MOBILITY PART OF THE ECOLOGICAL FOOTPRINT IN EDUCATION

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Abstract: Sustainability is key to the future of mankind and the fate of our civilization. Most of the sustainable development goals, defined by the UN, and most of the global problems are strongly related to the *ecological footprint*, which measures human demand on nature, expressed as a single, easy-to-understand number that is scalable from an individual to a global level. The use of *ecological footprint* in education is being promoted by an international team of several institutions, by developing digital tools for both online and offline education under an Erasmus+ scheme. The part of *ecological footprint* that is associated with mobility (of both humans and goods) comes mostly from the amount of CO_2 produced by the means of travel (car, plane etc.). This excess CO_2, which comes from the high-energy lifestyle of today's societies, is the major cause of global warming, which most regard as the most imminent threat to human civilization on Earth.
In this paper we show some properties of the mobility part of the individual *ecological footprint*, how the size of it can be reduced and how it can be included in the education of teenagers.

Introduction

Definitions

Ecological Footprint: a measure of the demand populations and activities place on the biosphere in a given year, given the prevailing technology and resource management of that year. [Wackernagel 1996]

Biocapacity: a measure of the amount of biologically productive land and sea area available to provide the ecosystem services that humanity consumes – our ecological budget or nature's regenerative capacity.

Ecological Footprint (referred to as footprint or EF henceforth) and biocapacity values are expressed in units of area (in global (meaning globally averaged) m^2-s gm^2 or hectares gha) necessary to annually provide (or regenerate) such ecosystem services. They include: cropland for the provision of plant-based food and fiber products; grazing land and cropland for animal products; fishing grounds (marine and inland) for fish products; forests for timber and other forest products; uptake land to neutralize waste emissions (currently only the areas for absorbing anthropogenic carbon dioxide emissions are considered in the form of forests); and built-up areas for shelter and other infrastructure. [Borucke 2013]

Footprint categories of individual consumption

The aim of the "*e-co-foot*: E-co-logical Footprint Training - digital resources for online and offline education" Erasmus+ 2017-1-AT01-KA201-035037 project [www.e-co-foot.eu 2020] is to provide *online and offline learning and teaching material, background material and software and e-learning tools* in 5 European languages in an international collaboration, between akaryon GmbH, a research based Austrian SME specialized in environmental educational informatics, the Viennese NGO Plattform Footprint, the Savaria Chemistry

Department of the Eötvös University in Hungary, the Greek Environmental Education Center Pertouliou-Trikkeon and the Vasile Lovinescu College, a Romanian VET high-school providing courses in ecology and environment. The aim of providing these teaching materials for schoolchildren of age 10-19 years in Europe, is to sensitize them to ecological problems and at the same time to give them sound information on ecological problems within their reach so that by changing their habits, attitudes or consumption patterns they can contribute to fight global ecological problems (first of all climate change) and calm their conscience at the same time. It makes much easier to get touched and involved, if it is not about ecological problems or overconsumption of a whole society or the "average citizen", but the very steps you are taking yourself, your own consumption.
Although EF is calculated from statistical data [Global Footprint Network 2019] of countries, and are calculated for average citizens, there are certain parts of the EF which can be directly attributed to certain actions or basic needs of the individual. In these teaching materials the EF of only the *individual consumption* is discussed in detail.

According to the Global Footprint Network [Global Footprint Network 2019], the participating countries had the following per capita ecological footprints (in global hectares per year (gha/yr) for the year 2016): Austria 6.03, Greece 4.27, Hungary 3.61, and Romania 3.09. The average for the whole world was 2.75, and 4.56 for Europe. Note that the worldwide available biocapacity for that year was 1.63 gha/yr per person only!

