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Analyzing the ecological footprint at the institutional scale – The case of an Israeli high-school

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ABSTRACT

One way in which institutions can implement the idea of sustainability is through the use of ecological indicators that will characterize the current situation and help determine where to focus efforts in order to achieve the goal of sustainability. The use of the 'Ecological Footprint Analysis' (EFA) represents an innovative attitude to calculate the load that an institution imposes on the natural environment. The goal of this study is to illustrate the benefits of using EFA at the institution scale. Our case study is the ecological footprint of one high school in the city of Haifa, Israel. We present a unique method integrating between institutional and individuals' sourced data concerning consumption patterns at the institutional level. We then present the breakdown of the school footprint into four main components: electricity, transportation, food and materials. The results of our research reveal an overall footprint of 314 global hectares (gha), from which food and electric power are the main components followed by materials and transportation. Based on the results, we developed scenarios for potential future reduction of the high school ecological footprint.

1. Introduction

In recent decades, several indicators and concepts for measuring sustainability have been suggested. One indicator receiving a lot of attention in academic, policy and education circles is the Ecological Footprint Analysis (EFA). EFA is a quantitative tool that uses material and energy flows to estimate the biophysical 'load' that human populations or industrial processes impose on ecosystems around the world (Rees, 1992; Wackernagel and Rees, 1996). It recognizes that energy and resource exploitation (and the assimilation of CO_2 emissions) can be associated with a corresponding dedicated land/water ecosystem area. EFA, therefore, determines the total ecosystem area (global hectares) required to produce the resources consumed and to assimilate certain CO_2 emissions produced by a specified human population.

Footprint accounts have been calculated for various scales: the entire planet (e.g., Wackernagel et al., 2002; GFN, 2011), specific nations (e.g., Kitzes et al., 2007; Wackernagel et al., 1999; Haberl et al., 2001; Monfreda et al., 2004; Moran et al., 2008), cities and regions (e.g., Warren-Rhodes and Koenig, 2001; Barrett et al., 2002; Wood and Lenzen, 2003; Aall and Norland, 2005; Collins et al., 2006; Wackernagel et al., 2006; Kissinger and Haim, 2008; Scotti et al., 2009), and for specific industrial production and supply processes (e.g., Kissinger et al., 2007; Kissinger and Gottlieb, 2010).

Another scale receiving attention in recent years is the institutional scale. Calculating the ecological footprint at the institutional level has two potential merits: (1) approving the environmental accounting of institutions by monitoring sustainability performance; (2) raising awareness to sustainability principles and practices by collaborating individuals (e.g., students, employees) in the process of monitoring, collecting data, results and derived action plan for reducing the institutional ecological footprint.

Holland (2003) and Weidmann et al. (2009) focused on business EF, where the latter used an Environmental Input Output approach to calculate the EF. Weidmann (2008) presented the EF of governmental institution (the Scottish parliament). Several studies including Conway et al. (2008), Flint (2001) and Li et al. (2008) focused on higher education institute footprint. To date no academic paper focused on the ecological footprint of schools.

The overall goal of the present study is to illustrate further the potential use of the EFA as an indicator of sustainability at the institute scale, by exploring the case of an Israeli public high school. We present a detailed, step by step footprint calculation procedure adjusted for institutions pursuing sustainability.

Our paper presents the results of a one-year research project (2008/9) in one of the largest public high schools in the city of Haifa, Israel. The study presents an original, unique calculating approach adjusted to the institute scale. As different from other studies at

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the institutional scale, this study integrates between existing institutional data and a detailed survey among the institute students. The research measured the size of the school's EF, and its components were analyzed and discussed. Analyzing the EF enabled us (researches, teachers and students) to monitor and identify the school's 'ecological loads' and to explore directions for minimizing those 'loads'. In a recent paper (Gottlieb et al., 2012), we discussed in details the educational process and implications of EF in schools. That paper described an educational program for sustainability that was held by the first author at the studied school. The current paper highlights the methodological procedure and presents a detailed analysis of the school EF components. Furthermore, while indeed as suggested by some researchers EFA presents a snapshot of the current situation (e.g., Van Vuuren and Smeets, 2000), the present study attempted also to develop footprint reduction scenarios at the institutional level based on changing behavior and consumption patterns.

