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THE ANALYSIS OF THE ECOLOGICAL FOOTPRINT OF MAJOR DIET TYPES

Humans are the element of the natural food networks; however, their position is quite specific due to consumption of bigger volumes of natural resources than it is necessary for their survival. It is also true in case of food consumption: wrong diet, globalization and fashion trends make people eat more food that is not local. The aim of the survey is to assess the ecological footprint of major diet types and current situation with food consumption and its environmental value in Ukraine. The analysis of statistical data shows that a citizen of a developed country requires an ecological area of about 6.1 gha with 30–40 % intended for food, while the world average amount is 2.7 gha. But different types of diet produce different ecological footprint and different impacts on the environment. The environmental impacts of meat production are the most intensive and include generation of waste, water consumption, habitats destruction, greenhouse gases emissions and soil pollution. On the other hand, vegetarian diet is not enough to make the food system sustainable without improvement of agricultural practices, renewable energy introduction and implementation of principles of sustainability into all spheres of life. Ukrainians have moderate financial and physical access to food according to the world statistics. Being forced to spend 50–55 % of monthly budget on food, they consume too much fat and sugar, and too little fruit, vegetables, dairy and fish. Big volumes of food bought and eaten, especially meat, are considered to be the reflection of prosperity. In order to analyze the current situation with nutrition patterns, the survey is conducted among the students. The results show that food is bought in supermarkets without consideration of its ecological status and almost half of students adhere to meat based diet. Most respondents are not willing to change their diet types. Thus, we may assume that in the future the pressure on the environment from food production and consumption will grow in Ukraine. Therefore, now it is necessary to work on prevention of food losses, and educating people how they can reduce their food footprint by minor behavioral changes.

Keywords: biocapacity; environmental impacts of agriculture; human trophy level; diet footprint; food losses.

Introduction. Movement of nutrients is started with the producers to consumers of the first order, further to the second-order consumers of carnivores and finally to decomposers, and inorganic substances return to the producers. The system is closed. Often, living organisms in nature interact with each other more complexly and visually this interaction is more like a network, known as a food web. Food networks are formed because any member of any food chain is also a link in another food chain: it is consumed and consumes several types of other organisms (Lindemann, 1942). A food web or food network extends the food chain concept from a simple linear pathway to a complex network of interactions. The more trophic levels are involved, the more sustainable this ecosystem is (Chapin et al., 2002).

Humans are also the element of the food network; however, their position is quite specific and could be referred as top predator. This is due to humans' consumptive features, which include presence of additional needs out of survival provision: communication, traveling, housing, goods and services etc. As a result, humans use much more resources than those necessary in the form of food. However, the consumption of food has also gone out natural limits: wrong diet and food surplus have become the reflection of

high living standards; globalization and fashion trends make local food not good enough and makes exotic food products to travel around the world, consuming resources on transportation. As a result, 2016 has become the first year in our history when the number of people with obesity outweighed those starving. This claims the need to assess the potential ecological footprint of major diet types and current situation with food consumption and its environmental value in Ukraine.

To investigate the ecological footprint of different systems of nutrition the following tasks were set:

1. Analyze and compare the impact of different diets on ecosystems.
2. Describe the correlation between ecological footprint and diet peculiarities.
3. Develop the list of recommendations for reducing of human impact due to diet.
4. Explore the food basket of the average Ukrainian, compare population data.
5. Conduct a survey among students to define their ecological footprint.
6. Analyze the current situation with food footprint among youth.

Ecological footprint of various diets. To measure the volume of the necessary natural resources the concept of

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ecological footprint was introduced. The ecological footprint is the amount of biologically productive land that is wholly devoted to supporting a human's needs (Wackernagel, 1994). Ecological footprints include the amount of area needed to provide food (growing crops and pasturing cattle), reproduction of consumed forest products, fiber and materials, as well as the area of built-up land and fishing areas and the amount of area needed to absorb wastes such as trash, CO₂, and sewage. It is more than just the area required to provide energy; it is a measure of each person or population total impact on the environment. The concept of ecological footprint encompasses all types of environmental services used by man and competing for productive areas.