The four main categories where everyday life of an individual impacts the biocapacity of Earth is: *Nutrition, Housing, Mobility* and *Other consumption*. This last category contains the part of consumption which does not fall into the three previous categories (typically clothing, appliances, furniture, electronic devices, paper, etc.). There are several factors in each category which will have a major impact on the individual footprint. The size (and proportion) of these categories vary from country to country based on the industrialization, habits, lifestyle, climate and natural resources of the country, to just name a few of the variables. Based on country-specific statistical data gathered by the participants, the distribution of the footprint into the four aforementioned most important categories of consumption were calculated. There is considerable difference between the different participating countries, but most of these main categories account for roughly 20-30% of the footprint. An example of this can be seen in *figure 1*.
For each category we sum up the main components or factors which influence the size of the EF. The *Nutrition* part of the footprint mainly depends on the amount and type of food one consumes. Meat and animal products have a disproportionately large footprint compared to vegetables. Also, the distance the food travels has a high impact on its footprint. Consequently, if one has a balanced, healthy nutrition according to the food pyramid, and has a healthy lifestyle with sports and no overweight, and eats local, seasonable and mainly vegetable-based food, this portion of the individual footprint is not large.
The main component of the *Housing* part of the footprint is the energy needed to construct and operate (the latter being usually much larger) the houses/apartments people live in. So, the individual footprint is decided by the size and material of one's home, when it was built, what type of heating it has and how energy efficiently it is operated, and of course by the climate itself.
The *Mobility* part of the footprint depends on how much a person travels and by what means. The covered distance comes from daily commute to/from work/school, plus business and leisure trips. The most common means of transport can be in the order of increasing footprints: on foot – by bicycle – by public transport – by car – by airplane.

The *Other consumption* part of the footprint is the sum of the footprints of other individually consumed products and/or services. The most common and important types in this category are paper consumption, furniture, home appliances, sports equipment, clothing, electronics: PC-laptop, mobile phone etc.
The part of the footprint that cannot be attributed to the consumption or action of individuals but to the whole community is usually referred to as *grey footprint*. It is country-specific, like the ecological footprint itself, and contains the footprint of roads, hospitals, schools, courts, police and all public buildings. It is only mentioned in the teaching materials briefly, as it cannot be easily changed by the lifestyle or habits of an individual, so it is more out of reach of children.

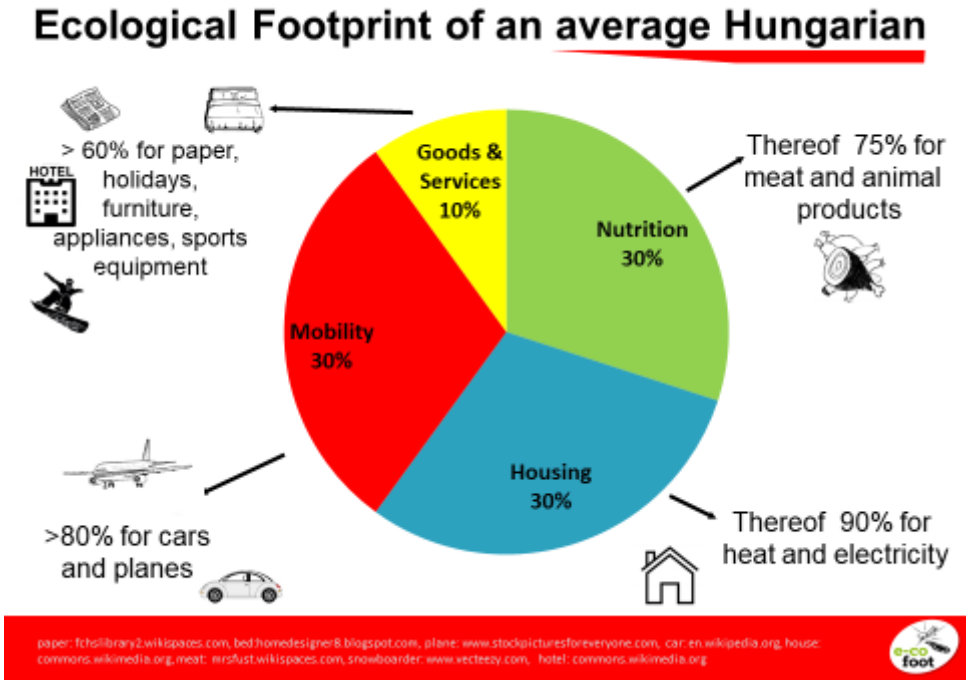

Figure 1. The respective sizes of the four main categories of individual ecological footprint, in Hungary

