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Assessment of Ecological Footprint of Educational Institutes in Bilaspur District of Himachal Pradesh

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ABSTRACT

The ecological footprint is a resources accounting tool that measures how much land and sea area is available on earth, and how much of this area is appropriatefor human use. The present study was conducted in the year 2020-21to assess the ecological footprint of schools. Five components *viz.* electricity, water, solid waste, transportation, and material (paper) consumption of selected 13 Government Senior Secondary Schools of Bilaspur district were analysed. The total ecological footprint (EF) of all the selected educational institutes was found to be 2417.46 gha and per capita, EF was 0.58 gha.The highest ecological footprint was found to be 544.48 gha in GSSS, Berthin, and per capita highest ecological footprint was calculated as 0.59 gha and the lowest EF (91.43 gha) was in GSSS, Ghumarwin and per capita, EF was 0.53 gha. The highest (1.47 gha) biocapacity was observed in GSSS, Berthin,and the lowest biocapacity (1.33 gha) was estimated in GSSS, Bilaspur. The component-wise contribution towards total EF was 23.34 gha, 0.012 gha, 83.66 gha, 2213.58 gha, and 0.062 gha respectively in energy, water, material, transportation, and solid waste. In Jhandutta Block, the maximum number of students and staff members falls under the sustainability scale of 60–120, which indicates that an extra campus is required to support their lifestyle. In Ghumarwin and Bilaspur blocks, the maximum number of the population falls under the sustainability scale of less than 60, which means that resources are used efficiently. In Swarghat block, the maximum population falls under the scale of 120–180, which indicates that students and staff arenot utilizing the resources efficiently.

KEYWORDS: Biocapacity, ecological footprint, ecological deficit,global hectare, resources, sustainability

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1. INTRODUCTION

Humanity depends upon the natural resources of the earth for supporting our lifestyle. Human activities consume resources and produce waste. An ecological footprint shows how much individual human beings have an impact on nature. EF is a way to measure human consumption demands on nature, it includes the impact of electricity, transportation, food, water, waste, etc.The ecological footprint is well- known resources accounting tool that measures how much biologically productive land and water area; an individual, a city, a country, or humanity uses to produce the resources it consumes and absorb the waste it generated using technology and resources management (Wackernagel and Rees,1996; Syrovataka, 2020). The estimation of a nation's ecological footprint helps in knowing how many people a nation can support in a particular lifestyle (Ferguson, 1999). Economic and human activity, as well as spatial units such as cities, regions, nations, and the entire globe, can be calculated using EFs(Van Den Bergh and Grazi, 2013, Ventoulis, 2001). Currently, resources such as fossilfuels, and agricultural and forest products, have been squeezed along with the constantly increasing GDP (Chen et al., 2006). EF is the method that represents the suitability of a given population on the carrying capacity of the total system(Nunes et al., 2013).

Ecological footprint analysis has been used since the early 1990s as a measure of sustainability for geographical regions, products, and activities (Klein-Banai et al., 2011). The first step in reducing natural resource waste is to track usage trends for commodities like water, energy, and natural gas. The EF of the university of A Coruna(UDC) was 2177 gha in 2016, 148 times its biocapacity. 92% of 2177 gha was generated by car trips. The per capita EF of transportation from residence to the UDC campus grewby 17% during 2008–2020. Such cases show thatthe depletion of natural resources has worsened and become a serious global environmental issue (Wackernagel et al., 2004, Kitzes et al., 2007). Global sustainability would be achieved if all humans were able to live within their particular regional/ territorial carrying capacity. However, the population of all the urbanised regions and many countries as a whole exceeds regional carrying limits, and their survival is reliant on trade, primarily imports (Rees, 1992). When the ecological footprint of a nation is smaller than its biocapacity, it is sustainable. A study was conducted atthe National Institutes of Technology Allahabad, in which the total EF was 4397.03 gha which is approximately 20 times more than biocapacity (Husain and Parkesh, 2018). A study was conducted on the EF for assessing sustainability in schools. The EF of the school was found to be 320 gha during 2008–2009 (Gottileb et al., 2012). Wang (2013) analysed the ecological footprint of Taiwan from 1994–2007 and found it as 6.54 gha per people in 2007. The total ecological footprint of Taiwan was 42 times the area of Taiwan. Global overshoot has increased the number of environmental consequences such as shrinkage of forest area, fishery collapse, increased greenhouse gas emissions, drinking water scarcity, and eventually, climate change (Rosenburg et al., 2010). Auckland, New Zealand's primate city was found to have the largest regional footprint of 2.32 million ha (McDonald, 2004).