Ecological footprints vary widely among individuals and among societies. The United States has close to the largest footprint (9.6 hectares), while many countries in Africa, Asia, and South and Central America have per capita footprints less than 2 hectares. According to the World Wildlife Fund for Nature, the area of productive land and sea available on earth amounts to only 1.4 hectares per person, which humans currently exceed (Living Planet Report, 2016).

Opposite parameter is biological capacity or biocapacity of global ecosystem or national ecosystems. Biocapacity is the ability of an ecosystem to produce useful biological materials and to absorb waste generated by humans, using current management schemes and extraction technologies (Rees, 1992).

Countries with a high level of human development tend to have a greater ecological footprint per capita than "planetary limit" set for all people. Poorer countries face the problem to provide high living standards without exceeding available biocapacity of the country and the world on the whole. Although the world's poorest countries are the most vulnerable, interrelated problems of food, water and energy safety affect everyone (Popp et al., 2010).

Population grows rapidly, and this trend multiplied by high ecological footprint per capita leads to increasing pressure on the resources of the planet. The investigation of the food industry impacts on the environment is important now more, than ever.

The recent statistics published by the Global Footprint Network, a citizen of a country with high income, in order to maintain the desired level of well-being, requires an ecological area of about 6.1 gha (or 170 square feet per day), which is over than double of the world average (2.7 gha) (Living Planet Report, 2016). Food consumption is the first constituent of this value, providing around 30–40 % or 1.8–2.4 gha per year. As a result, every individual needs approximately 60 square meters to meet their global needs for food. The estimate takes into account the fact that, on average, a citizen who lives in a high-income country follows a diet of 2 650 kcal per day, considering the consumption of both food and drink, including food waste (Gerbens-Leenes et al., 2002).

There is a wide agreement that culture, religion and traditions knowledge are major factors, having influence on diet what and how we eat (Tukker et al., 2011). From an evolutionary perspective, the search for food has played a fundamental role in the evolution of human culture (Pimentel and Pimentel, 2003). However, the biological necessity of food has become secondary to the meaning that food has acquired in human culture and religion. Food is loaded with

symbolic value in all societies. It has become a means of communication, of creating and reinforcing social relations, of expressing one's personal or group identity (e.g. ethnicity, class, gender, religion) (Alonso, 2015).

According to the biological action of food, four types of nutrition are distinguished: rational, preventive, therapeutic and dietary. Also, based on the composition principle it is possible to determine such types of nutrition: omnivorous, carnivorous, lacto-ovo-vegetarian, vegan, macrobiotic, raw food and fruitarians. The widely known complex combinations of food products formed under certain conditions or for certain purpose are weight reduction, Nordic, Atkins, Zone and Mediterranean diets.

A group of French researchers recently decided to use food supply data from the UN Food and Agricultural Organization (FAO) in 176 countries from 1961 to 2009 to calculate human trophy level (HTL) for the first time (Bonhommeau, 2013). On a scale of 1 to 5, with 1, being the score of a primary producer, and 5, being a pure apex predator, they have found that based on diet, humans score is 2.21 – roughly equal to that of pig (Bonhommeau, 2013). However, they also found that while the worldwide HTL varies widely: the country with the lowest score (Burundi) was 2.04, representing a diet that was 96.7 percent plant-based, while the country with the highest (Iceland) was 2.54, reflecting a diet that contained slightly more meats than plants (Bonhommeau, 2013). The basic trend, in other words, is that as people become wealthier, they eat more meat and fewer vegetable products. The environmental impacts of eating meat include generation of waste, consumption of high quantities of water, habitats destruction for pasture areas creation, emission of greenhouse gases and other pollutants (Steinfeld et al., 2006).

Thus, decaying livestock waste emits fetid gases, which contain up to 60 compounds: ammonia, amines, sulphides, volatile fatty acids, alcohols, aldehydes, mercaptans, ethers and carbonyls, – the decomposition of these wastes reduces of oxygen content. Except direct consumption of water, wastewaters, containing high levels of nitrogen and phosphorus compounds are discharged into natural waters.

The daily output of excrement depending on gender and age group ranges from 0.5 to 12.4 kg per animal. The average moisture of cattle excrement can be from 86 to 97 % dry matter content – from 0.17 to 4.93 % for the day. All these become the agents of soil pollution (Steinfeld et al., 2006). So, the transition of the world's population from a plant-based diet to predominately meat diet is threatening to the stability of biosphere (Ciati & Runini, 2012).