Ecological footprint of different modes of travel

The components and sizes of EF associated with different modes of passenger transport can be seen in *figure 2*. Some of these data seem evident and does not need any explanation. Human-powered transport (on foot, by bicycle) has a very small footprint, whereas the energy need for engine-powered ground transport is determined by the friction, the air resistance (drag) and the payload to vehicle ratio. The figure clearly shows how huge the EF of flights are, especially the relatively short (less than 1500 km) flights. The reason for this is that the airplanes consume the most when they are accelerating and climbing. There are 2 other factors that make air travel by far the ecologically unfriendliest mode of transport: usually a very long distance is covered, very fast, and the exhaust gases pollute the atmosphere at a very high altitude where the air is very thin and thus most vulnerable.
In most European countries the biggest component in the mobility footprint is traveling by car. By looking at more closely on the EF of different car technologies in *figure* 3, it can be seen that hybrid technology does not make the cars significantly eco-friendlier. The red arrows indicate the deviation of the EF from the average car, so a smaller traditional car consumes less than a big new hybrid. The EF of electric cars is mainly determined by the mode electricity is produced. In the figure we used the Hungarian electricity mix, which is.

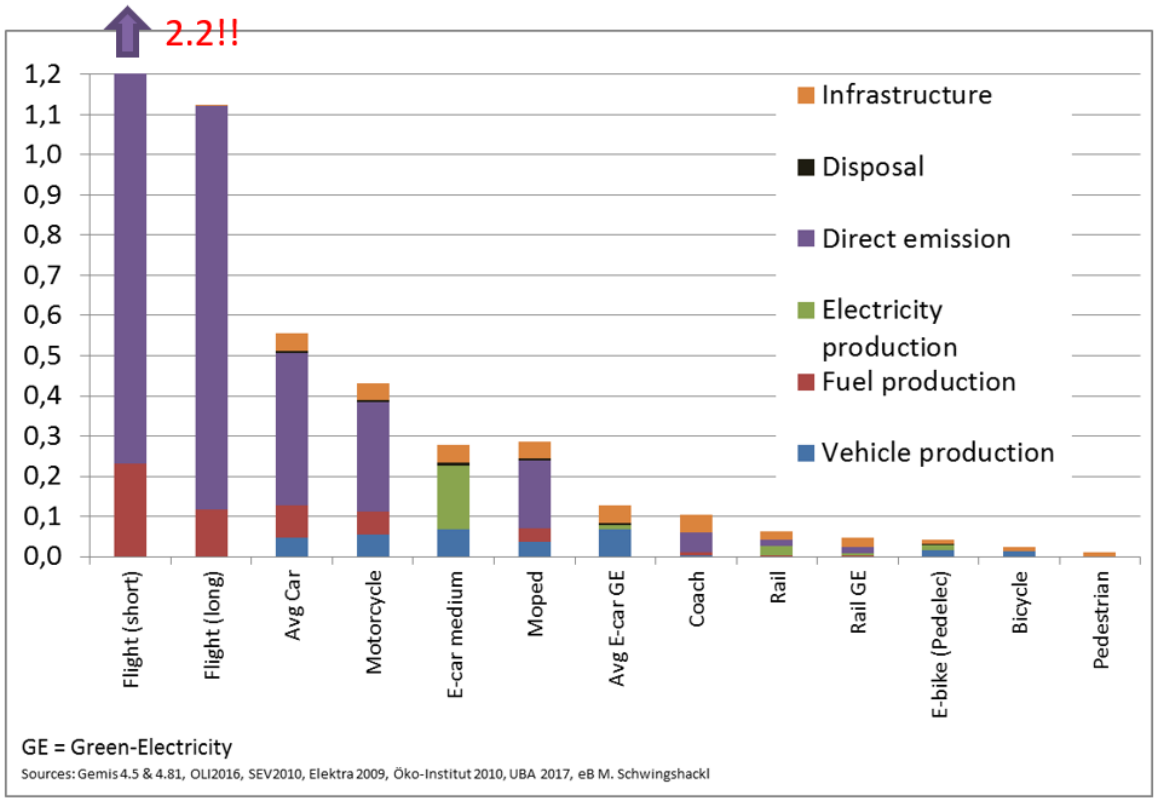

Figure 2. The components and sizes of the ecological footprint of different means of passenger transport (in gm²/passenger km).

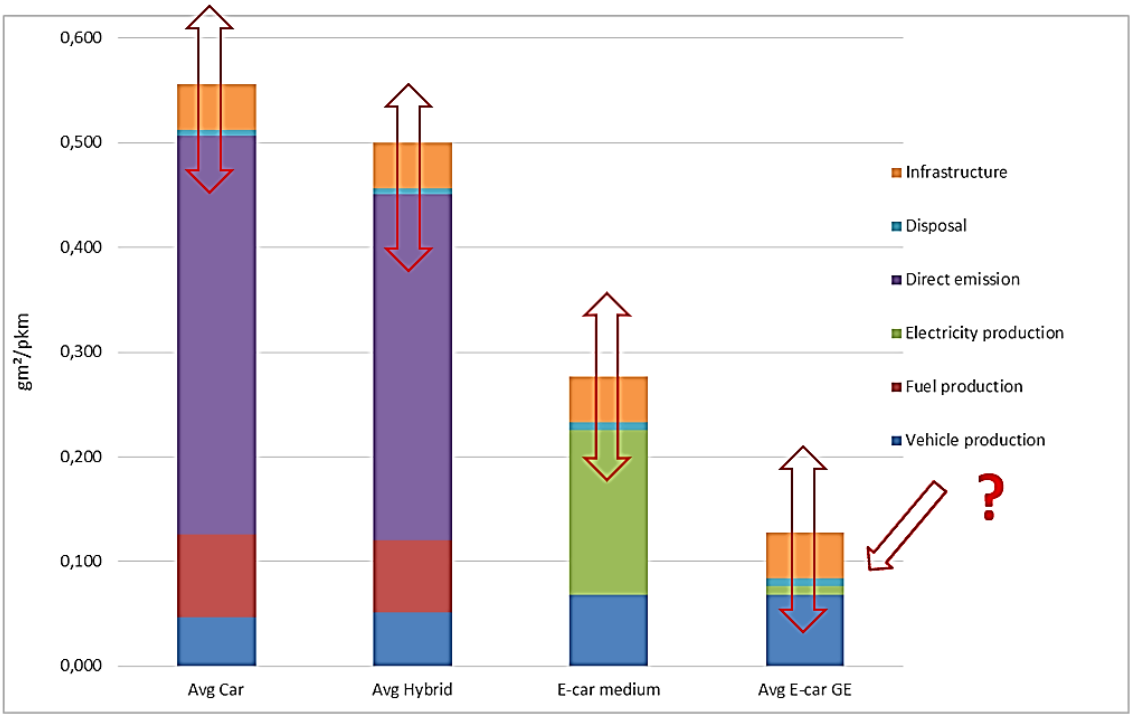

Figure 3. The components and sizes of the ecological footprint of different car engine technologies (in gm²/passenger km).

