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Devising Ecological and Energy Footprint as Measurement Indicators

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Abstract

By analyzing and measuring the values of the personal Ecological and Energy Footprint, as indicators of sustainability, and by using social networks, important information can be obtained about the attitude of the individual toward nature, and the awareness of their impact on the habitat. This analysis would enable us to undertake personal and collective initiatives directed toward a more rational use of the existing resources, as well as raising the quality of life and sustainability. According to statistical data and fact-oriented material which has been collected, it is anticipated that the research will reveal a low awareness among respondents about the impact they have on sustainability with their personal lifestyle. As research methodology used qualitative methodology and to collect the data used questionnaire. Also collected different data from the Ministry of Ecology and later processed them using different Software Tools. Findings, issues and recommendations have been provided, discussed and argued.

Keywords: Ecological and Energy Footprint, data processing, impact on sustainability, data analytics

JEL classification: A31

Introduction

One among many other major problems that we face today is the provision of sustainable energy supplies for our world. The well-known global problems refer to: increased energy use, limited raw fuel reserves, increased living standard pressure, and global warming.

The entire shift of the civilization progress towards "sustainable development" depends to a large extent on the transition from the use of conventional energy sources to alternative ones. In view of the above, and in order to promote alternative sources, it is necessary to emphasize that the basic tool for this shift is Energy Management.

According to [9] "the concept of Energy Management includes energy efficiency, energy saving, energy tariff and determining the appropriate type of energy and its price. A close link between energy and the environment has highlighted the issue of Energy Management. The fundamental goal of Energy Management is to produce goods and provide services with the least cost and least environmental effect. Both energy management and sustainability programs lead to controlling efficiency, as they are both based on a foundation of continuous improvement. They are mutually beneficial; sustainability measures can be a positive

influence on energy management to encourage looking beyond immediate cost reductions and invest in initiatives like renewable technologies. The energy management measures can provide practical solutions to the sustainability assignments to reduce energy that contributes to an overall reduction of carbon emissions. Working together, these measures and assignments can address all aspects of energy demand, energy supply and sustainability to ensure a facility reaches its potential efficiency, maximizes cost savings, decreases its environmental footprint, and builds transparency. " [9]

Addressing the issue of developing sustainable energy systems is crucial today and Energy Management and sustainability programs differ in terms of mission, scope and how established they are. Understanding these differences can help communication and approaching the solution in much better way.

Table 1

Energy Management vs. Sustainability: Mission, Scope, Organizational History

	Energy Management	Sustainability
Mission	Reduce costs, increase operational efficiency, energy audit	Environmental savings, social benefits, increase transparency
Scope	Energy management policy, strategy and execution	Environment, social and economic
Organizational history	Established	Relatively new

Source: Jamieson, 2014

Literature Review

The Ecological Footprint has been devised as such by United nations in early 1990s and has impacted and stimulated different research projects and grabbed a lot of attention. It has been reported by the Institute for Scientific Information (ISI) [8] "Web of Knowledge delivered over 500 journal articles for 'Ecological Footprint', with an increasing trend from 2001 to 2008, while the Google search engine delivered more than 2 million hits and Google Scholar more than 14000 hits for 'Ecological Footprint'. This is an impressive rate of activity since the first academic article on the concept of the Ecological Footprint was published in 1992". As this topic falls in very interesting area, some of the references exist only as web pages, not as works in peer-reviewed publications. It was only later that [2] for the first time used the term 'Ecological Footprint' when he addressed and criticized different economic models, arguing that more attention should be paid to natural resources and how much can it sustain themselves.

The Energy Footprint is viewed as a part of the Ecological Footprint expressed in area gha units [3]. It was defined as "the amount of nature that would be necessary to absorb CO₂ emissions from fossil fuel combustion and electricity generation through the use of sequestration values for world-average forest" [7]. According to [1] "the Energy Footprint was considered as the sum of all those areas used to sequester CO₂ emissions from the consumption of non-food and non-feed energy [8]. Although the humanity is being exposed to the accelerating energy-related environmental issues, the Energy Footprint did not receive enough attention from Footprint users until Ferng focused for the first time exclusively on the analysis framework for it". According to [1] "Ferng's initiative highlights the importance of the Energy Footprint independent of the Ecological Footprint in energy scenario analysis

by using an input–output analysis (IOA) based framework. Over the past years, an expanding list of researchers has chosen to concentrate exclusively on the topic of the Energy Footprint. Depending on updated data obtained from the Intergovernmental Panel on Climate Change, the calculation of the Energy Footprint has been revised with a fraction of approximately 30% of the total anthropogenic emissions for ocean uptake" [2]. According to [4], currently, more researchers prefer to explore new ways and measure differently the Energy Footprint. Some initial objections to the original method in terms of how energy is accounted for has been partially overcome by the development of specific models or indicators. Several sub-footprints have been generated, such as the Fossil Footprint, the Nuclear Footprint, and the Electricity Footprint [7].