A study was conducted on 33,000 students at Politecnico di Torino, a Higher Education Institution (HEI) located in Northern Italy. Transport had the highest share with 49.4% out of the total campus impact, whereas energy covered 40.1% (Genta et al., 2022). Natural resources were plentiful in the past and the population was less but now the situation has changed. The EF of land continues to increase as the world population becomes more urbanized. Therefore, the challenge is to find a way to tackle the problem and make a balance between the productivity of natural resources and human consumption. An average personin a developed country consumes 32 times more than an average personin a poor country, and if everyone consumes the same amount as citizens of a developed country, the quickly growing population will cause major problems (Diamond, 2008). The EF of Metro Vancouver was calculated where water represents the largest material flow through Metro Vancouver followed by transportation fuel (Moore et al., 2014). The NFA is one such accounting system, meant to track human demand on the biosphere's generative and absorptive capacities (Borucke et al., 2013). Sustainability refers to a state in which human consumption does not exceed nature's productivity. With the help of the sustainability scale provided by the Environment Protection Agency, if a person falls down the sustainability scale of less than 60 it means very little resources and land are needed to support his/her lifestyle.

The results from National Footprint Accountsindicate that humanity's ecological footprint is 1.7 piles of earth and that global ecological overshoots continue to grow (Lin et al., 2018). A study conducted atthe University of Redlands,United Statesmeasured EF was 2300 ha or about 40 times the area of campus (Ventoulis, 2001). The ecological footprint method is a biophysical methodology that captures directly or indirectly some of the basic services that human societies rely on, and provides otherwise-impossible insight into human underuse of such resources (Mancini et al., 2018).

2. MATERIALS AND METHODS

The study was conducted during the year 2020–2021. Bilaspur district has a latitude of 31.3407° N, and a longitude of 76.6875° Eis well connected between Punjab and Chandigarh, and Manali (a tourist place) hence, its developmentisvery fast. The ecological footprint (EF) of Government schools at the 10+2 level canassist in providing a clear image of the footprint of such micro-level locations. In the Bilaspur district,there are 128 Government Senior Secondary Schools (GSSS) out of which 13 schools (10%) were selected randomly and depicted in Figure 1.

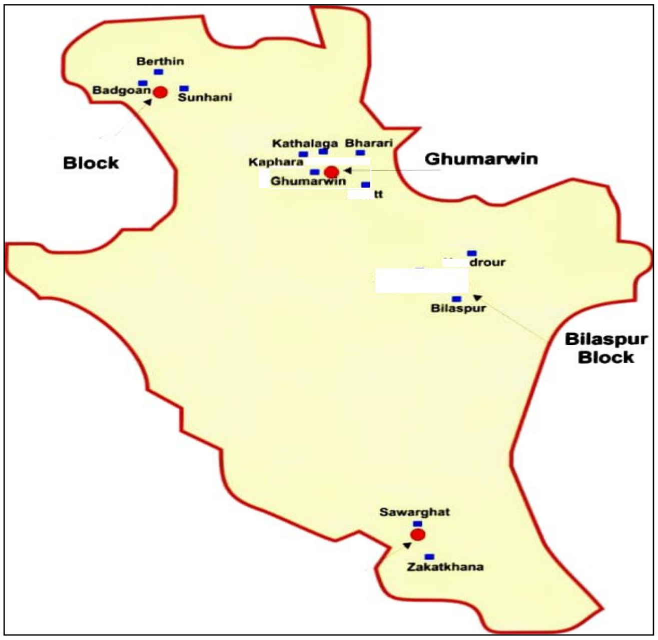

Figure 1: Map of the study area

To assess the ecological footprint of educational institutes, the consumption in different sectors of energy, water, transportation, and material was considered obtained from the school's administration. The main purpose of finding ecological footprint is that the total consumption and waste are converted to biologically productive land area which is required to produce goods and services for human consumption and waste generated by them.

2.1. Component wise ecological footprint assessment:

2.1.1. Electricity footprint

Electricity footprint captures the carbon dioxide emission that result in the generation of electricity consumed by the schoolsand it is calculated by using following formula given by Gottileb et al. (2012).

electricity footprint (gha/year)=energy land ((gha/kWH)/year)×kWH (year) …………(1)

2.1.2. Water footprint

Water footprint captures the total consumption of water in the schools. It is the annual water consumption in school multiplied by the land area required for supporting 1 ml of water. It is calculated using formula

water(gha/year)=total consumption((gha/m3)/year)×m3(year) ……………………………………(2)

2.1.3. Material footprint

Material footprint capture the energy land required to produce the items in terms of land needed to sequester the CO_2 emission. The material EF (paper) was calculated with the formula given by Gottileb et al. (2012).

material print (gha/year)=items per year (kg)×EF per items (gha/kg) ……………………………………………………..(3)

2.1.4. Transportation footprint

In order to assess the EF of transportation, data of vehicles movement was recorded at entry gate of schools. The calculation includes the distance by each student and staff travels to school and home, number of days during the study period and mode of transportation used.The EF of transportation was calculated using formula given by Gottlieb et al. (2014).

transportation print=distance from school (km)--×times per year×EF per passenger ((gha/km)/year) ……..…………….. (4)

2.1.5. Solid waste footprint

The solid waste footprint captures the amount of waste generated annually in the campus and how much area is required to absorb the waste generated in the area. The waste footprint is given by Habibi et al. (2015).

