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Ecological Footprint and Carbon Footprint of Organic and Conventional Agrofoods Production, Processing and Services

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1. Introduction

The Ecological Footprint (EF) measure the natural capital demand of human activities (Wackernagel and Rees, 1996 and 2002) and reveal the sustainability of consumption patterns on individual, local, national and global scales (WWF, 2008).

The ecological footprint measure the natural capital demand of human activities (Wackernagel and Rees, 1996) and reveal the sustainability of consumption patterns on individual, local, national and global scales (Arrow, 2002). Ecological footprint model assumes that all types of energy, material consumption and waste discharge require productive or absorptive capacity of a finite area. Six types of ecological biologically productive area (arable land, pasture, forest, sea space, built-up land and fossil energy land) are used to calculate the Ecological Footprint and ecological capacity (Wackernagel et al., 2002).

The ecological footprint estimates the ‘‘minimum land necessary to provide the basic energy and material flows required by the economy’’(Wackernagel and Rees, 1996). The consumption elements are converted into a single index: the land area to sustain the lifeliving among human consummation groups. The area of land or sea available to serve a particular use is called biological capacity (biocapacity) and represents the biosphere's ability to meet human demand for material consumption and waste disposal. The degree of unsustainability is calculated as the difference between actual available and required land. In the original ecological footprints model created by Wackernagel and Rees (1996) and reformulated by Chambers et al. (2000), the land areas included were mainly those directly required by households with autoconsumation life style. In the original ecological footprint model, land categories are weighted with equivalence and local yield factors, in order to express appropriated bioproductivity in world-average terms (Wackernagel et al., 2002). The present tendency is to emphases the potential of local food to contribute at the sustainable development, maintaining regional identities and support modern organic agricultural (Defra, 2007; Everett, 2008). Organic agro-production refers to agriculture which does not use artificial chemical fertilizers and pesticides, and respect animals lived welfare in more natural conditions, without the routine of using drugs or antibiotics, common in the intensive livestock farming. The most commonly reasons for consuming organic food are: food safety, the environment, animal welfare, and taste (Soil Association, 2003). The

principal environmental reason for localizing food supply chains is to reduce the impacts of food miles—the distance food travels between being produced and being consumed —and to reduce the energy and pollution associated with transporting food around the world. Local food is a solution to the problem of food miles (Subak, 1999).
The aim of the first part study were: (i) to compare conventional and organic agro-foods, by means of the EFE method using LCA protocol and (ii) correlate the EF values with the carbon emissions generated in the production and distribution chain.

1.1 Protocol of investigation

In the present paper research, EF was evaluated with the 3 main components (or modules):

i. EF_B, the basic or gross EF of raw materials (agriculture production surface footprint);
ii. EF_P, the EF for agro-food production and processing;
iii. EF_T, the EF of retail transport.

The EFE were conducted by grouping the raw foods under the variables of nature, type of production system and transportation facilities.
In the calculation of product-specific EF we consider all the quality-controlled life cycle information including energy, materials, transportation and wastes. To calculate EF, the inputs of different kinds are first converted to the corresponding actual area of land/water ecosystems needed to produce the resources or assimilate the emissions, converted in global hectare (*g*ha) by means of yield and equivalence factors. The equivalence factor reflects the difference in productivity of land-use categories. The yield factor reflects the difference between local and global average productivity of the same bioproductive land type (Monfreda *et.al.*, 2004).
In LCA method, the EF of a food item is defined as the sum of direct land occupation and indirect land occupation, related to the total CO2 emissions from fossil energy associated with the transformation (industrial processing) and transportation cycle:

$$EF_i = EF_B + EF_P + EF_T \quad (1)$$

In formula (1) EF_B is the basic EF related to the land occupation 6 types identified, calculated with the formula (2):

$$EF_B = \sum_{i=1}^{n} F_i qF_i \quad (2)$$

Where: EF_B is the EF of direct land occupation (m2), F_i is the occupation of area by land use types i (m2) and qF_i is the equivalence factor of land yields based on FAO Database (FAO,2007).
The environmental impact generated by the transportation system was calculated with the original equation (3):

$$EF_T = EF_C + EF_{TS} + EF_{CO_2} \quad (3)$$

Where: EF_T is the EF value for transportation system adopted for the raw materials; EF_C is the EF value for the production of the fuel consumed in the transportation of raw foods;

EF_{TS} is the EF value for the transportation state in the refrigeration units; EF_{CO_2} is the EF value involved by the pollution generated with the emission of CO_2 in course of the transportation cycle.

1.2 Results and discussions

The CO2 Emissions and EF for farm vegetables were presented in Fig.1. The tomatoes and cucumber produced in the conventional manner shown the greatest value of CO2 emissions correlated with the EF value. The reducing of EF value by conversion to the organic agricultural procedures determined a reducing of the environmental impact with 47% in case of carrots, 29% in tomatoes case and 19% in cucumber case, respectively. The ratio of CO2 emission in conventional to organic agricultural producing methods was range from 1.05 in potatoes case to 1.896 in case of tomatoes.

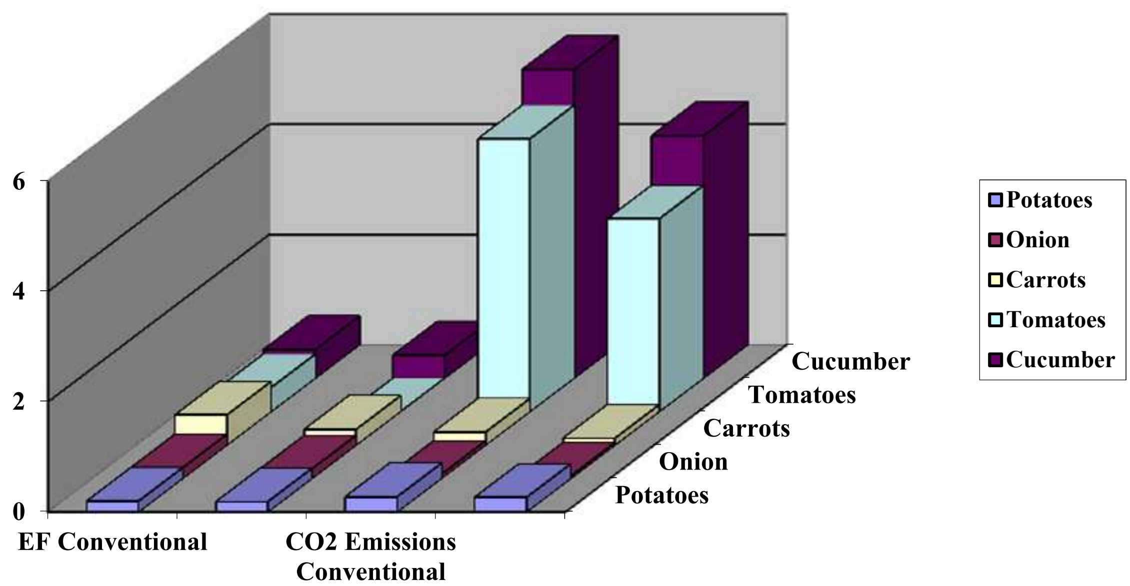


Fig. 1. CO2 Emissions (t CO_2 /t) and Ecological Footprint (gha/t) for farm vegetables

The CO2 emissions from cereals were between 0.190 and 4.60 tCO_2 /t (Tab.1).The lowest emissions were found for organic cereal production. Rice were 5 to 20 times more emissions-intense (4.55 t CO_2/t) than the regular cereals (wheat, rye).

Cereal	Carbon Emissions t CO_2/t	EF gha/t	Agro-Production System
Wheat	0.19 0.45	1.83 4.09	Organic Conventional
Rye	0.65 0.75	1.15 1.33	Organic Conventional
Rice	4.60	3.04	Conventional

Table 1.1. CO2 Emissions and EF for farm cereals

Pork meat is environmentally more favorable than chicken, which is more favorable than lamb and beef. Beef is found to be around 5 times more CO2-emissions intense than pork meat (Fig. 2), with the greatest EF value of 12, 18 gha/t in the conventional production system. The conversion to an organic production system determinate a reducing of environmental impact calculated as brut EF of 31, 03-45, 8%, depending on capacity and efficiency of the production farm. Chicken meat have the lowest impact on the total EF of ready to eat foods created with this type of meat.