Currently, some researchers focus on "the redefinition of the Energy Footprint as the sum of all area used to sequester CO₂ emissions from the consumption of non-food and non-feed energy" [7].

Currently, Footprint indicator has shown as very interesting topics for researchers, and policy makers, and the implications have been investigated from different perspectives like in similarities, differences, and interactions between some selected Footprints. However, there is not yet a completely satisfactory and generally accepted Footprint that can simply represent the overall impacts of human activities as the "golden standard" indicator [3].

Following [6] we refer to this as, namely, the "Footprint family". This concept of "Footprint family" is initially applied only in a very limited number of papers. The term "Footprint family" was first advocated simultaneously and independently by [3] and [4] some other studies have discussed similar topics without mentioning the term "Footprint family". For instance, [5] designed a composite Footprint indicator as a single measure for the sustainability of a given option. [3] developed an integrated footprint-based approach for environmental labelling of products. [2] reviewed a series of environmental indicators and proposed the Ecological and Carbon Footprints to be the most appealing indicators for enterprises. According to [1] "presented are a lot of comprehensive overview of the environmental, social, and economic Footprints that can be used to measure the three pillars of sustainability. Steen-Olsen used a MRIO (multiregional input-output) model to quantify the total environmental pressures due to consumption in the EU by calculating the carbon, water, and land Footprints. Feng presented a critique on some of these integration schemes".

Results and findings

Based on Table below, results of this study reveal that the university students' average Total Ecological Footprint is two times bigger (6.45 gha) than the Macedonian national average (3.1 gha). Furthermore, most of their Ecological Footprint comes from their Energy Footprint (65%).

Table 2
Final Results from the Analysis

	All	Male	Female	National
Total Ecological Footprint (gha)	6.45	6.47	6.42	3.10
Energy Footprint (gha)	4.22	4.21	4.23	2.20
Carbon Footprint (CO₂ emissions in tons per year)	12.26	12.24	12.28	5.10
Energy Footprint (% of total Ecological Footprint)	65%	65%	65%	61%

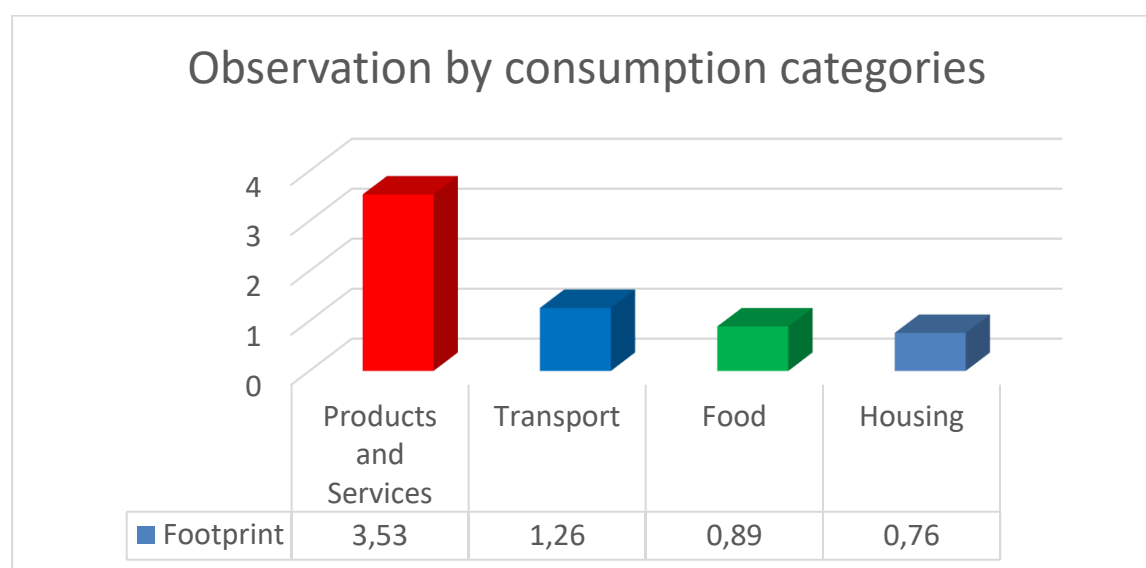
Source: Authors' work

As it can be seen from Figure 1, according to the consumer categories, the most important share in the Total Ecological Footprint is held by the following three categories: Products and Services (3.53 gha), Transport (1.26 gha) and Food (0.89 gha).