Waste Footprint=Total waste per year (kg)×Land fill area×EF (gha/kg) ……………………………………………(5)

2.1.6. Ecological deficit

The ecological deficit formula was given by Monfreda et al., 2004.

Ecological deficit=biocapacity (gha)-footprint (gha) …..(6)

3. RESULTS AND DISCUSSION

3.1. Ecological footprint in selected schools of Bilaspur district

Table 1 indicated that the ecological footprint of selected schools in Bilaspur district for various components *viz.* electricity, water, material, transportation and solid waste. The EF capita^{-1} of electricity varied from 0.0019–0.01 gha. The lowest per capita EF of electricity was observed in GSSS (Bharari) 0.0019 gha and highest was founded in GSSS(Swarghat) 0.01 gha. A study was conducted in Israeli high school in which total EF was 314 gha out of which food and electric power were the main components followed by materials and transportation (Gottlieb et al., 2012).

The EF capita^{-1} of water varied from 0.0000001–0.00006 gha. The lowest per capita EF (0.0000001 gha) observed in the GSSS (Chatt), GSSS (Ghumarwin) and highest (0.00006 gha) was found in GSSS (Berthin). The impact

Table 1: Ecological footprint of selected schools

Components	Electricity		Water		Material	
School	EF	Per capita	EF	Per capita	EF	Per capita
Badgoan	1.6300	0.007000	0.0001	0.000002	3.3400	0.014000
Berthin	7.0300	0.00780	0.0057	0.00006	64.8000	0.07200
Sunhani	1.48000	0.0075000	0.00002	0.0000004	0.86400	0.0044000
Chatt	1.18000	0.0067000	0.00002	0.0000001	0.30240	0.0018000
Kaphara	1.20000	0.0060000	0.00002	0.0000003	0.72000	0.0039000
Kathalag	1.4800	0.002900	0.0001	0.000008	2.1600	0.004300
Ghumarwin	0.77000	0.0045000	0.00009	0.0000001	1.29600	0.0076000
Bharari	1.0400	0.00190	0.0025	0.000008	3.0240	0.00560
Kandaur	1.6300	0.005200	0.0005	0.000002	0.5400	0.001700
Chandpur	1.4300	0.005200	0.0002	0.000001	0.8640	0.003000
Bilaspur	1.4200	0.005100	0.0008	0.000004	1.4400	0.005200
Swarghat	2.030	0.01000	0.001	0.00005	2.590	0.01290
Zakatkhana	1.0200	0.003800	0.0007	0.0000004	1.7200	0.006500
Total	23.34	0.0736	0.012071	0.000175	83.6604	0.1429
Mean	1.795385	0.005662	0.000904	1.04846	6.435415	0.010992
SD	0.431335	0.00226274	0.00042426	1.131337	1.145513	0.001485
CV	24.03	39.96	46.93	107.9	17.800	13.5

Table 1: Continue...

Components	Transportation		Solid waste	
School	EF	Per capita	EF	Per capita
Badgoan	120.8000	0.520000	0.0013	0.000029
Berthin	473.0000	0.52000	0.0019	0.000017
Sunhani	104.06000	0.5200000	0.01280	0.0002500
Chatt	91.97300	0.5255600	0.00190	0.0000150
Kaphara	98.27900	0.5200000	0.003200	0.0000360
Kathalag	260.7000	0.520000	0.0038	0.000099
Ghumarwin	89.35000	0.5256000	0.01280	0.0001800
Bharari	279.6000	0.52560	0.0045	0.0000012
Kandaur	164.4900	0.525500	0.0016	0.000018
Chandpur	142.9500	0.52560	0.0013	0.000065
Bilaspur	145.0500	0.525600	0.0004	0.000002
Swarghat	105.640	0.52560	0.007	0.00003
Zakatkhana	137.6900	0.525600	0.0085	0.000046
Total	2213.582	6.80466	0.06154	0.00081
Mean	170.2755385	0.523435	0.004692	6.07692
SD	11.94303	0.00396	0.005091	1.83848
CV	7.013	0.7565	108.5	30.24