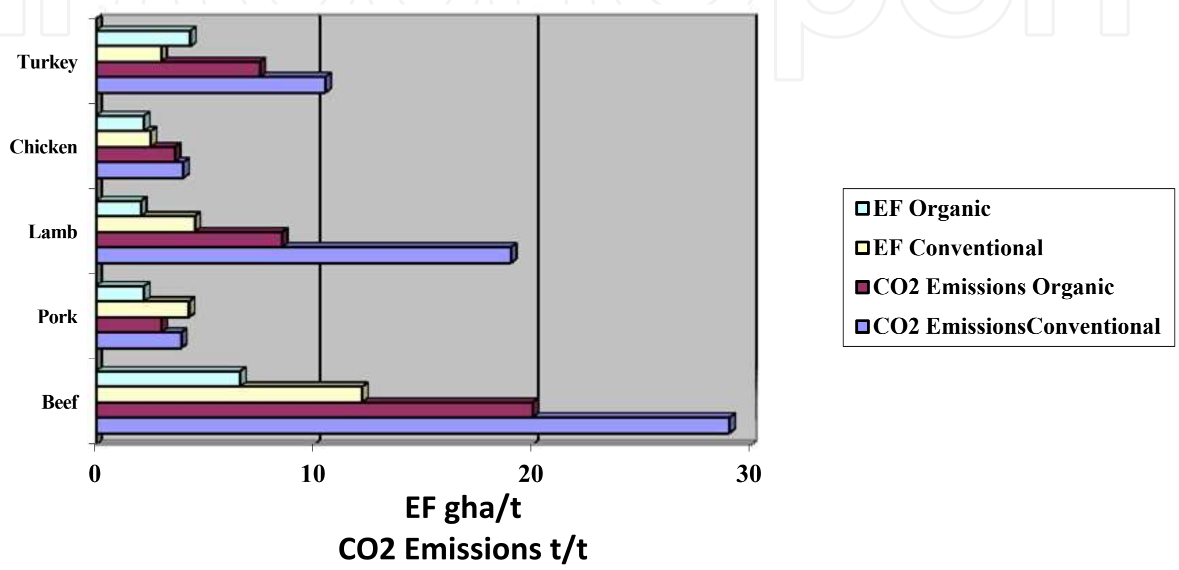


Fig. 2. CO2 Emissions (t CO_2 /t) and Ecological Footprint (gha/t) for farm meats

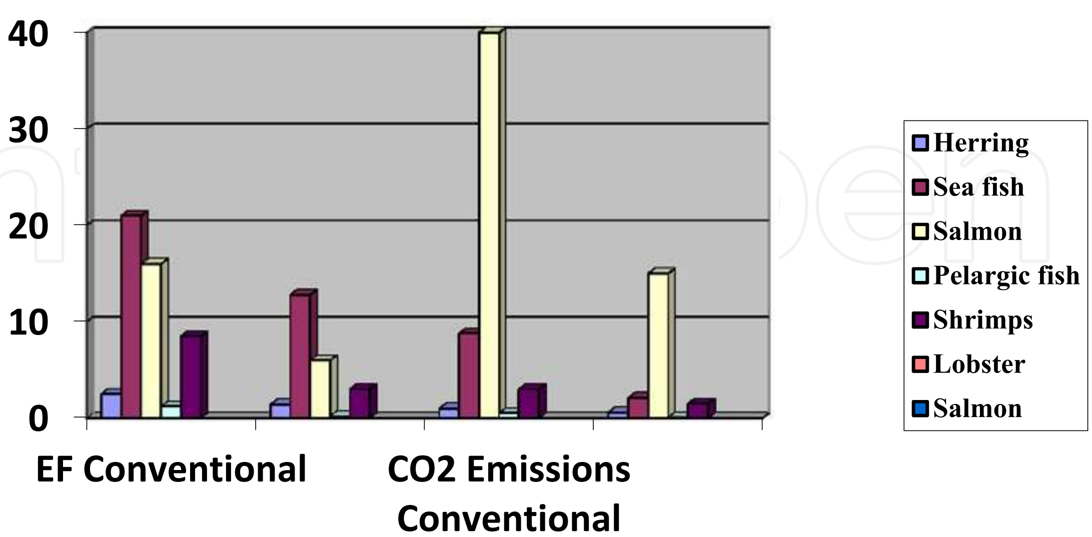


Fig. 3. CO2 Emissions (t CO_2 /t) and Ecological Footprint (gha/t) for seafoods

Pelagic fish species such as herring or mackerel have the lowest CO2 emissions in organic production case 0.08t CO2/t of fish (Fig.3). The deep-sea species and farmed carnivorous fish, such as salmon, generate the higher pressure both in term of CO2 emissions and EF impact.
Marine transport system with great capacity and efficiency generate the lowest emissions of 0.012 kg CO_2/t km in compare with an average capacity facility truck which cause emissions of 0.075 kg CO_2/ t km (Tab.2).

Transport System	Emission CO_2 kg /t km	EF gha/t
Air (EU)*	0.725	0.357
Air (transatlantic)	0.710	0.35
Rail	0.015	0.006
Trucks**	0.075	0.031
Marine	0.012	0.005

* 1 kg of diesel/kerosene corresponds to 3.15 kg CO_2
** Diesel has 85.9% carbon content by weight so the emission factor will be 0.859 × 3. 6667 = 3.15 tCO_2/t diesel (Carbon Trust, 2006).

Table 1.2. CO2 Emissions and EF for various transportation systems

The Table 3 shows that the transport of melon to Romania (Bucharest) from Brazil (Sao Paulo) by sea generate an added value of 0.033 gha/t at the brute EF of food (0. 35 gha/t), due to the greater capacity of the shipping facilities in comparison to air transport system, taking in account the potential for wastage implied by the longer travel chain. Avocado transported by air from South Africa (Cape Town) to Romania (Bucharest) imply the greatest EF correlated with the CO2 emissions 0.760 gha/t, while the transport by air generally is the most not-environment friendly type of transport. The transport by road may be 9 times more Eco-friendly than the transport by rail.

1.3 Conclusions

The conventional production system were found to have a EF value in average with 50% higher than in organic processing, mainly due to the agricultural and packing procedures. The lowest CO2 emissions were found for organic cereal production (1.15gha/t in rye case). Pork meat production is less emission intense than chicken, which is more environmentally favorable than lamb and beef. The reducing of EF in case of organic production is in the range of 1,05 (potatoes)-1,89 (tomatoes) times in vegetables case, 1.15 (rye)–2.23 (wheat) in cereals case, 1.03(chicken)-1.93(turkey) in meats case and dramatically more in case of sea foods 1.64 (shrimps)-5.9. Pelagic fish species such as herring or mackerel with low CO2 emissions register the highest reducing of EF in case of organic conversion of production and Eco-friendly distribution system.

Food, origin and transportation system	Emission in the transportation cycle kg CO_2/t	EF, gha/t	EF Transp. gha/t
Avocado, South Africa (Cape Town), aircraft	0.870	1.26	0.76
Smoked Salmon, South Africa (Cape Town), aircraft	0.870	6	0.76
Cherry , Spain (Madrid), aircraft	0.797	0.20	0.195
Melons, Brazil (Sao Paulo), marine	0.033	0.35	0.033
Tomatoes, Italy (Roma), truck	0.32	0.31	0.065
Tomatoe , Italy (Roma), train	0.030	0.31	0.006
Wine, Italy (Roma), truck	0.32	0.112	0.065
Virgin Olive oil, Italy (Roma), truck	0.32	3.17	0.065

Table 1.3. EF for Organic Agro-food transported from abroad to Romania (Bucharest)

2. Part 2

In the second stage of the research a comparative evaluation of durable development strategy for a public University UGAL (Dunarea de Jos University) using 2 assessment tools is proposed: ecological footprint(EF) versus Carbon Footprint Analysis(CF).The durable development indicators were calculated based on the evaluation of 2010 total flows for foods, energy, transport system and wastes management using Life Cycle Assessment (LCA)methodology. The general aim is to reduce the Ecological Footprint of the public institution by a rational use of natural resources and to educate the university community on the ethics of sustainability.In addition, the assesment of ecological impact of activities related with the University management due to a green strategy to addopt in the sustainability of buildings and green areas, energy and resources use.

2.1 Introduction

The actual world is moving towards a severe limitation of resources. Energy resources, essential for human well-being, are approaching to their peak point.
Human demand on ecosystem services continues to increase without a correlation with the regenerative and absorptive capacity of the biosphere. The natural capital may increasingly become a limiting factor for the future human demand. Humanity is posed in front of a major nature transformation and to face serious environmental challenges at global and local scales. The ecological attitude and sustainable behaviour has become a necessity in the

recent decades (Chambers et al., 2000). In the original ecological footprint method, only emissions of CO2 from energy use were considered without the influence of greenhouse gases, land clearing, enteric fermentation in livestock, industrial processes, waste, coal seams, venting and leakage of natural gas. Since the formulation of the ecological footprint, a number of researchers have criticised the method as originally proposed (Arrow, 2002; Costanza, 2000). In nowadays, the EU caterers are concerned about the environmental and sustainability issues, including the provenance and production methods of procured food, waste management, energy and water consumption (Dawe et al., 2004). Universities are public institutions that move to become more sustainable. New ways to measure progress are being sought such as Carbon Footprint Analysis (CFA) and Ecological Footprint Analysis (EFA). Many universities have adopted broad environmental responsibility and/or sustainability policies (Van Den Bergh, 2010). All the public Universities have a particular social responsibility in encouraging best environmental practice, due to their considerable influence on societal development (Albino and Kühtz, 2002).