2. Background

2.1. The EF as indicator for sustainability in institutions

The measurement of sustainability for institutions, cities, regions, and nations is a complex undertaking. The broad nature of sustainability makes it difficult to find indicators that not only encompass a wide range of aspects, but also remain specific enough to allow explicit policy and action plan formation at the national, regional and organizational levels. One indicator that seeks to address the full scope of sustainability is the ecological footprint. The EF was defined by Rees (1992, 2000) as the total area of land and water ecosystems required for defined population to produce their resources and to assimilate their wastes, wherever these ecosystems are located.

While the EF has been calculated previously for institutions (Wood and Lenzen, 2003), studies have generally focused on regions and nations (see for example, Bicknell et al., 1998; Lenzen and Murray, 2001; Simmons et al., 2000; Van Vuuren and Smeets, 2000; Wackernagel et al., 2004). Such studies have highlighted the global impacts of consumption, but have not provided the intricate information at the local level needed for remediation. Detailed local information is particularly important for institutions, which have the opportunity to mitigate their impacts by controlling and directing their own institutional behavior. In fact, an institutional EFA provides guidance on where effort to achieve sustainability is best focused. Institutional EFA allows consumption to be viewed in two related ways. First, it is possible to determine where the greatest impact is occurring. Second, it is the ability to rank-order consumption based on contribution to the footprint.

Universities are one type of institutes which have a particular role in promoting sustainability. In recent years, a number of campuses have published EFA studies (Conway et al., 2008; Dawe et al., 2004; Flint, 2001; Klein-Banai and Theis, 2011; Li et al., 2008; Venetoulis, 2001). Venetoulis (2001) calculated the ecological footprint of the U.S. University of Redlands. The calculation involved three main components: water, energy, and waste output.

In more recent studies, Conway et al. (2008) and Li et al. (2008) have calculated the EF of the University of Toronto at Mississauga (UTM), Ontario, Canada and Northeastern University (NEU), China, respectively. The calculated EF was comprehensive and included beyond water, energy and waste, also, food and transportation. There are several similarities among the above mentioned studies and other, in results and methodological aspects. From the result aspect, closer examination of the calculated components reveals the largest component was the ecological footprint of energy (above 50% of the total EF). Most of the data required for calculation was collected from the institution (for example, faculty administrations). However, as noted by Rees (2003), it is the individuals' components of the institutional footprint that offer the greatest benefit for sustainability management.

2.2. The EFA as an ecological indicator (calculator) for individuals

A significant means for developing the EF as a popular indicator for sustainability has been the development of several on-line calculators (Franz and Papyrakis, 2010). Environmental NGOs, such as the World Wildlife Fund, the Global Footprint Network, and several government ministries, such as the Austrian agriculture ministry and the Australian ministries of environment and forestation, are offering an on-line EF calculator as a service on their websites.[1] Such online calculators enable individuals to calculate their load on the natural environment and estimate the degree of environmental damage in terms of the area of land that would result if all residents of Earth were to consume as they do (GFN, 2011). However, most calculators do not quantify the volume of consumed items, but rather convert the monitory value of purchased products or behaviors patterns. For example, data related to food consumption or regarding travel methods are measured according to the cost of purchase in money terms and the corresponding number of hours in which the various means of transport are used (e.g., the WWF calculator). Another way of gathering data is through posing questions to the user regarding the degree of frequency in the use or consumption of various products. For instance, in the field of food consumption, among other things, the question would be: "How often do you eat meat?" The scale of responses would vary between "never" and "very often" (e.g., the Global Footprint Network calculator). These methods of data gathering are convenient for the user, but they are not as precise as data gathering based on quantitative consumption figures per kW h (energy consumption) or per kg (food consumption). Furthermore, in EF calculators, local factors (e.g., the mixed sources of electricity production, agricultural yield per hectare, specific modes of transportation, etc.) are not taken into account or are not available to the user, such as conversion factors through which one can convert food and material consumption (e.g., paper) into area size in EF terms. As a result, the data on which the measurements of EF calculators are based do not allow for the development of reliable calculations and scenarios through monitoring and the intelligent management of resources. Therefore, in order to be more adjusted as an indicator of sustainability in institutions, the EF analysis should be based on detailed quantified and localized data, integrate a more dynamic analysis of key variables, illustrate clearly the links between individual action and aggregate environmental impacts and should combine between data from administrations and individuals. Furthermore, the method of calculation should be transparent with regard to the way in which EFA is conducted.

3. Method

Since its first appearance, EF measurements are calculated either using the compound or component-based method, or with a hybrid combination of these methods.

