resources and this demand is presented in the form of global average area in units of global hectare. It is a biologically productive land area in hectares with the world average bio productivity [6].So, it gives a measure of land area required by any population for the production of renewable resources. Ecological footprint of consumption includes the area (in global hectares) [7] which is required for the production of all the consumed materials and the waste absorption. While, on

the other hand Ecological footprint of production is the sum total of all the footprints of the resource and waste generation in a given area. This includes cropland, grazing land, forest land and built-up spaces (Figure-1).
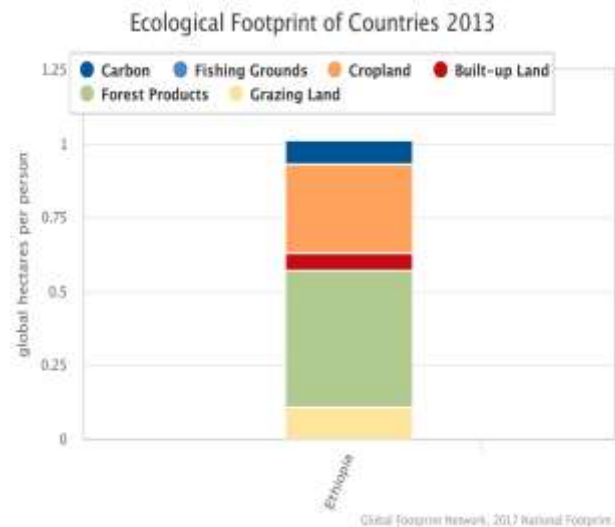

Figure 1. Ecological Footprint of Ethiopia in 2013 (Data Source: Global Footprint Network, 2017 National Footprint Accounts)

Study Objective and Scope

The main focus of this current paper is to assess the ecological footprint and analyze Sustainability for Debre Berhan University, Ethiopia. The specific objectives are

- To evaluate the waste management output and strategies
- To perform Ecological analysis by integrated environmental management approach
- To do sustainability analysis for the University

The Study Area and Methodology

Study Area

The study area is Debre Berhan University located in Debre Berhan, North Shewa Zone, and Amhara Region, Ethiopia. This University is 130km to Addis Ababa in north direction. The topography within 2 miles of Debre Berhan contains very significant variations in elevation, with a maximum elevation change of 1,270 feet and an average elevation above sea level of 9,078 feet. Within 10 miles contains very significant variations in elevation (4,393 feet). Within 50 miles also contains extreme variations in elevation (9,941 feet).

The university is located in 102hacters area. The total DBU population including regular students, staff and faculty are 13,538. This includes total number of regular students - 11,329, Administrative staff -988, Technical assistant staff - 165 and Academic staff- 1106 in the year 2017-18.

Research Methodology

This Ecological footprint analysis calculator is used for the estimation of total area of productive land and water for maintaining the university's resource consumption and for the management of the waste resources over a period of one year. This involves material usage and consumption, energy use, transportation using fossil fuels, water use, and waste categories (recycled and non-recycled waste) disposal. This is applicable to all the university resource consumption within the university [8]. The total university population data was obtained from University Registrar office and Human Resource department. Various departments are contacted for information collection either personally or telephonically and the world average and country's data were collected from online reliable research sources. It is required to get the information about the total number of staff, faculty and regular students that form the university population which is used in deriving the footprint analysis.

Data Input

All the consumption values even if in variety of units, are used as input unit less values and helps to convert all the data into consumption of land area (Table 1).

Purpose of Factors

These factors help to scale the productivity of the land as per their equivalence factors (Table-1) multiplied by the world average in the land productivity.

Table 1. Equivalence Factors for Ecological Footprint Consumption Per Capita Ethiopia-2013[9]

Land Category	Equivalence Factors
Fossil energy (carbon)	0.08276
Built-up area	0.060226
Crop land	0.299086
Fishing ground	0.001896
Forest area	0.456929
Grazing Land	0.111458

EFA Calculation Design

This is very unique in its feature since it works according to the organizational structure and helps to streamline the data so that specific resource category can be targeted for the ecological footprint reduction strategies. All the impact categories are identified and evaluated in the calculator. All the calculator equations are listed in (Table 2).

Table 2. Ecological Footprint Consumption of Each Component in University

Paper Consumption   Consumption (reams)/435 (reams/tonne) * (1.32 ha-yr/tonne = EF [ha-yr]
Waste Consumption   Paper waste [kg] * 0.0028 [ha-yr/kg] = EF [ha-yr]   Glass waste [kg] * 0.001 [ha-yr/kg] = EF [ha-yr]   Aluminum waste [kg] * 0.0094 [ha-yr/kg] = EF [ha-yr]   Plastic waste [kg] * 0.0036 [ha-yr/kg] = EF [ha-yr]
Water Consumption   Consumption [m3] * 0.00008 [ha-yr/m3] = EF [ha-yr]
Energy Consumption   Conversion factor = (fraction hydroelectric) * (footprint for hydroelectric) + (fraction natural gas) * (footprint for natural gas) + (fraction coal/oil) * (footprint for coal/oil)
Fossil Fuel Consumption   Consumption [L of diesel/yr] * 0.000867 [ha-yr/L] = EF [ha-yr]   Consumption [L of unleaded gasoline/yr] * 0.000774 [ha-yr/L] = EF [ha-yr]
Car Drop Offs   [∑(% in distance category) * (annual km)] * (# students dropped off) # of car km * 0.00018126 [ha-yr/km] = EF [ha-yr]
Built Up Land Area   Consumption [m2] * 0.000006 [ha-yr/m2] = EF [ha-yr]

Results and Discussion

In this section results of ecological footprint are evaluated and analyzed from various resources like water, energy, paper and waste output at the University of Debre Berhan. All these findings of ecological footprint are evaluated to find out the sustainability of the University [9].