University students were used as subjects because they are understood to be the future managers of our natural resources. There is an equal number of 35 male and 35 female respondents. The average age is 19 years old. Average age was expected given that the respondents are students. The youngest respondent is 18 years old, while the oldest is 22 years of age. The Ecological Footprint approach was applied in this case in order to compare the environmental impact between genders. The same web-based software created by the Global Footprint Network was used to convert the consumption data into its equivalent Footprint values.

Gender wise, the male respondents have a slightly higher personal Ecological Footprint (6.47 gha) than female respondents (6.42 gha). It should be noted that most of the Ecological Footprint from all the respondents (both male and female) is attributed to their Energy Footprint (65%). This could be explained by the fact that students are more likely to purchase products and services, and travel (that uses great amount of resource which produces CO₂ emissions).

Figure 1
Ecological Footprint of the Respondents by the Consumption Category

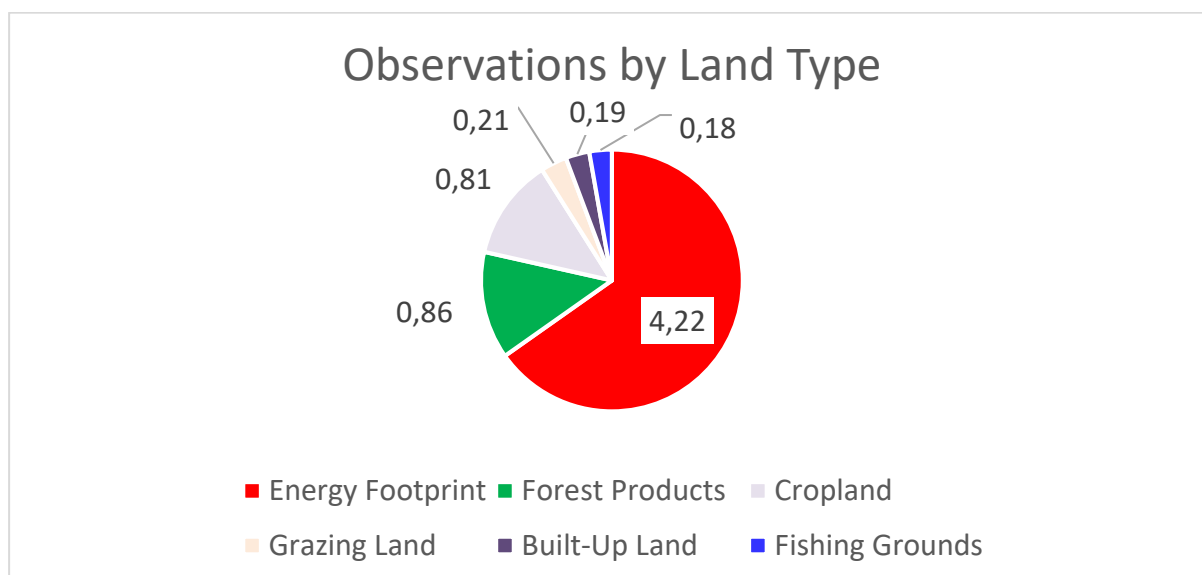


Source: Authors' work

As it can be seen from Figure 2, according to the types of land, the largest share in the Total Ecological Footprint of our respondents is due to the forest land needed to absorb the carbon dioxide (4.22 gha).