The choice of method is determined primarily by scale (size of the entity measured) and the format of available data. Like most other footprint studies at the institute scale we used the component EF approach. The component approach initiated by Barret (2001), Chambers et al. (2000), Simmons et al. (2000) divides the overall studied institute into the different components of its activity

[1] www.footprint.wwf.org.uk, www.ecologicalfootprint.com, www.myfootprint.org.

(e.g., transportation, use of electric power, solid waste generation etc.) and calculates the footprint of each component. That approach allows researchers and the studied entity to identify the relative contribution of different activities to the overall footprint. Many of the EF values for certain activities are pre-calculated using data appropriate to the region or institution under consideration. This method has the benefit of greater local transparency, which facilitates comparisons between impacts of different activities and experimentation with possible scenarios that are sustainable or unsustainable (Simmons et al., 2000).

Municipal high school 'E' is one of the largest public high schools in the city of Haifa, with 1520 students and 47 classes from the seventh grade to the twelfth grade (12–18 years old). Our research focuses on the 2008/9 school year. The school EF calculation procedure includes the following steps: consumption patterns documentation; creating EF conversion factors; calculation of each component.

3.1. Step 1: documenting consumption patterns at school

The research disaggregates the school activities into the following components: electric power consumption, transportation to and from school, food consumption, materials consumption and waste production. These components represent the main consumption categories of the high school and its students'. One unique contribution of this study is connected to the data gathering method, integrating several data sources in order to get a full picture of the institute (i.e., the school) consumption patterns. As different from studies at the urban/regional scale, which quite often integrates local data with top-down national data (e.g., data on electric power supply is usually available at the urban scale while food consumption is only available at the national scale), the institutional scale allows gaining more information of consumption patterns using data available at that level and complete it by asking the member community (i.e., students and staff in this case).

(a) *Data from the school administration* – like any other institute quite a lot of the required data is available at the institute level and is being documented. This includes for example data on the annual electric power, water and office paper consumption that was obtained from the school administration personnel.
(b) *Data obtained by questionnaires distributed among students* – institutes rarely documents the personal behavior and consumption patterns of their 'clients' and staff, in this case the students. However, to fully calculate the school EF our study had to gather data on such components as modes of transportation, food consumption, and students' material consumption (e.g., paper, plastic bottles and aluminum cans). We therefore used questionnaires. The questionnaire was designed to ask a sample number of students from all grades ($N = 333$) about their consumption patterns and their modes of transportation during one week at school. Two classes from each age group of students were selected for distributing questionnaires, with each age group comprising between 6 and 8 classes. Therefore, the 333 students that were sampled represent 6 different age groups, starting from students of 12–13 up to 17–18 years old. For documenting food and material consumption habits, the students were asked to indicate out of a list of items the number of times they consumed certain items during the previous week.

With regards to modes of transportation, we asked: "During the previous week how many times did you come to school and returned back home by the following means: public bus, private car, motorcycle, bicycle, on foot?" The data is a representative sample of the total consumption patterns of all the students ($N = 1520$) during one school year (2008/9).[2]

3.2. Step 2: creating EF conversion factors

The second step was to create a conversion datasheet that expresses the EF per unit of consumption, i.e., the land (in global hectare units) required. While the goal is to be able to capture the entire life cycle of consumed items or activities some components are presenting only part of that life cycle. For example in our study food and materials conversions are based on a full life cycle conversion, while electric power and transportation conversion reflects energy and CO_2 emissions in the processing/final use phase. Conversion factors in this research can be divided into two sources: local data originated from communication with service providers (e.g., bus company, electric utility company); and previous EF studies (see Table 1). The EF studies used here were Barrett et al. (2002) and Kissinger and Haim (2008). The first focused on the EF of the city of York (UK) and the latter with that of the city of Ra'anana (Israel).

3.3. Step 3: Calculating the EF of each component

3.3.1. Electricity

Captures the CO_2 emissions resulting from generating the electric power consumed by the school. The data is converted into the associated land area required for sequestering the CO_2. We have multiplied the conversion factor by the school's annual electricity consumption (2008/9),[3] as can be seen in the following equation:

$$\text{Electricity print (ha/yr)} = \text{kW h (kW h/yr)} \times \text{energy land (ha/kW h)}$$

3.3.2. Transportation

Captures the CO_2 emissions while commuting. The calculation combines the distance each student travels to school and back home, the number of days during the study period, and the mode of transportation (i.e., private vehicle, public bus, walking or cycling):

$$\text{Transportation EF (ha/yr)} = \text{distance from school (km/day)} \times \text{times per year} \times \text{EF per passenger (ha/yr)}$$

This is an ideal example of integrating several data sources at the institutional level. Data on the number of students and their home address (at the neighborhood scale) was obtained from the school administration; data on particular travel patterns (i.e., walking, private vehicles, public bus) was obtain from the students questionnaires; conversion factors were derived from several external sources (Table 1).