A number of campuses have published EFA assessment results (Burgess and Lai, 2006; Conway et al., 2008; Dawe et al., 2004; Flint, 2001; Li et al., 2008; Venetoulis, 2001; Wright, 2002) but only two studies regarding a large public university (Janis, 2007; Klein-Banai et al., 2010). A comprehensive and consistent comparative study of EFA versus CFA results for a Eastern Public University is not available in the scientific literature.

The objective of the present research is to evaluate the actual Eco-impact of UGAL activities by using the EFA and CFA methodology. In the medium term, UGAL intention is to promote a sustainable green policy with the following major objectives:

1. decreasing the material (foods, packages, utilities etc.) and energetic waves as daily activities inputs;
2. improvement of the air quality;
3. improvement of the energetic quality performance and green energy production;
4. improvement of the water management system;
5. improvement of the green facilities management.

The present part of research compare the results generated by 2 Eco-Indicators (Ecological Footprint and Carbon Footprint) as important markers in the evaluation of future greening strategy that will be adopted for the first time by a Eastern public University from Romania (UGAL).

2.2 Materials and methods

The data involved in the Eco-Indicators assessment were obtained directly from the UGAL campus and general administrative management office. The UGAL campus population in 2010 consisted of 10.000 full-time students, 8000 part-time students and 1358 employed staff. The total UGAL facilities area is in average 11gha and the building area is about 5.4 gha. The EFA methodology was based on Wackernagel and Rees procedure (1996). In the calculation of specific EF we take into account all the quality-controlled life cycle information including energy, materials, transportation and wastes. To calculate EF, the inputs of different kinds are first converted to the corresponding actual area of land/water ecosystems needed to produce the resources or assimilate the emissions. The EFA results were expressed as units of EF in global hectare with world average biological productivity, for the purposes of adding areas together and comparing results across land types. The CFA is based on the calculation of CF for materials and processes with known quantity of fuel, energy or raw material multiplied by an conversion factor, which is a rate of tons of CO2e emitted per quantity of the material consumed (DEFRA, 2009). Greenhouse gases emitted through transport and the production of food, energy, utilities (electricity, gas, coal, water) for University activities and services are expressed in terms of the amount of CO2e emitted, in tonnes units. The methodology is highly compatible with ISO 14042 requirements. Both methodologies generate the information and data necessary for the Eco-indicators assessment by analyzing and quantifying the flows of all resources (inputs) and produced waste (outputs) on the campus (canteen and student's residence) and in all UGAL facilities. The input data for the Eco-Indicators assessment were presented in Table2.1, Table 2.2.1, Table 2.2.2 and Table 2.3.

Element	*Value*
UGAL total students	18000
Full time students	10000
Part-time students	8000
UGAL total employes	1358
In-campus students	3400
Average total menus served per day	400
Active weeks per academic year	45
Total menus served per academic year	82000
Snack menus served per academic year	4100
Lunch semi-complet menus served per academic year	41000
Lunch complet menus served per academic year	4100
Dinner menus served per academic year	32800

Table 2.1. General assessment elements

Utility item	Consummation
Electricity, MWh	1423
Gas, m3	175313
Water, m3	72808.76
Coal, Gcal	5557.08
Car traffic, km	29588

Table 2.2.1. Utilities consummation in UGAL

Wastes categories	Total Quantities kg/year
Domestic waste	5291.81
Food wastes	419.26
Garden wastes	2439.76
Paper ,packages waste	636.84
Plastic waste	538.52
Glass waste	646.18
TOTAL	9972.37
TOTAL per Employee	7.34

Table 2.2.2. Wastes collected in UGAL

Commodities Item	Consummation, t/year
Beef meat	0.626
Pork meat	2.906
Poultry	5.337
Fish	0.089
Vegetables	19.568
Pulses, Flavourings	0.436
Eggs	0.602
Milk	1.362
Cream	0.423
Cheese	0.372
Pasta	0.403
Rice	0.648
Sugar	0.090
Vegetable oils	3.274
Flours	0.357
Cereals	1.468
TOTAL	35.862

Table 2.3. Commodities Consummation in UGAL canteen

2.3 Results and discussions

The results of EFA include the basic lifecycle data for food consummation, energy demand, food wastes and transportation (Table2. 4). The results of CFA include the basic lifecycle data for food consummation, energy demand, food wastes and transportation (Table2. 5).

Component	EF, gha
Energy	12301.674
Electricity	1302.045
Gas	5953.629
Coal	5046
Water	380.425
Wastes	3.025
Transport	1479.4
Traffic car	1479.4
Commodities (Foodprint)	559.565
EF UGAL 2010	14724.089
EF per student	0.818
EF per capita	0.760
Ecological Foodprint per in campus students	0.016
Ecological Foodprint per student which serve the meal in the campus area	1.39

Table 2.4. UGAL Ecological Footprint Assessment

Component	CF, tCO2Eq
Energy	1358.451
Electricity	1148.361
Gas	143.406
Coal	66.684
Water	0.80
Wastes	3.3
Transport	5177.9
Autoutilitares (175 g/km)	5177.9
Commodities	43.722
Total CF, UGAL 2010	6584.173
CF per students	0.365
CF per capita	0.340

Table 2.5. UGAL Carbon Footprint Assessment

The calculated EF value per students is 0.818 gha and per capita 0.760 gha. The Eco-Indicators values are reasonable in compare with the WWF recommendation (average of 1.9 gha per capita) and the values reported by the other universities (Table 6). Energy, transports and foods are the most important parts of the total EF value. In the food processing department, vegetables, poultry, beef and vegetable oils have the greatest ratio in the total EF due to the greatest amount in the daily canteen use. In fact, only beef induce the leading impact on the total agro-foods EF and CF, respectively. Vegetables, milk, fruits and cereals have the lower value of EF and the ratio proposed in the optimized Eco-menus must be increased in order to generate a significant reducing of the total EF. The poultry items present the lowest ecological and emissive impact, in average with 3 times less than beef items. The regular use of low-carbon fish (mackerel, herring) could reduce substantially the meal's average carbon footprint. The food commodities created by an intensive processing such refining (oils, sugar), dry substance concentration (cream, cheese, pasta, cans) or extraction (flour) multiply the EF value of the raw material with the number of concentration /extraction degree. This is a strong reason for avoid the large quantities of industrialized foods, herbs, eggs and red meats and valorise the raw, unprocessed and fresh local/traditional products as input in the canteen production. In terms of gas emissive effect, the EC per student is calculated at 0.365 tCO2Eq/ year and EC per capita is 0.340 tCO2Eq/ year. The electricity represent 84.5% from total emission generated by all forms of energy used in UGAL facilities and the transportation system cover 78.64% from total CF. Food commodities have a minor impact on the total CF (0.066%) and the undercollected wastes (7.34 kg/year, employees) represent an insignifiant part (0.005%, 3.025 EF units per year). In the food processing department the pork items are environmentally more favourable than chicken and the chicken items are more environmentally favourable than lamb and beef. Beef is found to be around four times more CO2-emissions intense than pork meat. The comparative results of the present research and prior studies conducted in other campuses and universities are presented in Table 2.6.

	University								
	Dunarea de Jos University Galati (UGAL)	University of Illinois at Chicago	University of Newcastle	Holme Lacy College, UK	Northea-stern University, China	University of Toronto at Missis-sauga	Colorado College	Kwantlen University College	Ohio State University Columbus
Year	2010	2008	1999	2001	2003	2005	2006	2006	2007
EF, gha	14724.08	97601	3592	296	24787	8744	5603	3039	650,666
Ratio EF to land area	897.81	1005	26	1.23	50	97	154	81	916
EF per capita	0.76	2.66	0.19	0.57	1.06	1.07	2.24	0.33	8.66
Energy %	83	72.66	47	19	67.97	69.40	87	28.90	23.30
Trans-port,%	10	12.60	46	23	0.08	16.10	1.40	53	72.24
Mate-rials and Waste, %	0.02	11.83	2	32	5.74	4	na	na	4.46
Paper, %	na	na	na	na	2	na	na	7.20	na
Food, %	3.8	2.60	2	25	21.80	9.20	10	9.60	na
Built-up land,%	na	0.18	2	1%	0.44	1.20	na	1.10	w/ transport
Water %	0.02	0.14%	1	w/built-up land	2	0.20	1	0.16	na
Source	Vintila, 2011	Vene-toulis, 2001	Flint, 2001	Dawe et al., 2004	Li et al., 2004	Conway et al., 2004	Wright, 2002	Burgess and Lai, 2006	Janis, 2007

Table 2.6. Comparison of EF for colleges and universities

The results are very much similar with the others presented in the previsious works, in terms of EF per capita and ratio of the principal UGAL EF elements (energy 83%, transport 10%, water 2.5%, food 3.8%, wastes 0.02%) from the total EF value. The proportion of the energy module is overload because of the traditional technologies involved in the general management and the ratio of food is underload because only 11.7% of the total UGAL in-campus students eat in the canteen facilities every day.