Ecological footprint of Water Consumption

The ecological footprint of total water consumption both indoor and outdoor is 44.308 ha-yr. This is the reasonable component for the university consumption and it is an estimate since most of the water is used for irrigating the lawns and project field crops [10]. Water is used mainly on the campus for drinking, irrigating the campus areas, washrooms and for various other washing purposes.

Ecological footprint of Waste Consumption

This component includes various types of waste of glass, cans, paper and bottles from the university. The ecological footprint is 67.582 ha-yr which is for the total number of students, staff and faculty in the university. Solid waste coming out from university is segregated -Paper-10kg/bag, Plastic-2.72kg/bag, Glass-9.30kg/bag, Cans-1.81kg/bag [10].

Ecological footprint of Paper Consumption

This includes the Paper Reams used as Virgin paper in the campus, Newspapers and other small toilet roll papers. The ecological footprint is 1.52 ha-yr which is for the total number of students, staff and faculty in the university [11].

Ecological footprint of Energy Consumption

The energy consumption includes two components electricity and fossil fuel consumption [11] in the university. The energy print associated with electricity is 1695.78 ha-yr and the energy print for fossil fuel is 28.068ha-yr. The total energy print is 1723.848 ha-yr. The energy consumption of University is based on the Energy Mix of the local blend. Hydroelectricity power generation which is 96% out of which 92.4% comes from waste and biomass followed by oil (5.7%) and hydropower (1.6%). University owns various buses, cars and vehicles for commuting purposes and as a drop off for the students.

Ecological footprint of Built-Up land

The Campus built-up land includes the area of buildings, parking lots, road space, and all impermeable surfaces [12]. The ecological footprint for this is 2.4ha-yr. (Table 2)

Debre Berhan University Ecological Footprint

The ecological footprint for the University is the total of all the evaluated footprints [13] which is 1839.65 ha-yr or 4599.145 acres (Table 3). This is about 18 times the area of the campus(102ha/255acres).The ecological footprint of campus per capita is just 0.34.

Table 3. Ecological Footprint Per Capita of University Campus Area

Foot-print types	Footprint Component	Percentage of total	Per capita foot print(ha-yr)	Per capita foot print(acres)
Hydro print	44.308	2.41	0.0033	0.00825
Waste print	67.582	3.67	0.005	0.0125
Electricity print	1695.78	92.17	0.125	0.3125
Fossil fuel print	28.068	1.52	0.0021	0.00525
Paper print	1.52	0.083	0.0001	0.00025
Built-up Land	2.4	0.13	0.0002	0.0005

The total ecological footprint analysis of University is calculated by adding up all the footprint categories which gives the campus ecological footprint score. This value of Ecological Footprint (EF) can be converted to acres by multiplying with factor of 2.5 since 1 hectares equals 2.5acres. This gives the value 4599.145 acres. This footprint of university is 18 times the total campus area is 102 ha or 255 acres. The total campus population of students, staff and faculty is 13,538 so this gives the approximate per capita footprint in acres 4599.145/13,538. The per capita university footprint is 0.34. If we compare this value with the amount of footprint space available per person in the country [14] which is 1.0123 so according to this the EF values of university campus space available per person is almost three times short of Ethiopia's footprint [15] but if compared on the world scale then the recommended space for per person is 5 acres or 2 ha per person. The university campus footprint is 15times short of the world average footprint per capita (Table 4). This clearly proves that the amount of natural resources consumed and waste generation from university is greater than the amount which is naturally absorbed but still this consumption gap of demand and supply is not very huge so some environmentally beneficial consumption factors can further reduce these numbers.

Table 4. Ecological Footprint Data Analysis

Campus Footprint (acres)	Recomm-ended Footprint (acres)	Footprint space per person in	World Footprint space per	Campus Footprint per person

		Ethiopia (acres)	person (acres)	(acres)
4599.145	21,660	1.012	5	0.34

Sustainability Analysis of University

The total of university space in acres (255) and university hydrospace in acres (84) gives the sustainable value of 339 acres which is Ideal Sustainability [16]. Strong sustainability is the area of 1.6 acres per person on world average (excluding food, arable and pasture land) while weak sustainability is 3.4acres per person on world average (Table 5).

Table 5. Recommended Sustainability Values

Ideal Sustainability	Strong Sustainability	Weak Sustainability
339 acres	21,660acres	46,029 acres

Conclusion and Recommendations

The total measured ecological footprint for the Debre Berhan University is approximately 4599.145 acres while the area of campus is 102 ha or 255 acres (which is 18 times). The campus per capita footprint is very less 0.34 [17]. Food, arable and pasture land is not available on the campus so it made a total of 1.6acres out of world average which is 5 acres per person [18]. The total available footprint space for the university should be 1.6*13,538 is 21,660 acres. The measured footprint space is just 4599.145 acres which is approximately 5 times less than the required space. This proves that the university footprint space is 4599.145acres which is not ideal but strong sustainability as compared to the world average.

Acknowledgments

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