3.3.3. Food print

Food consumed by the students during their stay in school either brought from home or bought at the school's cafeteria. Our study covers the EF of the main food items consumed. While the data presented in Table 1 presents conversion factors of grocery items such as cheese, chocolate and bread, we had to calculate the EF of sandwiches consumed by students by summing up the ingredients

[2] 213 days excluding weekends, holidays and summer vacation.
[3] According to the Israeli Electric Corp. (IEC) public high school use electricity as follows: air conditioning (60%), lighting systems (20%), computerization (10%), and electrical equipment (10%).

Table 1
EF conversions.

Item	EF per unit global square meter (gm^2)	Source
Egg	25 gm^2/kg	Kissinger and Haim (2008)
Cheese	36 gm^2/kg	Kissinger and Haim (2008)
Fish	80 gm^2/kg	Kissinger and Haim (2008)
Beef	247 gm^2/kg	Kissinger and Haim (2008)
poultry	41 gm^2/kg	Kissinger and Haim (2008)
Vegetable	5 gm^2/kg	Kissinger and Haim (2008)
Fruit	10 gm^2/kg	Kissinger and Haim (2008)
Bread	11 gm^2/kg	Barrett et al. (2002)
Chocolate	87 gm^2/kg	Barrett et al. (2002)
Non-chocolate confectionery	26 gm^2/kg	Barrett et al. (2002)
Electricity	2 gm^2/kW	IBS (2008)
Private vehicles	0.3 gm^2/km	DEFRA (2007)
Bus	0.08 gm^2/km	EGGED (2004)
Paper	24 gm^2/kg	Barrett et al. (2002)
Paper (recycled)	19 gm^2/kg	Barrett et al. (2002)
Plastic bottles	23 gm^2/kg	Barrett et al. (2002)
Plastic bottles (recycled)	21 gm^2/kg	Barrett et al. (2002)
Aluminum cans	67 gm^2/kg	Barrett et al. (2002)
Aluminum cans (recycled)	36 gm^2/kg	Barrett et al. (2002)

according to their relative weight (e.g., accounting for the number of Tuna sandwiches and measure the weight of ingredients in that sandwich). The EF per food item is multiplied by the quantity of food gauged to be consumed annually:

$$\text{Food print (ha/yr)} = \text{items per year (kg/yr)} \times \text{EF per item (ha/kg)}$$

3.3.4. Materials print

Our research covers three types of materials: paper, plastic bottles and aluminum cans. The EF for paper represents two types of land: the ‘forest land’ needed to produce the fiber, and the ‘energy land’ needed to absorb the CO_2 generated by energy used to manufacture the paper. Calculation of the EF of plastic bottles and aluminum cans accounts for the energy required to produce the item in terms of land needed to sequester the CO_2 emissions (Table 1). That footprint per item is then multiplied by the overall material used by the school community during the research period as follows:

$$\text{Materials print (ha/yr)} = \text{items per year (kg/yr)} \times \text{EF per kg (ha/kg)}$$

3.4. Developing ‘changing consumption scenarios’

After calculating the school footprint we focused on each of the studied footprint components and developed some initial scenarios to the influence of changing consumption patterns on the institute EF. It is important to emphasize that we did not attempt to present the most extreme reduction but rather to enable students to explore and understand how different modes of behaviors, such as traveling by public bus, eating less meat, recycling and reducing waste, can reduce the EF. Therefore, these scenarios assume for example constant rates of energy and material consumption and only examine changing composition (e.g., less meat more vegetables), or behavioral patterns (e.g., walking or traveling by bus to school).

3.5. Study limitations

The current research has some limitations concerning calculation and data gathering methods. One major limitation is that not all necessary data were available (e.g., beverages) therefore, some commodities left out of the study. Also for lack of data our calculation of food EF does not cover packaging. Further limitation of relying on an EF calculation includes the incomplete nature of the approach because the impact of materials such as toxic wastes and ozone depletion are not considered (Moffatt, 2000; Rees, 2000; Kitzes and Wackernagel, 2009). Therefore, as noted by Wackernagel and Rees (1996), any measure of EF should be regarded as a conservative measure for sustainability. Furthermore, it should be noted, that EF analysis, like any other accounting model, represents a methodology that is far from being perfect and one that continues to change with new technology and updated conversions.