2.4 Conclusions

Both EF and CF represent efficient and consistent tools to measure sustainable development by comparing scolar communities consumption of natural resources and the corresponding bio-capacity. The principal conclusions of the Eco-Indicators assessment are as followings:

- the energy consummation for food processing is in average 3.967MWh/t, 10% from total energy consumed in UGAL;

- meats commodities are the greatest emissive items involved in the daily menus and the potential environmental damage is estimated at 74.56% from the total foods EF (Foodprint value);
- the primary agricultural products present the lowest EF value; in contrast, a greater industrialisation food degree due to a proportionally increasing of foodprint value (in case of refined foods as oils, sugar or food derivates such as cream, butter or cheese);
- as a general rule, the degree of the principal compound from the dry substance concentrated in the industrialisation process represent the factor of multiplying the EF value of the raw food;
- the average wastes generated in a day is 0.036t and in average the ratio food/food wastes is 3.59/1;
- the smallest impact on both gas emissive effect (CF) an EF value is generated by the wastes 0,02% from total EF, followed by water 2.5% and food 3.8%.

As a general rule, the choice of raw materials have a considerable impact on greenhouse emissions. Different food ingredients such low-carbon fish and meats can reduce substantially a meal's average foodprint**.**

3. Part 3

In the third stage of the research, the ecological footprint analysis (EFA) was conducted in order to analyze the environmental impact of improved catering processing system by using an increasing amount of 15-25% regional organic agro-foods and 50% less amount of meat in the daily meals created for "Dunarea de Jos" University Galati (UGAL) students in 2010. The ecological footprint (EF) was proposed as a tool to measure progress towards the future goal of increasing the "Dunarea de Jos" University (UGAL) sustainability.

In the calculation of product-specific EF were considered all the life cycle assessment (LCA) elements including energy, materials system and wastes.Comparative analysis of agro-food origin (local, regional, national, EU) were conducted for the 6 main ingredients included in the daily menus of UGAL students. The variables of EF for the transportation system were capacity and distance. Independent studies, students collected data for the calculation of UGAL canteen footprint and analysis of surveys were conducted as methodology of the present research.

3.1 Introduction

Nowadays, the EU caterers are concerned about environmental and sustainability issues, including the provenance and production methods of procured food, waste management and energy and water consumption (Lintukangas *et al.,*2007). In the last 5 years, there has been a growing interest in the phenomenon of 'alternative agro-food networks', and locally sourced organically produced food has been suggested as a model of sustainable consumption for a range of economic, social and environmental reasons (Mikkola, 2008). Today, the most commonly cited reasons for consuming organic food are: food safety, the environment, animal welfare, and taste (Soil Association, 2002). Food co-operatives, farmers' markets, community supported agriculture groups among others were formed in order to provide consumers with organic and locally grown food. They aim to revitalise local food economies and to protect the environment (Walker and Preuss, 2008). Political recommendations encourage catering organisations to increase the use of local and organic food 10–15% annually. Caterers often perceive the procurement of local and organic food as a problem in terms of budgets, tenders and logistic efficiency (Taskinen and Tuikkanen, 2004). A professional social service include the issue for ecological sustainability in their professional daily operation (Koester et al., 2006).

The present paper research investigate the impact on menu EF of introducing more local organic foods and less meat, at the same nutritional balance imposed by the EU regulation for healthy young's nutrition in public establishments.

3.2 Model for calculating the ecological footprint for daily menus of UGAL students

The EF is a function of population and per capital material consumption. In order to evaluate the improving of student's daily menu EF by replacing 50-100 % of red meat products (beef) with fishy products in the weekly meals created for UGAL student's in 2010, the researchuse the ecological footprint evaluation (EFE).

According to the original calculation model of Wackernagel and Rees [6] a modified original calculation model for the menu EF calculation is proposed:

$$EF= \sum_{I=1}^{N} EF_{i} \bullet f_{i} \tag{3.1}$$

In the Equation (3.1), EF_i is the EF per menu ingredient i (m²) calculated with LCA methodology; f_i are the ratio of natural ingredient i in the daily menu; N is the number of food ingredients considered from the menu structure (N=6 in the present research). The meal components (N) included in EFE were red meat, poultry, fish, vegetables (fresh fruit, garnish vegetables), milk products and bread.

The data of food origin and transportation system for EFE were obtained directly from the UGAL canteen management office. The EFE were conducted by grouping the raw foods under the following variables of origin and transportation system:

i. local-low capacity isotherms, transportation cycle under 50km;
ii. Regional-big capacity isotherms, transportation cycle under 200km;
iii. National- big capacity isotherms, transportation cycle under 1000km;
iv. UE- big capacity isotherms, transportation cycle under 10000km.

From the analysis of the students survey questionnaires, 60% of total UGAL students have 5 meals on a week in the canteen and the fish products are the main course (150g) once in a week. In average, 702 meals with fishy products are designed in a week and the total consuming value in an academically year (9 months) is about 947.7 kg. The total consummation of red meat is 300g/student, week and in an academically year the canteen process 1895.40 kg.

The UGAL student's daily meals were composed with hors d'oeuvre, main dish & garnish & salad and dessert (total meal weight 380g). Four meals, two traditional (MC1, MC2) and two Eco (EC1, EC2) were composed and subsequently analysed under EFE protocol:

MC1-Red Meat (beef) 50%; Veg-25%; Milk dessert 15%; Bread 10%.
MC2- Meat (poultry) 50%; Veg-25%; Milk dessert 15%; Bread 10%.
EC1-Red Meat (beef) 25%; Fish 25% Veg-25%; Milk dessert 15%; Bread 10%.
EC2- Fish 50%; Veg-25%; Milk dessert15%; Bread 10%.

The EC1 menu were designed for a reducing with 50% of the meat content and in EC2 red meat is completely eliminated and replaced with fishy products in the main dish recipes. The ratio Animal Origin Product/Vegetable Origin Product (AOP/VOP) was designed at 65/35%.
The increasing amount of local organic foods (fish, vegetables, milk, products, bread) in EC1 and EC2 were of 25% and 50% respectively, compared with MC1, MC2.

3.3 EFA methodology based on Life Cycle Assessment (LCA) method

In the calculation of product-specific EF we consider all the quality-controlled life cycle information including energy, materials, transportation and wastes.
In LCA method, the EF of a food item is defined as the sum of direct land occupation and indirect land occupation, related to the total CO_2 emissions from fossil energy associated with the transformation (industrial processing) and transportation cycle:

$$EF_i = EF_B + EF_P + EF_T \tag{3.2}$$

In Equation (3.2) EF_B is the basic EF related to the land occupation 6 types identified, calculated with the formula (3.3):

$$EF_B = \sum_{i=1}^{n} F_i \, qF_i \tag{3.3}$$

Where: EF_B is the ecological footprint of direct land occupation (m2), F_i is the occupation of area by land use types i (m2) and qF_i is the equivalence factor of land use (Table 3.1). Fish yields for the RO and world yields were based on FAO evaluation (FAO, 2007).

EF Parameters	Value
Equivalence factor Forest	1.4
Equivalence factor built-up area	2.2
Equivalence factor primary cropland	2.2
Equivalence factor hydropower area	1.0
Equivalence factor pasture	0.5
Equivalence factor marine area	0.4
Fraction CO2 absorbed by the ocean	0.3
Sequestration rate of CO2	0.4
Fossil fuel emission intensity of CO2	0.07

Table 3.1. The equivalence factors and primary parameters involved in the EF calculation

In the EF methodology Yield and Equivalence factors averages is used in the area component in order to make adjustments due to bio-productivity differences of the same land type between various regions and of different land types globally. EF_P is calculated from the EF_B value with the average yield of the catering processing in the UGAL canteen.