A widely adopted vegetarian diet may not be enough to make the food system sustainable, unless greener agricultural practices, such as the adoption of renewable energy, are also implemented (Popp et al. 2010; Ciati and Runini, 2012), equally, environmental vegetarians have to incorporate green living into their dietary lives, which would engage people in a range of other activities to protect, repair, sustain, or enhance the environment.

The analysis of dietary variations in Ukraine. In the international rating of The Global Food Security Index 2014, compiled by The Economist, Ukraine is on the 52nd place out of 109 countries surveyed on the parameters of financial and physical access to food. The first two places are occupied by the USA and Austria, the Netherlands and Norway take the third place. Expenses for food products

make up to 50–55 % of the monthly budget of the average Ukrainian family, while, for example, in Germany – it is up to 20 % (Bezusov et al., 2015).

In the menu of Ukrainians, sugar and sweets account for 14 % of the diet; flour and porridge in Ukrainians make up 36 %, the share of fish, eggs and dairy products on the table is 11.5 %, meat is about 9.2 % (Bezusov et al., 2015). As noted, the population consumes too much fat and sugar, and too little fruit, vegetables, dairy products. At the same time, Europeans consume fruit and vegetables 1.5–2 times more than Ukrainians. According to most analysts, the meager ration of Ukrainians is associated with a number of reasons, including national culinary traditions, insufficient knowledge of healthy nutrition among the population, a constant rise in food prices, as well as problems in the agricultural sector, and poorly developed food culture.

In recent years, there has been a trend towards a decrease in purchasing power among the majority of the population. Over the last 30–40 years on the Ukrainian menu is based on three basic elements – potatoes, cereals and bakery products. We consume mainly eggs, milk and dairy products, vegetables, potatoes and bread. Fruits and meat are eaten much less. Most Ukrainians save on fish, because it's expensive. Along with a decrease in the consumption of the most of the food products inherent in the Ukrainian people, it is becoming increasingly common to switch to various food systems and types of diets (Mardar, 2015). However, in case of growing prosperity Ukrainian families tend to switch not to healthier diets, but to more intensive meat consumption and overall increase of food bought and eaten. The result is, of course, not favorable for the health, moreover, the trend of obesity formation in such case is more attributed to children, as their parents tend to create the conditions of abundance in every aspect of life.

Methods and materials. In order to analyze the current situation with nutrition patterns, it was decided to conduct the survey among the students of the National Aviation University. They were offered a special questionnaire, which included the following questions:

1. What best describes your diet? Options are: vegan, vegetarian, omnivore, carnivore, top of the food chain (the difference from carnivore is in the amount of meat consumption – once a day or at every meal).
2. Where do you obtain most of your food? Options are: farmers markets, natural foods markets, supermarkets, restaurants, fast foods or take-outs and their combinations.
3. How often do you select foods that are certified organic or sustainable? Options are: most of the time; sometimes; almost never.
4. Which choice best describes how much you normally eat? Options are: one large meal and light snacks per day; two large meals and several snacks per day; three large meals and several snacks in between.
5. Do you have a garden or share one to grow your own vegetables and herbs? What is the approximate size of your garden plot?

The questioning was conducted during the classes on Fundamentals of Ecology and included students of various backgrounds.

Results analysis. In the course of the survey 698 students from the 1st to 4th year of study were asked about their

type of diet, and the ecological footprint of each individual student, and generally all students were defined.

In processing the data, it turned out that most of the students buy food in supermarkets (because of the cost and availability), and not on farmers markets or natural food markets (which sometimes offer more expensive food and are distant from central parts of the city). The most of the questioned people does not consume organic food products: the percentage of those who constantly buy such products (20 %) is nearly three times (2.65) less than those who almost never take it (56 %). As for the daily food regime in most cases it includes two or three major meals, including a snack, and organic food. So, using the approaches developed by Bonhommeau and his colleagues the food footprint 14 % are defined as 3.3 gha due to meat loving, 34 % also consume lots of meat and need 2.8 gha, 49 % take 2.5 gha, vegetarians make up only 3 % with 1.7 gha and vegans with 1.5 gha are very rare (only 0.28 %).