It also should be noted that data concerning individuals’ consumption patterns was gathered along short period of time, as result it might not be sensitive to changes in seasons, especially regarding food consumption and transportation modes of students.

4. Results

The calculated size of the high school EF was 314 gha for the year 2008/2009. This means that the land consumed by the high school community is 160 times larger than its physical or built-up land which accounts for only 2 ha. As presented in Fig. 1, the main EF components are food (38%, 114 gha), electricity (35%, 113 gha), followed by materials (19%, 62 gha) and transportation (8%, 25 gha).

4.1. Analyzing the school’s EF

Table 2 presents a detailed breakdown of the school EF. It illustrates the contribution of specific activities and consumption

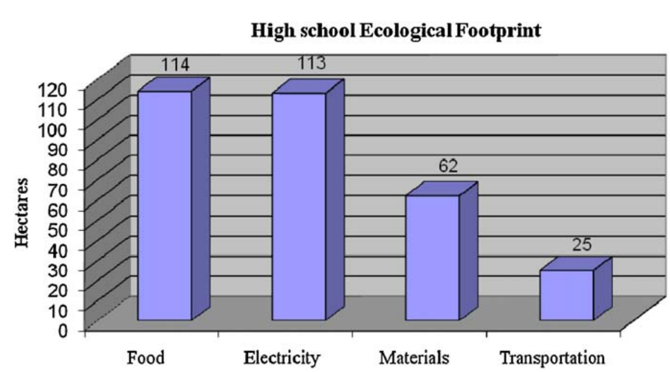

Fig. 1. High school EF.

Table 2
EF of the school according to consumption patterns.

Item/activity Food	Annual consumption Number of items	Conversion factors Global square meter (gm^2)/item	Student EF Global square meter (gm^2)/item	School EF Global hectares
Egg sandwich	16,980	2.1	26	3.6
Cheese sandwich	125,090	2.1	171	26.3
Tuna fish sandwich	15,300	5.1	53	7.8
Chocolate sandwich	50,130	2.8	92	14
Cold cut beef sandwich	12,370	10.1	82	13
Cold cut poultry sandwich	37,110	1.7	43	6
Fried poultry sandwich	25,480	7.3	125	18.6
Chocolate confectionery	23,350	4.3	66	10
Non-choc confectionery	34,620	1.3	33	4.5
Fruits	46,540	1.8	53	8.4
Vegetables	27,920	0.6	13	1.7
Total food print			757 gm^2	114 gha
Electricity	kW h	gm^2/kW h		
Lighting systems	107,630	2	151	23
Air conditioning	322,890	2	447	68
Computerization	53,810	2	72	11
Electrical equipment	53,10	2	72	11
Total electricity print			742 gm^2	113 gha
Materials	Weight (kg)	gm^2/kg		
Paper (school) administration	2530	24	39	6
Paper (students) consumption	9710	24	151	23
Plastic bottles	5000	23	79	12
Aluminum cans	3160	67	138	21
Total materials print			407 gm^2	62 gha
Transportation	Commuting	gm^2/km		
Bus	62%	0.08	86	13
Private vehicle	20%	0.3	79	12
Walking or cycling	18%	0	0	0
Total transportation print			165 gm^2	25 gha
Total EF			2071 gm^2	314 gha 320 ha

patterns as well as highlighting their relative contribution to the school footprint. The major footprint sub-components are air conditioning (68 gha) followed by meat sandwiches (37.6 gha) and paper consumption (29 gha).

4.2. Developing an institute tailored ‘changing consumption’ scenarios

While the ‘snapshot’ approach presented above has educational benefits such as monitoring and raising awareness of sustainability limits, developing ‘changing consumption scenarios’ might encourage students and teachers to be engaged in an action plan and active collaboration with other stakeholders in the community (such as, NGO’s, the municipality, and the private sector) in order to reduce the school’s EF. These ‘changing consumption’ scenarios enable the students to explore and understand how different modes of behaviors, such as traveling by public bus, eating less meat, recycling and reducing waste, can positively influence the natural environment in terms of less occupied ecological space. Each of the following scenarios aims to reduce the footprint in one of the key activities in the high school: electricity, food, materials and transportation.

4.2.1. Scenario 1: food EF

Food represents the school’s major EF component. In developing this scenario we assumed that the total amount of food items brought to school and bought in the cafeteria will remain constant. This scenario explores the contribution of changing food composition in order to reduce the footprint. For example, if the consumption of egg and cheese sandwiches increases from 34% to 50% of the total food items and the amount of meat sandwiches, chocolate sandwiches and confectioneries is reduced by 50%, the total food print will decrease by 12% from 114 gha to 101 gha/yar.