The environmental impact generated by the transportation system was calculated with the original Equation (3.4):

$$EF_T = EF_C + EF_{TS} + EF_{CO_2} \quad (3.4)$$

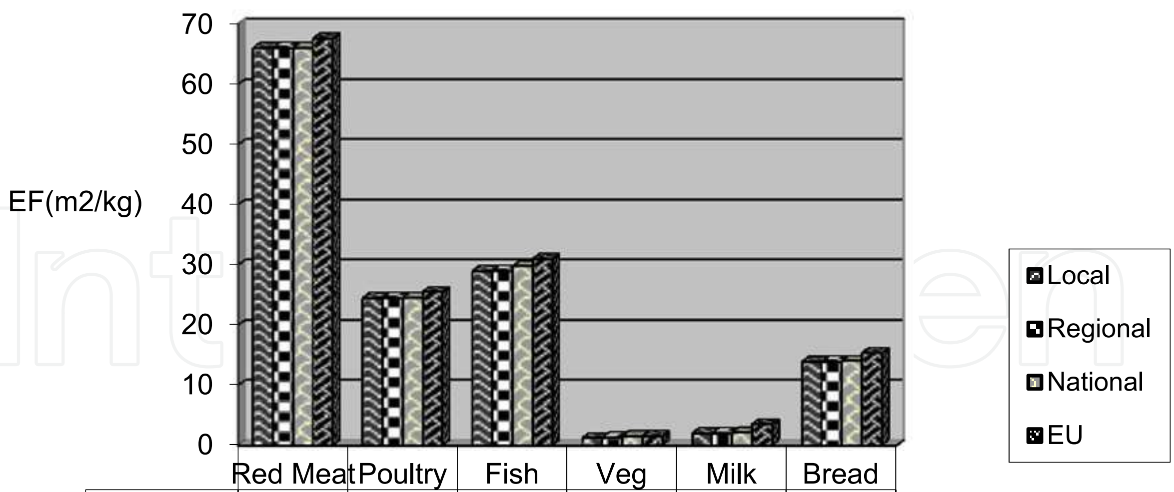
Where: EF_T is the EF value for transportation system adopted for the raw materials; EF_C is the EF value for the production of the fuel consumed in the transportation of raw foods; EF_{TS} is the EF value for the transportation state in the refrigeration units; EF_{CO_2} is the EF value involved by the pollution generated with the emission of CO_2 in course of the transportation cycle.

3.4 Results and discussions

The 6 main ingredients used in the structure of the daily menus of UGAL canteen were analyzed under EFE methodology using the LCA assessment protocol. The EF depending on origin and transportation system, in terms of distance and thermal state, were presented in Figure3.1. The red meat induced the leading impact on the total menu EF, beef especially because 1 Kg of meat imposed a consummation of minimum 5-6 kg of crops. The indigen fish species show a medium environmental impact, similar with the pork and poultry meat. The main fish species with UE origin analysed in the present research were hake (Merluccius merluccius), Sardina pilchardus, and Mackerel. If we consider the red meat EF as a reference, at the local level, we can reduce with 62.87% the menu EF if we replace the equivalent quantities with poultry and with 56.06% by replacing it with fishy product. The calculation of the integral bread EF were realised for EF of wheat equal with 8.31 and we obtain a value with 4.76 times lower than our reference. Vegetables and milk from local origin have the lower value of EF and the ratio proposed in the optimised Eco-menus must be increased in order to generate a significant reducing of total menu EF.

In the menu cases, the origin and transportation systems have a secondary impact in face of item ratio in recipe formula (Figure3.2). In all origin case investigated, MC1 trial with the greatest content of red meat, show the most extended value of EF, ranged from 12.82 units to 13.76 m2/menu.

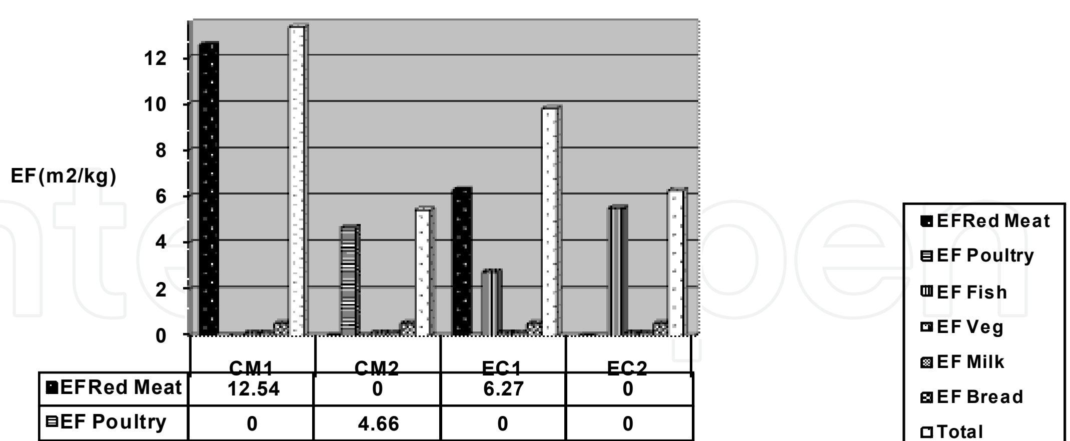
The origin of farm from canteen proximity imposed for all menu ingredients determined a reducing with 6.83% of the total EF reported at the UE origin and 3.97% reported at the national item origin. The MC2 menus trial show the lowest value of total EF due to the total replacing of beef with poultry, the category of meat with the lowest EF impact. In EC1 cases, a more balanced ratio of meat products were proposed in which half of red meat is replaced by fish and the EF were reduced with 27.45% in local origin of menu items and with 25.36% in UE origin case. EC1 is the most equilibrate menu in terms of nutritional balance, costs and environment impact. EC2 menus trial show a good total EF, slightly up to MC2 due to the impact of fish EF similar with poultry EF but with 2.27 times less than red meat (beef). The inclusion of ecologist wave strategy in the canteen future policy will due to a reducing of UGAL canteen EF with 17.27% in the food module and, also, a reducing of food costs with 20.83% only by doubling the MC2 menu in a week instead of doubling the MC1. In the actual state of UGAL canteen system, in 9 months of academically activity, EF per capita of student were evaluated at 0.9132 gha. The EF evolution trend could be improved at 0.7554 gha, by the simple replacing of analysed items with local sources and regular replace once in a week of beef with poultry or fish products.



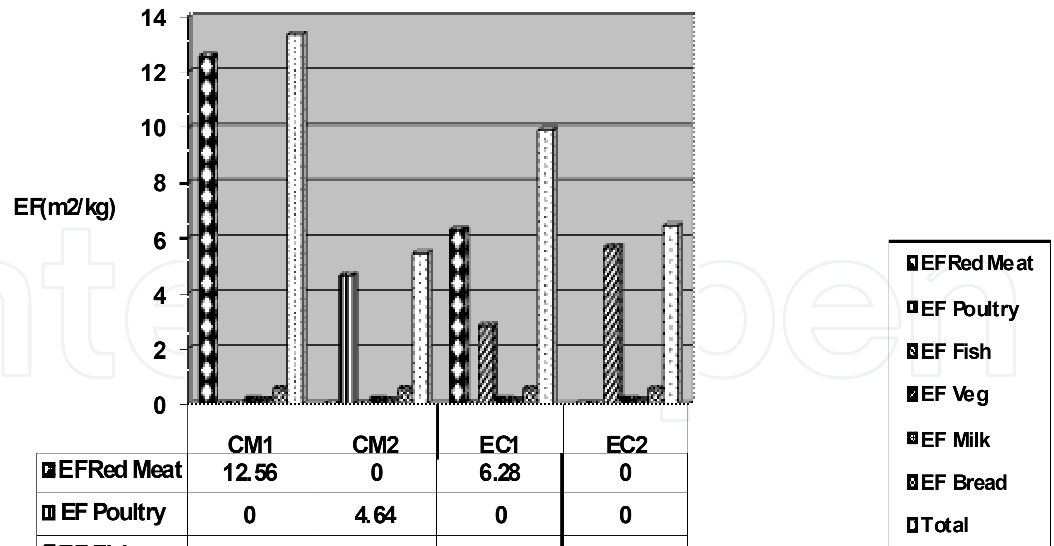
	Red Meat	Poultry	Fish	Veg	Milk	Bread
Local	66	24.5	29	1.2	2	13.85
Regional	66.03	24.53	29.03	1.3	2.03	13.87
National	66.05	24.54	29.74	1.5	2.14	14
EU	67.58	25.5	30.94	1.56	3.48	15.33