Ecological footprint is also represented in shares by biomes, with calculation of pasture land footprint, marine fisheries footprint, forestland footprint and cropland footprint. From this point, cropland and pasture are the major constituents of the food footprint, while fishing zone is not much involved. Forestland is also considerable one as we need to account transportation of food and trend to buying prepared food and fast food.

Interestingly, the statistical average for the country is 2.12 global hectares, which means that young people are feeding at more protein-rich diet. To make data more visual we can state, that if everyone used diet typical for top predators or carnivorous organisms in combination with carbon and housing footprint we would need over 2 planets to provide our needs, while the typical omnivorous diet would lead to usage of 1.5–1.8 planets.

Perspectives of food footprint reduction. The most controversial issue in relation to food footprint is the potential of environmental impacts reduction if people change their diet to become vegetarians. The results of modeling have showed that the emissions of harmful gases into the atmosphere from the food industry would be reduced by 60 % (Temme et al., 2013). And if everyone becomes vegan, emissions will be reduced by approximately 70 % (Pimentel and Pimentel, 2003; Tukker et al., 2011).

Food production, especially livestock, also takes a lot of territory. Together with harmful emissions, it destroys the natural diversity of species. With five billion hectares of agricultural land in the world, 68 % is used for livestock (Gerbens-Leenes and Nonhebel, 2010). If everyone shifts to vegetarian diet, 80 % land could be restored to meadows and forests will be able to absorb carbon and mitigate climate change. The recovered grasslands are restored habitats for populations of animals under the threat of extinction, such as wolves or buffalo (Gerbens-Leenes and Nonhebel, 2010).

Sprinhmann computer modeling shows that vegetarian diet would also contribute to the reduction of chronic diseases morbidity by 2050; mortality could also decrease by 6–10 % mostly by reducing cases of coronary heart disease, diabetes, stroke and certain cancers. Fewer chronic diseases related to diet, mean reducing medical bills, saving about 2–3 percent of global GDP (Tukker et al., 2011).

But in order to obtain these hypothetical benefits, meat products should be replaced with products, having equivalent nutritional value. Animal products contain more calories to nutrient substances than basic vegetarian food – corn and rice. Therefore the right choice of substitutes will be crucial, especially for those people who are undernourished, and their number in the world today is more than two billion (Pimentel and Pimentel, 2003; Tukker et al., 2011). At the same time, it is hard to say, whether the vegetarian civilization is able to support itself accounting the need to increase the intensity of soils exploitation for growing crops and combat the corresponding erosion and desertification. Likewise, the dependence on climate and weather conditions is higher for plants yield, that that for animal food production. And there arrives a new controversial issue – the need to introduce new genetically modified plants to provide stable levels of harvest.

So, in our opinion, more critical question now is how to prevent losses of food, since a huge amount of resources are spent on its production.

According to the data of the Food and Agriculture Organization of the United Nations (FAO) in 2015, the world volume of spoiled food is 1.5 billion tons in the initial equivalent of the product, and the edible part of this is up to 1.3 billion tons, including 44 % – vegetables and fruits; 20 % – fish and seafood; 19 % – cereals; 8 % – dairy products; 4 % – meat production; 3 % – oil seeds and legumes (Living Planet Report 2016).

The hydrocarbon trace from produced and discarded food reaches 3.3 billion tons of CO₂ per year. The total amount of water spent on the production of unused food (250 km³) is equivalent to an annual runoff of the Volga River or three times the volume of Lake Geneva (Living Planet Report 2016). Similarly, 1.4 billion hectares of land (28 % world's agricultural land) annually work on the production of wasted food (Bonhommeau, 2013).

Developing countries suffer from food losses (44 %) at the production stage, while medium and wealthy regions have the largest food waste (56 %) at the retail consumer level. Direct economic costs from lost food (in addition to fish and seafood) reach 750 billion US dollars per year (Bonhommeau, 2013).