4.2.2. Scenario 2: electric power EF

Electric power EF as presented in Table 2, 60% of the school electricity consumption used for cooling and heating. Reducing the use of air-conditioners by 50%, will reduce the overall electric power EF by 30% from 113 gha to 79 gha/year. Other means for minimizing the air-conditioning EF can include replacing older air-conditioners with newer, more energy efficient machines and adjusting the temperature scale to 23–24 °C in summer and to 20 °C in winter, which will ensure the most efficient use of electric power.

4.2.3. Scenario 3: transportation EF

Table 3 emphasizes the main variables that influence the transportation print: the number of students commuting from neighborhoods at different distances from the school, and their modes of transportation.

By changing student travel patterns – encouraging walking, cycling and the use of public transportation, the school can reduce its transportation EF. For example, if all students living within the radius of 2 km from school decide to walk or cycle and the rest of the students who live in radius above 2 km from school decide to travel by public transportation, the transportation EF of the high school will be reduced by 44% from 25 gha to 14 gha.

4.2.4. Scenario 4: material EF

The materials scenario based on reducing material consumption and recycling the waste. For example, if the consumption of paper in the school is reduced by 25% and the rest of the paper will be recycled (75%) the EF will decrease by 40% from 29 gha to 17 gha/yr. The same scenario was developed for aluminum cans and plastic bottles. If the total amount of these items is reduced by 25% and the rest (75%) is recycled, the EF will then decrease by 52% from 33 gha to 16 gha/yr. Therefore, by implementing these ‘changing consumption’ scenarios, the high school community has

Table 3
Transportation print of the high school.

Radius from school	Number of students	Modes of transportation			Total (km/yr)	Footprint per student (ha)	Total EF (ha)
		Bus (%)	Car (%)	By foot (%)			
2 km	631	40	26	34	537,600	0.009	5.60
3 km	340	70	22	8	434,500	0.015	5.13
5 km	224	77	14	9	190,850	0.016	3.75
6 km	192	88	11	1	490,750	0.025	4.95
8 km	103	87	12	1	307,150	0.030	3.17
Above 8 km	30	68	32	0	191,700	0.086	2.58
Total	1520				2,152,550		25 ha

the potential of reducing its total EF by 30%, which means bringing it down to 227 gha/yr.

5. Discussion and conclusions

The current study intended to support institutions pursuing sustainability by imparting a practical way to implement EF as an ecological indicator. Monitoring and analyzing the EF of institutions is an innovative and meaningful method for communicating the message of sustainability to individuals (e.g., students and staff). By analyzing the institution activities using the component approach, the institution can identify the relative contribution of specific activities to the institution ecological load.

Our study revealed that food and electricity consumption are the major components of the studied school footprint. It corresponds with the results of other studies (e.g., Wiedmann et al., 2006; Kissinger and Haim, 2008). However as different from those studies transportation turned to be the smallest component. This can be explained by the unique characteristic of the studied community and the fact that most students either walking to school or using public transportation.

Analyzing the results of the school's footprint highlights that the responsibility for EF reduction can be allocated between the institution (school administration) and the students (individual decisions and behavior). For example, in the domain of energy the institution might have the decisive and financial authority to install green technologies (e.g., solar panels) for significantly reducing the energy print. However, in the domain of food, changing consumption patterns is a more behavioral issue, and is the responsibility of the students themselves.

The paper presents two potential contributions for future studies at the institutional scale: methodological and educational. From the methodological perspective, to date only few EF studies focused at that scale and therefore the data availability is limited. To overcome this limitation, our research combined data from the school administration and data obtained by questionnaires distributed among students. This monitoring generates valuable information on the relative contribution of specific activities and behavior patterns to the overall school EF.

From the educational perspective, results of the EFA are presented as a single aggregate measure of land area; therefore it is generally simple for understanding and can help in transferring the message of 'ecological load' to the students and individuals in any organization[4]. Being able to account for the school EF makes it possible for individuals to understand that the impact of their activities and lifestyles go beyond the narrow boundary limits of the institution or of the family, community and city in which they live. In our study, The realization that the ecological area 'consumed' by the school students (320 ha) was significantly greater than that of the physical area of the school (2 ha) enables to capture the interdependence of the school population with resources found outside their geographical boundaries.