Menu ingredient

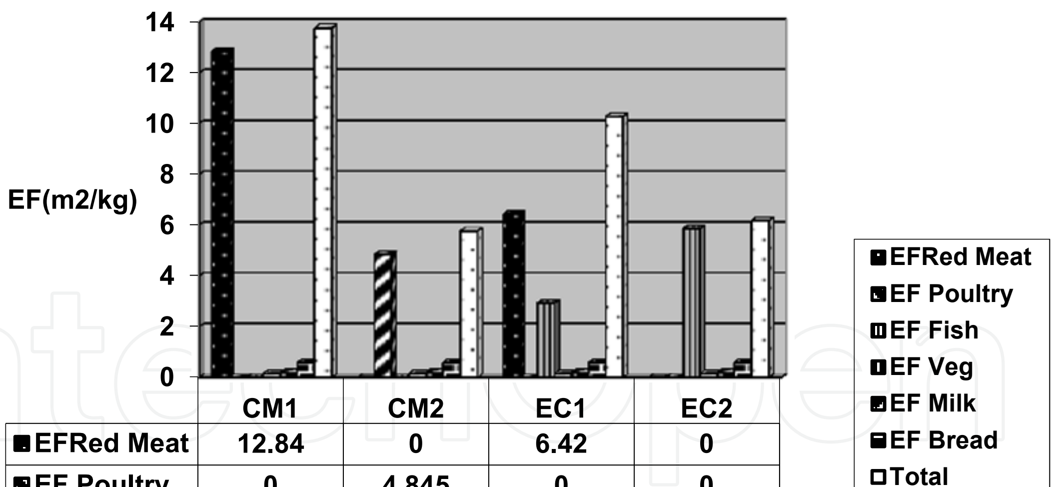
Fig. 3.1. Ecological Footprint value (m²/menu) for menus ingredients



	CM1	CM2	EC1	EC2
EFRed Meat	12.54	0	6.27	0
EF Poultry	0	4.66	0	0
EF Fish	0	0	2.75	5.5
EF Veg	0.123	0.123	0.123	0.123
EF Milk	0.115	0.115	0.115	0.115
EF Bread	0.528	0.528	0.528	0.528
Total	13.306	5.426	9.786	6.266



	CM1	CM2	EC1	EC2
EFRed Meat	12.56	0	6.28	0
EF Poultry	0	4.64	0	0
EF Fish	0	0	2.82	5.64
EF Veg	0.142	0.142	0.142	0.142
EF Milk	0.121	0.121	0.121	0.121
EF Bread	0.532	0.532	0.532	0.532
Total	13.355	5.437	9.895	6.435



	CM1	CM2	EC1	EC2
EFRed Meat	12.84	0	6.42	0
EF Poultry	0	4.845	0	0
EF Fish	0	0	2.93	5.86
EF Veg	0.148	0.148	0.148	0.148
EF Milk	0.186	0.186	0.186	0.186
EF Bread	0.589	0.589	0.589	0.589
Total	13.766	5.768	10.273	6.1783

Fig. 3.2. Ecological Footprint value (m^2/menu) for conventional and Eco-friendly menus designed with local, regional, national and EU origin ingredients

3.5 Conclusions

The EF has become a new efficient method to measure regional sustainable development by comparing humanity's consumption of natural resources and world biocapacity. EF estimates the environmental impact due to energy use and direct land occupation expressed in global hectares.

The following results were obtained in case of Eco-strategy implementation in the UGAL canteen: (1) reducing of UGAL canteen EF with 17.27% in the food module; (2) reducing of EF per student 0.7554 gha from 0.9132 gha; (3) a reducing of food costs with 20.83%.

The choice of raw materials can have a considerable impact on emissions. Different food ingredients such low-carbon fish and meats can reduce a meal's average carbon foodprint substantially**.** Actual statistics discussing about the contraction of the student population with 20% in the next 10 years and in the condition of resources limitation the Eco-management became a necessity in order to respect the regional biocapacity.

4. Part 4

In the final research stage, the ecological footprints (EF) analyses were conducted in order to evaluate the environment impact of improving actual catering system by replacing 50-100% of red meat products (beef) with local/regional fishy products in the weekly meals created for "Dunarea de Jos" University (UGAL) students in 2010. Product-specific EF was calculated from consistent and quality-controlled life cycle information of food products and services, including energy, materials, transport, waste treatment and infrastructural processes. The reducing of red meat products in the student's daily menus with 50% and the reducing of long food chain at the local/regional level determined a 36.24% average decreasing of actual menu EF and the replacing of red meat with fishy products a 72.2% reducing of Eco-menus EF. At least 20.83% less amount of money could be saved in the menu creations and if we replace one day in a week 50% meat with local fishy products and the average reducing EF for menu creation in an academic year could be in average 17.27%.

4.1 Introduction

The ecological footprint (EF) was initially conceptualised by William Rees (1992) and further developed by Mathis Wackernagel (1994). The EF estimates the ''minimum land necessary to provide the basic energy and material flows required by the economy'' (Wackernagel & Yount 1998, 2000; Wackernagel & Silverstein 2000; Petrescu et al 2010). EF provides a measure of the extent to which human activities exceed two specific environmental limits – the availability of bioproductive land and the availability of forest areas to sequester carbon dioxide emissions. The EF integrates (i) the area required for the production of crops, forest products and animal products, (ii) the area required to sequester atmospheric CO_2 emissions dominantly caused by fossil fuel combustion, and (iii) the area required by nuclear energy demand (Monfreda et al 2004).

In 2005 the global EF was 17.5 billion global hectares (gha), or 2.7 gha per person (a global hectare is a hectare with world-average ability to produce resources and absorb wastes). The total productive area (earth biocapacity) was 13.6 billion gha, 2.1 gha per person respectively. Humanity's footprint first exceeded the Earth's total biocapacity in the 1980s. The 2005 overshoot of 30% would reach 100% in the 2030 even if recent increases in agricultural yields continue (Flint 2001). This means that biological capacity equal to two

planets would be required to keep up with humanity's resource demands and waste production (FAO, 2002).
With an average growth rate of 6.9% per year, aquaculture is the fastest growing food production sector in the world. This rapid growth faces, however, some limitations in the availability of suitable sites and in the ecological carrying capacity of actual sources. The discipline of ecological engineering addresses and quantifies the processes that are involved with management of wastes as a resource (Coll et al 2006).
Ecosystem-based management (EBM) is an integrated approach that encompasses the complexities of ecosystem dynamics, the social and economic needs of human communities, and the maintenance of diverse, functioning and healthy ecosystems (Christensen & Walters 2004).
The public universities have a particular social responsibility in being role models for encouraging best environmental practice, due to their considerable influence on societal development. Recent studies concerning ecological footprints have been focussed in University settings, given their significant social responsibility. The demand for green product rises with the number of consumers who are sensitive to environment matter and especially their degree of sensitivity (Viebahn, 2002).
The present part of research investigate the impact on menu EF of introducing more local fishy products and less red meat, at the same nutritional balance imposed by the EU regulation for healthy young's nutrition in canteens.

4.2 Method of investigation

In order to evaluate the improving of student's daily menu EF by replacing 50-100 % of red meat products (beef) with local/regional fishy products in the weekly meals created for UGAL student's in 2010, this paper use the ecological footprint evaluation (EFE). The data of food origin and transportation system for EFE were obtained directly from the canteen management office of UGAL. The EFE were conducted for fresh fishy products with the following variables of food origin and transportation system:

i. Local- low capacity isotherms, transportation cycle under 50 km;
ii. National- big capacity isotherms, transportation cycle under 1000 km;

In the calculation of product-specific EF we consider all the quality-controlled life cycle information including energy, materials, transport, waste treatment and infrastructural processes. 60% of total UGAL Students have 5 meals on a week in the canteen and the fish products are the main course (150g) once in a week. In average, 702 meals with fishy products are designed in a week and the total consuming value in an academically year (9 months) is about 947.7 kg. The total consummation of red meat is 300g/student, week and in an academically year the canteen process 1895.40 kg. The UGAL student's daily meals were composed of hors d'oeuvre, main dish with garnish and salad and dessert (total 380g). The meal components evaluated in EFE were red meat, poultry, fish, vegetables (fresh fruit, garnish vegetables), milk products and bread. Four meals, two traditional (MC1, MC2) and two Eco (EC1, EC2) were composed and subsequently analysed under EFA experimental protocol:
MC1-Red Meat (beef) 50%; Veg-25%; Milk dessert 15%; Bread 10%.
MC2- Meat (poultry) 50%; Veg-25%; Milk dessert 15%; Bread 10%.
EC1-Red Meat (beef) 25%; Fish 25% Veg-25%; Milk dessert 15%; Bread 10%.