Conclusions. In environmental studies very little attention is paid to ecological effects of food production and consumption. However, the effects on the environment are dramatic and the results of the survey show that youth is not going to change something and the situation will get even worse. Thus, the questioning has showed that most of the students follows rich in protein diet types and are not willing to change it by switching to another diet types. As this trend is established for younger generation we may assume that in the future the pressure on the environment from food production and consumption will grow in Ukraine, especially accounting the tendency to increase the volume of food consumed and level of its exotics with increasing personal incomes. Immense information and educational efforts are necessary to change the stereotypes and make people more environmentally responsible in the questions of food consumption.

Moreover, it is impossible to shift to vegetarian diet completely, as it would mean the need to further expansion of agricultural lands, which are already almost totally

involved in active production process in Ukraine, or ban on export of food products to provide internal needs. However, there is a range of actions able to bring considerable benefits both for humans and for the environment. The first and the easiest is to buy local and seasonal food; buy as much food as one can eat; buy and cook food in moderate volumes to prevent its spoiling during storage; buy fewer products in cellophane and plastic packaging; adjust diet to age and physical activity during the day; make the diet as much plant based as possible: it is enough to exclude beef from the diet to get reduction of footprint by 42 %.

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АНАЛИЗ ЭКОЛОГИЧЕСКОГО СЛЕДА ОСНОВНЫХ ТИПОВ ПИТАНИЯ

Рассмотрены проблемы формирования воздействий сельскохозяйственного производства на окружающую среду с учетом основных типов питания населения. Освещены основные научные данные по экологическому следу питания человека. Проанализированы основные типы рациона, присущего людям на современном этапе развития общества, и его особенности в Украине. Установлено, что максимальное влияние на окружающую среду связано с производством продуктов питания животного происхождения. Проведено исследование режима питания среди студенческой молодежи и выявлено преобладание диеты, богатой мясными продуктами в сочетании с низким вниманием к вопросам экологичности всех групп пищевых продуктов. По результатам исследования установлена низкая мотивация к изменению типов питания на более сбалансированные. Установлено, что в данных условиях образовательные и административные усилия следует направить на сокращение потерь пищевой продукции при ее реализации и потреблении. Рассмотрены перспективы сокращения воздействия на окружающую среду в сельскохозяйственном секторе за счет перехода на рацион питания с большим долевым участием продуктов растительного происхождения. Выявлены основные проблемы на пути реализации данной инициативы в Украине. Предложены основные направления пропагандистской работы по внедрению в культуру питания поведенческих схем, способствующих сокращению нагрузки на окружающую среду.

Ключевые слова: биопродуктивность; влияние сельского хозяйства на окружающую среду; трофический уровень человека; экологический след рациона; потеря продуктов питания.

АНАЛІЗ ЕКОЛОГІЧНОГО СЛІДУ ОСНОВНИХ ТИПІВ ХАРЧУВАННЯ

Розглянуто проблеми формування впливів сільськогосподарського виробництва на навколишнє середовище з урахуванням основних типів харчування населення. Висвітлено основні наукові дані щодо екологічного сліду харчування людини. Проаналізовано основні типи раціону, притаманного людям на сучасному етапі, та їх особливості в Україні. Встановлено, що максимальний вплив на довкілля пов'язаний з виробництвом продуктів харчування тваринного походження. Досліджено режим харчування серед студентської молоді та виявлено переважання дієти, багаті на м'ясні продукти у поєднанні з низькою увагою до питань екологічності всіх груп харчових товарів. За результатами дослідження встановлено низьку мотивацію до зміни типів харчування на більш збалансовані. З'ясовано, що за таких умов освітні та адміністративні зусилля потрібно спрямувати на скорочення втрат харчової продукції під час її реалізації та споживання. Розглянуто перспективи скорочення впливів на довкілля у сільськогосподарському секторі завдяки переходу на раціон харчування з більшою часткою продуктів рослинного походження. Виявлено основні проблеми на шляху реалізації цієї ініціативи в Україні. Запропоновано основні напрями пропагандистської роботи щодо впровадження у культурі харчування поведінкових схем, що сприяють скороченню навантаження на навколишнє середовище.

Ключові слова: біопродуктивність; вплив сільського господарства на навколишнє середовище; трофічний рівень людини; екологічний варто раціону; втрата продуктів харчування.