Figure 2

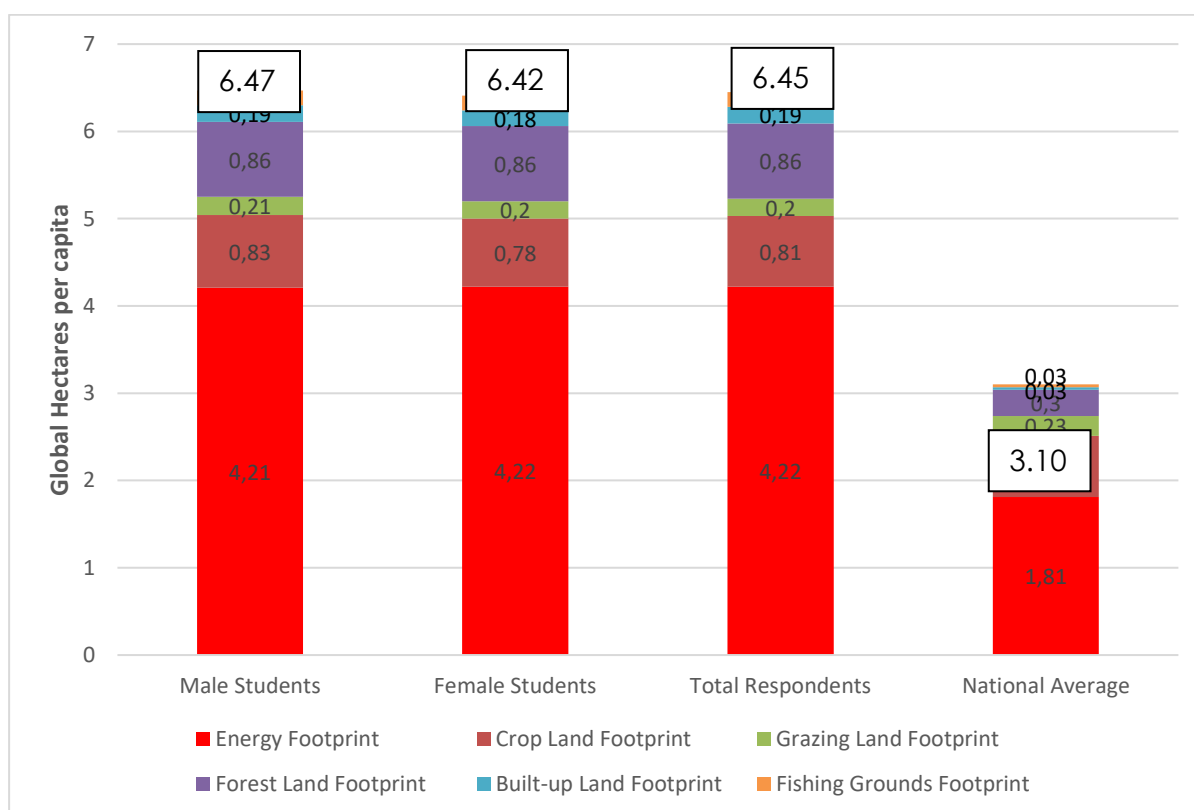
Ecological Footprint of All the Respondents by the Land Type



Source: Authors' work

Figure 3

Ecological Footprint Land Use Components of Respondents as Compared with the National Average (gha/capita)



Source: Authors' work

Furthermore, it is also noticeable that the respondents' Ecological Footprint percentage coming from the Forest Land Footprint (0.86 gha) is three times higher than the percentage of the same Ecological Footprint component at the national average of North Macedonia (0.3 gha). This can be explained by the nature of the occupation of the students, who tend to consume more paper products (leading to a higher Forest Land Footprint), as compared to the average citizen of North Macedonia. Moreover, an almost equal (if not the same) percentage distribution can be observed in terms of the Grazing Land Ecological Footprint component. This means that in terms of resource consumption based on grazing/pasture land (i.e. dairy products), the respondents' consumption behavior is representative of the average citizen of North Macedonia.

Based on gender, in both groups there is an almost equal distribution of Ecological Footprint components from the total Ecological Footprint except for the Energy Footprint, where the female respondents have a slightly higher Ecological Footprint (4.23) as compared to the male respondents (4.21). This difference only slightly contributed to the statistical difference in the Ecological Footprint among male and female respondents.

Conclusion and future work

Much effort has been put into developing predictive indicators for measuring Ecological and Energy Footprint.

The aspects that were explained in this research study are intended to help particularly researchers, as factors of change in the sustainability transition.

Many different Footprint-style indicators have been created and became complementary to the Ecological Footprint during the last two decades including the Energy Footprint. It is no doubt true that the Energy Footprint has become the most important but contradicted in Ecological Footprint analysis. In the most of the situations, the Energy Footprint is the largest contributor to the Total Ecological Footprint, defined in a proportion of nearly 50% or even higher.

In an emerging sustainability science, many studies focused on defining the indicators of sustainable development. Yet, to date, there are no clear indicator sets that are universally accepted, backed by convincing data, model and theory, precise data collection and analysis, and backed up institutionally. Why do we have this current situation? We offer three major reasons: (i) the enigma of sustainable development; (ii) the large number of purposes in measuring sustainable development; and, (iii) the confusion in using the same terminology, analysed data, and methods of measurement.

The Ecological and Energy Footprints as indicators of Sustainability and Energy Management are most useful as a tool for communication. They help to simplify the concept, and is a starting point to provide practical direction for a lifestyle change. The current devised Ecological Footprint Calculator assumes that the current measured data reflect how one always lives; however, lifestyle is influenced by different factors such as a person's age or time of year, and an Ecological Footprint will expand or shrink accordingly. The inevitable conclusion. Less is more; we all need to shrink our Ecological and Energy Footprints.

This research has revealed that the concept of sustainability is still perceived superficially among both student representatives and specialists in governmental institutions responsible for the sustainable development policies of the country. Our results from the questionnaire have shown a low understanding among students about the Ecological and Energy Footprints as indicators of Sustainable Development and Energy Efficiency. Therefore, scientific studies on issues

concerning the Ecological and Energy Footprints, and their public awareness, are very important.

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