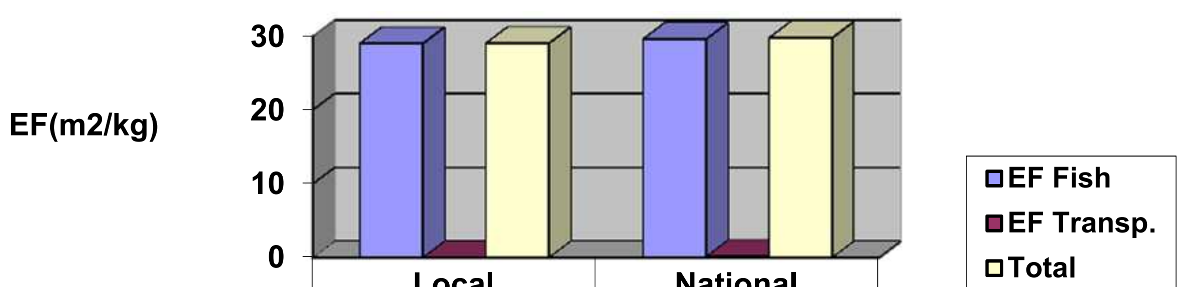
EC2- Fish 50%; Veg-25%; Milk dessert15%; Bread 10%.

The EC1 menu were designed for a reducing with 50% of the meat content and in EC2 case meat is completely eliminated in face of fishy products included in the main dish recipes. The ratio Animal Origin Product/Vegetable Origin Product (AOP/VOP) was designed at 65/35%. The increasing amount of regional organic foods (fish, vegetables, milk, products, bread) in EC1 and EC2 were of 25% and 50% respectively, compared with MC1, MC2. In term of costs management, the calculation of costs reducing were realised with an average market acquisition value of 2.85 Euro/kg in case of red meat and 1.66 Euro/kg in fish product case.

4.3 Results and discussion

The fishy ingredients used in the UGAL canteen (Horse mackerel *Trachurus trachurus*, Blue Fish *Pomatomius saltatrix*, Sprat *Sprattus sprattus sulinus* Antipa, Bonito *Sarda sarda*) are top quality, high nutritional value and with significant health benefits. The regular integration in the institutionalised canteens of the universities generated a reducing of the environmental impact, which is 2.69 times decreased compared with the red meat of local origin (Figure 4.1).

The proximity of Danube source give a better raw EF value for fish, reduced with 2% than national origin fishy products and the overall environmental impact will be decreased with 2.48% all the time when the local produced fish will be favourites in the canteen acquisition.



	Local	National
EF Fish	29	29.6
EF Transp.	0.0075	0.148
Total	29.0075	29.748

Fig. 4.1. Ecological Footprint value (m^2/kg) for fishy products

On the national origin basis, the results of EFE for one menu item utilised as main course in the weekly cycled menus for UGAL students show that the regular use of local instead national origin fishy products determined a reducing of the EF for transportation cycle of 94.93 % (Figure 4.2).

In all cases, the items with national origin determined an important increase of the recipe item EF despite the more productive value of the primary cycle compensated by the increasing of the resources consuming with the transportation in the refrigerated state. In the red meat case (beef), the EF value for raw brut products were reduced with 0.15% in case of national centralised farms. The high capacities of production farms due to high efficiency in the abatorization processing system but the transportation cycle with high capacity isotherms in the refrigerated state increase the meat EF with 0.148 units instead of 0.0075 in the local origin case (Figure4.3).

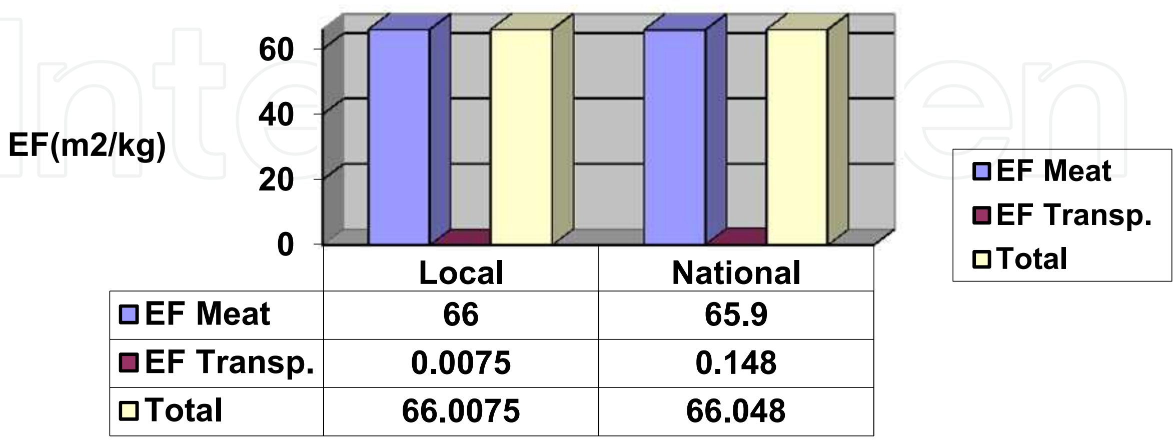


Fig. 4.2. Ecological Footprint value (m^2/kg) for red meat products

The EF for national common vegetables (potatoes, carrots, bean, fruits) is 1.5 units, with 20% greater than in the case of a local vegetables and with 13.33% increased in compare with the regional level (under 200km) source, respectively.
In the menu cases, the 50% replacing of red meat (beef) content in the daily menus with local fishy products in EC1 case and with 100% in EC2 case, on the conventional MC1 menu basis, generate a reducing of overall menu EF with 27.45% in EC1 case and with 54.83% in EC2 case.

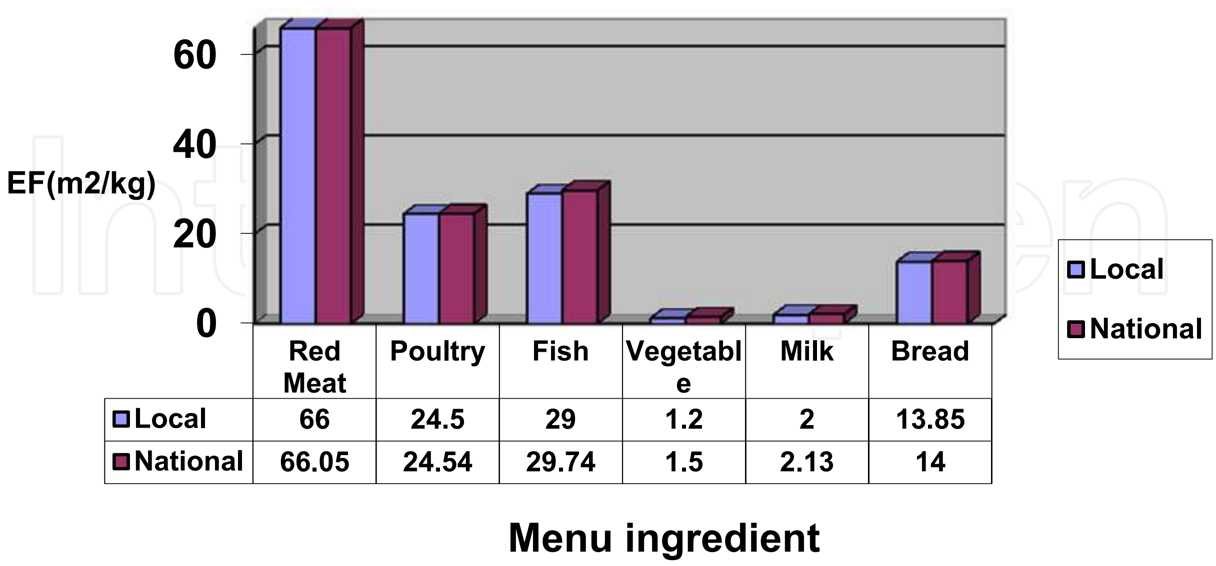
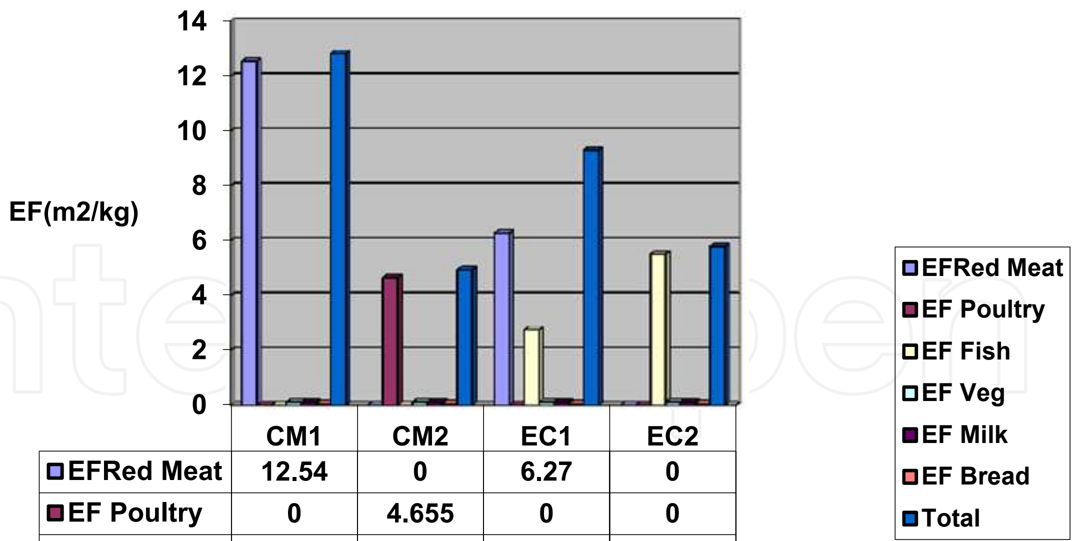
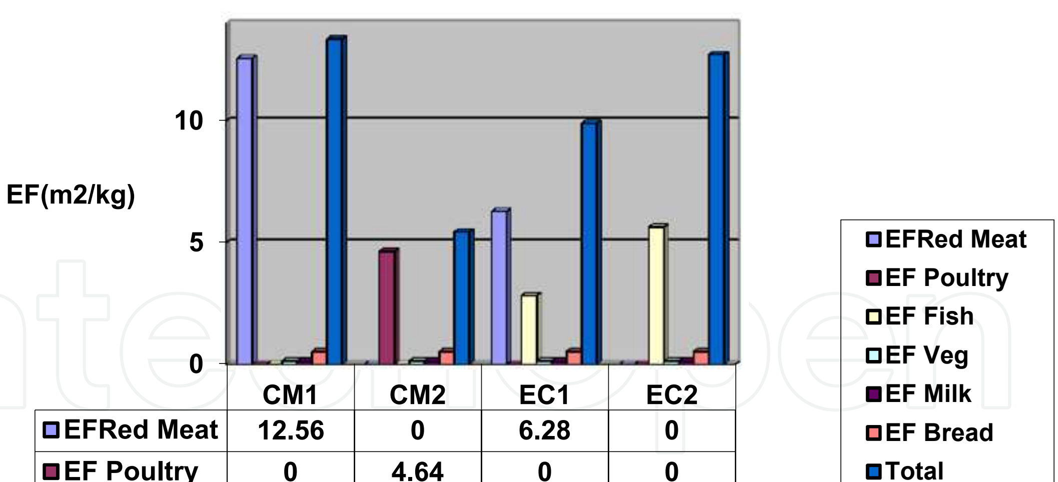