Since achieving sustainability requires the development of citizens who will actively participate in reducing their EF, the development of 'changing consumption' scenarios might be an important step in developing an action plan and pro-environmental behavior patterns, among students, aimed at reducing the EF. The 'scenarios' allows the footprint results to become more dynamic as it highlights the potential impacts of feasible behavior patterns and lifestyle changes. It has a potential to offer a range of institutional strategies, aiming to help individuals understanding the linkages between behavioral choices and impacts on the ecological systems.

In sum, the current study offers a unique method for calculating the ecological footprint based on institutional and individuals sources. Still, future studies should develop further this approach, including more sensitive research for longer periods of time, for example examining individuals and institutional behavior in different seasons (especially, in food and transportation), or comparing between different kinds of schools (e.g., public vs. private, urban vs. rural) or organizations (public vs. private).

[4] On the educational process accompanied to the calculation of the EF, see: Gottlieb et al. (2012).

References

Aall, C., Norland, I.T., 2005. The use of the ecological footprint in local politics and. administration: results and implications from Norway. Local Environment 10, 159–172.
Barret, J., 2001. Component ecological footprint: developing sustainable scenarios. Impact Assessment and Project Appraisal 19 (2), 107–118.
Barrett, J., Vallack, H., Jones, A., Haq, G., 2002. A Material Flow Analysis and Ecological Footprint of York. Stockholm Environmental Institute, York.
Bicknell, K.B., Ball, R.J., Cullen, R., Bigsby, H.R., 1998. New methodology for the ecological footprint with an application to the New Zealand economy. Ecological Economics 27 (2), 149–160.
Chambers, N., Simmons, C., Wackernagel, M., 2000. Sharing Nature's Interest. Earthscan, UK.
Collins, A., Flynn, A., Wiedmann, T., Barrett, J., 2006. The environmental impacts of consumption at a sub-national level. Journal of Industrial Ecology 10, 9–24.
Conway, T.M., Dalton, C., Loo, J., Benakoun, L., 2008. Developing ecological footprint scenarios on university campuses: a case study of the University of Toronto at Mississauga. International Journal of Sustainability in Higher Education 9, 4–20.
Dawe, G.F.M., Vetter, A., Martin, S., 2004. An overview of ecological footprinting and other tools and their application to the development of sustainability process audit and methodology at Holme Lacy College, UK. International Journal of Sustainability in Higher Education 5 (4), 340–371.
DEFRA, 2007. Guidelines to Defra's GHG Conversion Factors for Company Reporting. Department of Environment Food and Rural Affairs, UK.
EGGED, 2004. Environment and Community Report. "Egged" – Public Transport Operator, Israel.
Flint, K., 2001. Institutiona l ecological footprint analysis – a case study of university of New Castle, Australia. International Journal of Sustainability in Higher Education 2 (1), 48–62.
Franz, J., Papyrakis, E., 2010. Online calculators of ecological footprint: do they promote or dissuade sustainable behavior. Sustainable Development Published online in Wiley InterScience (www.interscience.wiley.com), doi:10.1002/sd.446.
GFN – Global Footprint Network, 2011. http://www.Footprintnetwork.org/en/index.php.
Gottlieb, D., Vigoda-Gadot, E., Haim, A., Kissinger, M., 2012. The ecological footprint as an educational tool for sustainability: a case study analysis in an Israeli public high school. International Journal of Educational Development 32, 193–200.