of water consumption on overall footprint of the village is relatively minor. This is due to the fact that when converting water consumption to land area, the direct equivalent of that water consumption in hectares is used as well as the energy needed to treat and transport this water. Therefore, water is seen largely insignificant natural resources in terms of the overall EF (Ryan, 2004). Material EFcapita^{-1} varied from 0.0017 gha GSSS (Kandaur) to 0.07 gha GSSS (Berthin). These results are in line with the study conducted by Singh (2019) who founded 41.94 gha EF for components material for YSP the University, Nauni. Among all the components, the highest EF was observed in for transportation sector. The EF capita^{-1}of transportation varied from 0.52–0.5256 gha. The highest EF was observed in GSSS(Berthin) as maximum staff members use personal vehicles attendingschoolsat a distance of 10–20 km daily. The result outcomes are in line with the study conducted by Lambrechts and Liedekerke, 2014 who notice that the sector transportation recorded half of total EF. The EF capita^{-1}of solid waste varied from 0.0004 gha GSSS (Bilaspur) to 0.0128 gha GSSS (Sunhani and Bilaspur). Component wise highest contribution of EF capita^{-1}was from transport (6.80466 gha) followed by material (0.1429 gha), electricity (0736 gha), solid waste (0.00081 gha) and lowest from water (0.000175 gha).

3.2. Biocapacity in selected schools of Bilaspur district

Table 2 indicated that all the selected schools were ecological reserve in land area to sustain their present population and their needs. The biocapacity capita^{-1}ranged from 1.33–1.47 gha. The lowest biocapacity 1.33 gha was calculated in GSSS (Bilaspur) and highest was observed in GSSS (Berthin) 1.47 gha. The ecological deficit of GSSS(Bilaspur) 0.79 gha was the minimum among all selected school and maximum was in GSSS (Kandaur) 0.90gha. The table also indicates that all the schools have sufficient reserve to sustain their lifestyle.

Table 2: Biocapacity (gha) and ecological deficit reserve^{-1} (gha) in selected schools of Bilaspur district

Schools	Population	Biocapacity/capita	EF/capita	Ecological deficit/reserve
Badgoan	230	1.37	0.54	0.83
Berthin	900	1.47	0.59	0.88
Sunhani	198	1.35	0.54	0.81
Chatt	175	1.34	0.53	0.81
Kaphara	187	1.33	0.52	0.81
Kathalag	496	1.34	0.52	0.82
Ghumarwin	170	1.35	0.53	0.82
Bharari	532	1.34	0.53	0.81
Kandaur	293	1.43	0.53	0.90
Chandpur	272	1.34	0.53	0.81
Bilaspur	276	1.33	0.54	0.79
Swarghat	201	1.38	0.54	0.84
Zakatkhana	262	1.35	0.53	0.82
Average	4192	1.36	0.54	0.83

3.3. Sustainability of selected schools of Bilaspur district

A sustainability scale of 60–120 means that your footprint has more of an impact on campus resources, if everyone lived like this, we would need an entire extra campus to support us. If the sustainability scale is 120–180, the footprint uses a large share of campus resources. If everybody lives like this,we would need 3 campuses to sustain us. If the sustainability scale is more than 180, indicated that we would need 4 campuses just to support us.

Table 3 revealed that GSSS (Ghumarwin), and GSSS (Bilaspur) have 10% of the population having a sustainability scale of more than 180 which means that an extra campus is required to support their living standards.The GSSS (Chatt) and GSSS (Kaphara) have more than 75% population under a scale of 60 which indicates that they consume minimal resources to maintain their lifestyle.

Table 3: Sustainability of selected schools of Bilaspur district

Schools	Population (No.)	Area (ha)	Sustainability			
			<60	60–120	120–180	>180
Badgoan	230	0.33	30	50	10	10
Berthin	900	0.93	25	60	10	5
Sunhani	198	0.24	30	45	20	5
Chatt	175	0.84	70	15	15	-
Kaphara	187	0.81	75	10	10	5
Kathalag	496	0.65	25	70	5	-
Ghumarwin	170	0.89	30	45	15	10
Bharari	532	0.50	25	55	15	5
Kandaur	293	0.66	25	75	5	-
Chandpur	272	0.16	65	20	10	5
Bilaspur	276	0.81	50	30	10	10
Swarghat	201	0.77	40	10	45	5
Zakatkhana	262	0.49	15	30	50	5

4. CONCLUSION

The total ecological footprint of all the selected educational institutes of Bilaspur district, HP was observed to be 2417.46 gha and the ecological footprint per capita was 0.54 gha. The biocapacity of all selected schools was 1.36 gha per person whereas the biocapacity of India is 0.45 gha person^{-1} which means that all the selected schools of Bilaspur district are in the ecological reserve. All the selected schools are found to be under a sustainability scale of 60–120.

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