Fig. 4.3. Ecological Footprint value (m^2/kg) for menus natural ingredients with local and national origin



	CM1	CM2	EC1	EC2
EFRed Meat	12.54	0	6.27	0
EF Poultry	0	4.655	0	0
EF Fish	0	0	2.755	5.51
EF Veg	0.114	0.114	0.114	0.114
EF Milk	0.114	0.114	0.114	0.114
EF Bread	0.052	0.052	0.052	0.052
Total	12.82	4.935	9.305	5.79

Fig. 4.4. Ecological Footprint value (m^2/menu) for Conventional and Eco-friendly menus designed with local natural ingredients



	CM1	CM2	EC1	EC2
EFRed Meat	12.56	0	6.28	0
EF Poultry	0	4.64	0	0
EF Fish	0	0	2.82	5.64
EF Veg	0.142	0.142	0.142	0.142
EF Milk	0.121	0.121	0.121	0.121
EF Bread	0.532	0.532	0.532	0.532
Total	13.355	5.437	9.895	12.715

Fig. 4.5. Ecological Footprint value (m^2/menu) for conventional and Eco-friendly menus designed with national ingredients

In case of national origin ingredients, a part of menu EF increasing produced by the replacing of red meat with fish is lost in the transportation cycle. The overall menu EF decreased at 25.91% in EC1 case and with 51.79% in EC2 case at CM1 basis (Figure 4.5).
The total EF of final menu depends on the items ratio at the same origin and transportation system. Raw beef have the greatest EF amount in the all experimented menu and the vegetables the lowest value added to total EF of menu. The white meat of local origin has a reduced impact on the total menus EF because the poultry EF were with 62.87% reduced compared with red meat at the same origin and transportation system. For this reason, a replacing of red meat with poultry determined a reducing of MC2 EF with 61.54% compared with MC1. The replacing with fishy local products in EC2 case determined a reducing with almost 54.83%of the overall menu EF, because the fish EF is with 15.5% greater than poultry EF. The menu formula MC2 show the best EF values if is composed with local origin ingredients. From the environmental, nutritional and financial point of views we recommended the EC2 formula at least once in a week and MC2 formula twice in every chart pre-planification of UGAL canteen. In the situation in which the management of UGAL canteen decide to change the actual state of menu chart 2 MC1 formula +MC2+ EC1+ EC2/week with 2MC2+MC1+ EC1+ EC2/week, the canteen food EF module could be reduced with 17.27% in an academic year, with the promotion of the local acquisition circuits.
The menus designed with all ingredients of national origin showed a increasing of the overall EF of 3.8-9.2% in CM1-CM2 menus cases, 5.9-10 % in EC1-EC2 menus cases, respectively. The transportation system in the refrigerated state of fish and milk due to a increasing of resources using measured with EF value of 94.93%. On the CM1 basis, there is the possibility to reduce the menu EF with 18.6% in the EC1 case and 19% in EC2 case. On the CM2 basis, the total EF reducing value for the complete menu were of 23.07% for EC1 menu and 51.79% for EC2 menu, respectively. In the same time, the price were consistently reduced for Eco-friendly menus which replace the red meat with local origin fishy products, with about 41.66% (from 1.80 Euro in case of CM1 menu to 1.05 Euro in EC2 case) in the same nutritional equivalence of the final menu.

4.4 Conclusions

The dominating components of ecological footprint were raw material production system and energy necessary for transportation. The reducing of red meat products in the student's daily menus with 50% and the reducing of long food chain at the local/regional level give a 36.24% average decreasing of EC1 menu EF and the replacing of red meat with fishy products a 72.2% reducing of EC2 menus EF. At least 20.83% less amount of money could be saved in the menu creations if we replace one day in a week 50% meat with local fishy products and the average reducing EF for menu creation in an academic year could be 17.27%. In the same time, the catering systems create an important bridge between young's and the local products and the sustainable development of the regions will be encouraged. The local origin of agro-foods reduce the environment impact despite the fact that the total efficiency is lower than in centralized regional or national farms, in terms of productivity and primary processing yield. The red meat induced the leading impact on the total agrofoods EF. Vegetables, fruits and cereals with local origin have the lower value of EF and the ratio proposed in the optimized Eco-menus must be increased in order to generate a

significant reducing of total EF. The results also indicate that using low-carbon fish (mackerel, herring) and meats (chicken, turkey) can reduce substantially a meal's average carbon footprint. *Promoting the daily menu planning including vegetable from proximity sources (short chain producers), the public catering system could have three types of advantages: nutritional, ecological and financial.* A rational and efficient network composed from a biological agriculture source of agrofoods and an environmental friendly transportation facilities generate the best result in the reducing total EF of the final ready to eat product. By reducing the quantities of meat, especially beef and sea fish and increasing the proportion of locally organic cereals, potatoes and fruits a reducing with 50% of total daily food EF is possible in case of a eco-attitude adopted in the public institution.
With the further development of international free market economy, the living standard and living quality of people will be improved constantly, which certainly will due to a constantly increasing of energy and raw material consummation.
A global eco-strategy must be constructed in the near future in order to reduce our actual EF on the individual, institutional and national scale

5. Acknowledgment

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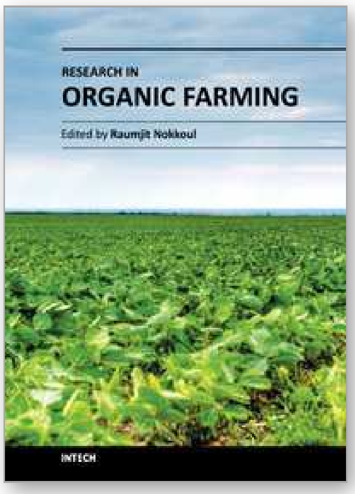

Research in Organic Farming

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This book has emerged as a consequence of the difficulties we experienced in finding information when we first started researching. The goal was to produce a book where as many existing studies as possible could be presented in a single volume, making it easy for the reader to compare methods, results and conclusions. As a result, studies from countries such as Thailand, Spain, Sweden, Lithuania, Czech, Mexico, etc. have been brought together as individual chapters, and references to studies from other countries have been included in the overview chapters where possible. We believe that this opportunity to compare results from different countries will open a new perspective on the subject, allowing the typical characteristics of Organic Agriculture and Organic Food to be seen more clearly. Finally, we would like to thank the contributing authors and the staff at InTech for their efforts and cooperation during the course of publication. I sincerely hope that this book will help researchers and students all over the world to reach new results in the field of Organic Agriculture and Organic Food.