Haberl, H., Erb, K., Krausmann, F., 2001. How to calculate and interpret ecological footprints for long periods of time: the case of Austria 1926–1995. Ecological Economics 38, 25–45.
Holland, l., 2003. Can the principle of the ecological footprint be applied to measure the environmental sustainability of business? Corporate Social Responsibility and Environmental Management 10, 224–232.
Israel Bureau of Statistics, 2008. Statistical Abstract of Israel. IBS, Jerusalem, http://www1.cbs.gov.il/reader/cw_usr_view_Folder?ID=141.
Kissinger, M., Fix, J., Rees, W.E., 2007. Wood and non-wood pulp production: comparative ecological footprinting on the Canadian prairies. Ecological Economics 62, 552–558.
Kissinger, M., Gottlieb, D., 2010. Place oriented ecological footprint analysis: the case of Israel's grain supply. Ecological Economics 69, 1639–1645.
Kissinger, M., Haim, A., 2008. Urban hinterlands: the case of an Israeli town ecological footprint. Environment Development and Sustainability 10, 391–405.
Kitzes, J., Peller, A., Godfinger, S., Wackernagel, M., 2007. Current methods for calculating national ecological footprint accounts. Science for Environment and Sustainable Society 4, 1–9.
Kitzes, J., Wackernagel, M., 2009. Answers to common questions in ecological footprint accounting. Ecological Indicators 9, 812–817.
Klein-Banai, C., Theis, T.L., 2011. An urban university's ecological footprint and the effect of climate change. Ecological Indicators 11, 857–860.
Lenzen, M., Murray, S.A., 2001. A modified ecological footprint method and its application to Australia. Ecological Economics 37 (2), 229–255.
Li, G.J., Wang, Q., Gu, X.W., Liu, J.X., Ding, Y., Liang, G.Y., 2008. Application of the componential method for ecological footprint calculation of a Chinese university campus. Ecological Indicators 8, 75–78.
Moffatt, I., 2000. Ecological footprints and sustainable development. Ecological Economics 32, 359–362.
Monfreda, C., Wackernagel, M., Deumling, D., 2004. Establishing national natural capital accounts based on detailed ecological footprint and biological capacity assessments. Land Use Policy 21, 231–246.
Moran, D., Wackernagel, M., Kitzes, J.A., Goldfinger, S.H., Boutaud, A., 2008. Measuring sustainable development – nation by nation. Ecological Economics 64, 470–474.
Rees, W.E., 1992. Ecological footprint and appropriated carrying capacity: what urban economics leaves out. Environment and Urbanization 4, 121–130.
Rees, W.E., 2000. Eco-footprint analysis: merits and brickbats. Ecological Economics 32, 371–374.
Rees, W.E., 2003. Impeding sustainability? The ecological footprint of higher education. Planning for Higher Education 31 (3), 88–98.
Scotti, M., Bondavalli, C., Bodini, A., 2009. Ecological footprint as a tool for local sustainability: the municipality of Piacenza (Italy) as a case study. Environmental Impact Assessment Review 29, 39–50.
Simmons, C., Lewis, K., Barrett, J., 2000. Two feet – two approaches: a component based model ecological footprinting. Ecological Economics 32, 375–380.
Van Vuuren, D.P., Smeets, E.M.W., 2000. The ecological footprint of Benin, Bhutan, Costa Rica and the Netherlands. Ecological Economics 34 (234), 115–130.
Venetoulis, J., 2001. Assessing the ecological impact of a university: the ecological footprint for the University of Redlands. International Journal of Sustainability in Higher Education 12, 180–196.
Wackernagel, M., Onisto, L., Bello, P., Linares, A.C., Falfán, I.S.L., García, J.M., Guerrero, A.I.S., Guerrero, M.G.S., 1999. National natural capital accounting with the ecological footprint concept. Ecological Economics 29, 375–390.
Wackernagel, M., Rees, W.E., 1996. Our Ecological Footprint: Reducing Human Impact on the Earth, first ed. New Society Publishers, Gabriola Island, BC, Canada.
Wackernagel, M., Schulz, N.B., Dumling, D., Linares, A.C., Jenkins, M., Kapos, V., Monfreda, C., Loh, J., Myers, N., Norgaard, R., Randers, J., 2002. Tracing the ecological overshoot of the human economy. Proceedings of the National Academy of Science of the United States of America 99, 9266–9271.
Wackernagel, M., Monfreda, C., Schulz, N.B., Erb, K.H., Haberl, H., Krausmann, F., 2004. Calculating national and global ecological footprint time series: resolving conceptual challenges. Land Use Policy 21, 271–278.
Wackernagel, M., Kitzes, J., Moran, D., Goldfinger, S., Thomas, M., 2006. The ecological footprint of cities and regions: comparing resource availability with resource demand. Environment and Urbanization 18, 103–112.
Warren-Rhodes, K., Koenig, A., 2001. Ecosystem appropriation by Hong Kong and its implications for sustainable development. Ecological Economics 39, 347–359.
Weidmann, T., 2008. The Carbon Footprint and Ecological Footprint of the Scottish Parliament. ISAUK Research Report 08-1, pp. 1–12.
Wiedmann, T., Minx, J., Barrett, J., Wackernagel, M., 2006. Allocating ecological footprints to final consumption categories with input–output analysis. Ecological Economics 56, 28–48.
Weidmann, T., Lenzen, M., Barret, J., 2009. Companies on the scale comparing and benchmarking the sustainability performance of businesses. Journal of Industrial Ecology 13 (3), 361–383.
Wood, R., Lenzen, M., 2003. An application of a modified ecological footprint method and structural path analysis in a comparative institutional study. Local Environment 8, 365–386.