335 gCO_2/kWh. So, this is the amount of CO_2 emitted if you use 1 kWh from the Hungarian electricity system. E-cars in Hungary have a roughly 50% smaller footprint than traditional cars. However, if you use an e-car in Greece or Poland, where the electricity mix is substantially higher (more coal-fired power plants used), the EF of the e-car is as big as the EF of the traditional car! The smallest EF can be achieved for individual motorized mobility, if you use an e-car and charge it from your own solar panels, or from a green electricity supplier, when available in your country.

How to decrease the footprint of mobility

After showing some factual information about the magnitude of the EF of different travel means, pupils are taught how to decrease their mobility footprint. Arguments are also given to them why they should choose to walk or bike to school (it is fast, healthy, cheap, they can see more, the air is cleaner, and they help save the planet). If they live farther from school, they should use public transportation (smaller footprint, less accidents than car travel, chance to meet friends, read, work, use wi-fi) and not a car. If they have to use a car (no public transport around, parents insist on car, etc.) they should consider some ways to reduce its footprint. However, for most of the pupils, car travel is decided by their parents, so their acquired knowledge can only influence their parents, and their own future decisions. They should understand that the smart choice is to walk, ride the bike or use public transport. The more comfortable choice is the car, and this is the means of transport which contribute the most to the EF of mobility in most developed countries. They are taught how to reduce it the easiest and smartest way, by sharing the car with others by not traveling alone in a car. (Shared ownership of a car also contributes to the reduction of the vehicle production part of the EF, which is smaller, but still important.) Other decisions, which have a big impact on the EF of driving come up when buying a car: buying a smaller one with smaller fuel consumption, or even with advanced technology: electric car using green energy (from certified supplier or own solar power plant on roof). Some expert advice on the driving style can help to save some extra 10 to 30% on gas mileage: planning the route carefully, not taking extra miles, reducing speed, using the correct tire pressure and avoiding pointless acceleration and braking. A very important element in making travel decisions is the cost associated to it. So, it is very instructive for the pupils to learn that the real total cost of driving (including insurance, taxes, maintenance, service charges, tires, battery, fluids) exceeds the fuel cost 2-4 times!

Longer trips are usually taken when going on vacation. This is the part of the mobility EF where the biggest savings can be made by going to a closer location or taking the train instead of the airplane.

Another point where savings can be made is the transportation EF of the goods we consume. In our times it is not only people who travel too much. So do goods. If we buy local goods, we do not only help our neighbours or countrymen keep their jobs, but also lower the EF and help save the planet. However, the most important thing we should pay attention to while doing shopping is that we should not go by car to do the shopping in a distant shopping mall or plaza but on foot from a neighbouring shop or on the way home from school/work. The reason for this is that these last kilometres can yield the most to the transportation footprint of the goods, as the payload to vehicle ratio can decrease from more than one to less than 1/2000!

Messages about mobility and lifestyle

The ultimate aims of these teaching and learning materials about ecological footprint is to help our civilization to survive, making our lifestyles sustainable by teaching our youth how modern life can be lived without ruining our environment.

Pupils should be aware that all the elements of their lifestyle has environmental consequences: some have a big EF some have close to zero EF. There is a slide shown to them at the end of a lesson (*figure 4*) containing the most important steps to minimize their EF. Most important is to realize that being eco-friendly does not mean to stop enjoying life! On the contrary! Pupils should realize that the best things of life are free and EF-free, i.e. do not cost money and do not have big EF. So, according to the slide, pupils should "Enjoy life" by choosing to do things that have small EF, like spend more time and have fun with family and friends which has zero footprint as opposed to consumption which should be decreased. They learn during this course that by doing the right thing and stopping the waste of energy and resources (eating less, heating less, ventilating the room fast, going to school by bike, not flying to the other end of the globe just to go to the sea, etc.) they could and should lower their EF. In order to maximize this reduction, they are told which particular steps could lower their EF most significantly in the field of nutrition, mobility and housing. Some of these steps can be easily taken, like eating less meat and animal products, preferring local and seasonal products, or going by bike or public transportation, but some of the steps need a big investment which may be made later in their lives, like moving to a smaller, recently built, hence well insulated apartment which is close to public transport and use renewable energy source for heating and green electricity (or install photovoltaic panels on their houses). It is important that they learn what needs to be done and why, and they can also educate and persuade their parents, or friends to do so.

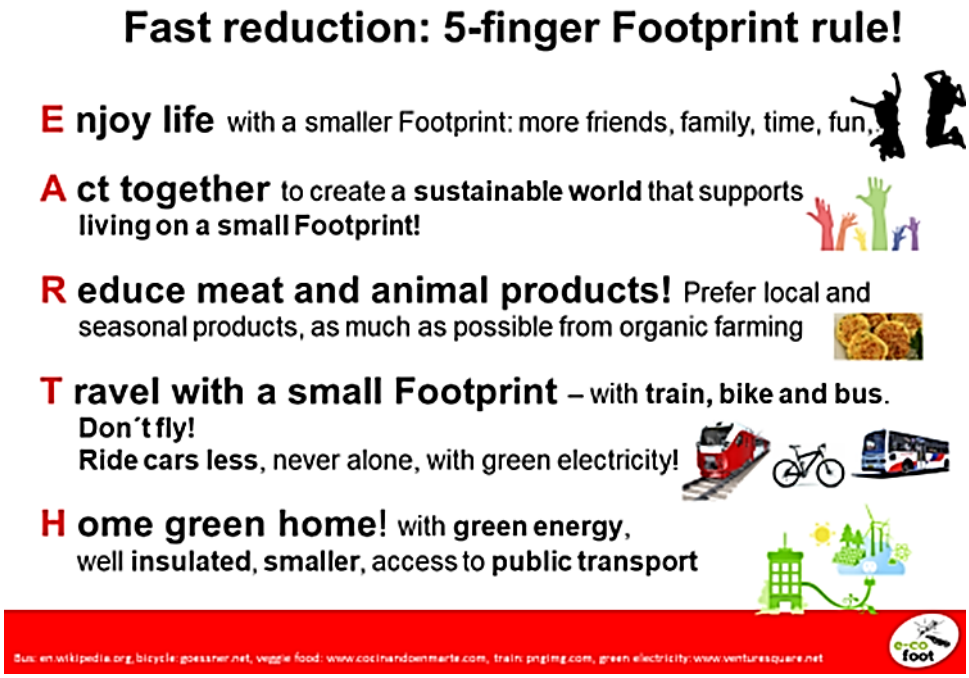

Figure 4. The slide shown to the pupils about how they could drastically reduce their ecological footprint.

It is a very important role of this teaching material that it empowers pupils to act on their own and not wait for "someone" else to solve the environmental problems. Another important role is to draw the attention to "act together" in these steps (*figure 4*). Everyone can act on his/her own to reduce the EF and reduce the exploitation of the resources of Earth. However, this has a limit. It is not enough for individuals to act, the boundary conditions, the rules of societies should be changed as well.

People need to act together, speak out, start movements, contact representatives to enact rules which make ruining the environment not worthwhile or even forbidden! It is a known fact for example that building new roads (or widening old ones) generate more traffic, and politicians like to spend our money on new roads, or coal-fired power plants. People should act together to stop public spending on activities harming the environment or promoting such activities. These activities should be banned or at least taxed accordingly (like the fairosene initiative [Fairosene 2020]).

Conclusions

It has been shown how the mobility part of the individual ecological footprint was included in a teaching material developed for European pupils of age 10-19. By becoming aware of the unsustainable nature of our present societies, pupils can learn how to decrease their own footprints by traveling less and choosing human-powered or public transportation. It is also shown how eco-consciousness can help building a sustainable future.

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