“PLANT AND ANIMAL BASED AGRICULTURE WITHIN ENVIRONMENTAL SUSTAINABILITY”

By

Alena Zhadanava

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

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Committee in charge:

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ABSTRACT

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The problem investigated in the current thesis is the one of the environmental degradation throughout the world as well as possible innovative solutions that can contribute to the environmental sustainability. However, a different approach that has been taken in this regard, is dealing with livestock production, the main reason for which is providing meat and dairy products to ensure food security. In its turn, livestock has a major impact on the environment, in particular, deforestation, land degradation, water depletion and pollution as well as air pollution by the major agricultural GHG associated with livestock production, in particular methane (CH_4) and nitrous oxide (N_2O), which subsequently makes a big contribution to climate change.

The author believes that shifting mainly to the plant based agriculture and subsequently to the plant food consumption or vegetarian life style contributes to the environmental sustainability, in particular, the decreased amount of GHG emissions due to decreased livestock based agriculture, as well as a subsequent decreased consumption of the natural resources such as land and water.

The author intends to conduct a regression analysis on a comparative basis focusing on major big and small meat producing countries. While analyzing the impact from livestock production and plant based agriculture, the author uses the data from Food and Agricultural Organization (FAO) in terms of amounts of GHG released through such animal and plant agriculture processes as livestock production – cattle, sheep and goats, pigs, poultry, as well as vegetables and cereal production, and fertilizers application, etc., and it is expected to prove the prevailing efficiency of plant based agriculture. Although there have been studies carried out regarding both types of agriculture, there are still blank areas filled with doubt and skepticism about plant based agriculture being more environmentally sustainable. Therefore, there is an intention in this research to undertake an analysis regarding the production in both types of agriculture as well as show that big meat producing countries are significantly more CO_2 intensive in comparison with small meat producing countries, which will eventually signify that this is meat production that is particularly detrimental in terms of CO_2 emissions in agriculture.

It is important to emphasize the significance of finding innovative and productive solutions in order to slow down the environmental degradation. This is where plant based food production and eventually shifting to plant based food consumption and vegetarian diet approach comes into place shedding light on how changing eating habits can significantly improve the environment and contribute to its sustainability.

For the Planet. For the People. For the Animals.

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First and foremost, I express my appreciation to KDI School of Public Policy and Management for the priceless opportunity to study and be among professional and experienced people from all walks of life.

I would like to extend my deepest gratitude to my research supervisor, Professor Tae Yong Jung, for his support and genuine interest in my thesis, for guidance and the posed challenges, without which it would have been next to impossible to complete the present dissertation.

I would also like to thank the academic staff for their professionalism and support they were always willing to provide, especially Professors Cho Dongchul for his encouragement and patience in grasping the Quantitative methods, Professor Lee Yong Shik, for his motivation in undertaking challenging aspects.

This dissertation would not have been possible without my parents' support and belief in me. They instilled strong values in me and the ongoing willingness to learn and contribute.

I would especially like to thank my friends I met during KDI School experience. In particular, Vyshnevskyi Iegor, for his reliability, support, and encouragement, Dina Suleimanova and Elina Akhtiyarova, for being there for me, my European classmates Vladisav Potezica and Djurdja Djurisic for their friendship and interest.

I am thankful to all those people around the world who are willing to make life on our planet better, to all those who are striving for environmental sustainability and sustainable development, to the ones who are struggling to find solutions to global issues such as climate change, environmental degradation, food insecurity, and animal rights. I am thankful to the ones being skeptical about plant based agriculture and vegetarianism as a life style, as it motivates even more interest in exploring the ways to show how beneficial the transition to this type of agriculture and particularly vegetarian diet could be for all living beings and overall environmental sustainability on our planet.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

GHG – Greenhouse Gases

FAO – Food and Agriculture Organization

UNEP – United Nations Environmental Program

CO_2 - Carbon dioxide

CH_4 – Methane

N_2O – Nitrous oxide

1. INTRODUCTION

With a rapid growth of environmental issues, such as *climate change, land use and degradation, deforestation, habitat destruction, water and air pollution*, etc. the situation on the planet has been gradually deteriorating. It is important to note however, that there is one common feature that might be traced among the above mentioned issues. In particular, the fact that they are all related to the *anthropogenic effect* on the natural environment, stands indisputable. If we indeed are willing to reduce the human impact on the environment, then there is a need to look at the core of the issues and analyze their causes from different perspectives.

It is common knowledge that nowadays humans have developed a number of ways to improve their wellbeing that at the same time provoke deterioration of environment. It is obvious that such human activities as energy supply, industry, forestry, agriculture, transportation, commercial and residential buildings, waste and wastewater are playing a crucial role in emitting greenhouse gases (GHG). Those GHG can be classified as Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Fluorinated gases (F-gases). While CO_2 is considered to be one of the most destructive GHG, being mostly responsible for major climate change issues [1], however it is noteworthy that other GHG might bring in even more destructive impacts, such as methane produced by livestock in agriculture which is estimated to be 21 times more powerful than $CO_2$4. And this is where agriculture is actually bringing its major contribution.

Since one of the most burning issues nowadays is the one dealing with the environment and its degradation, it is eventually, inseparably connected with the climate change. Although numerous articles have been published, many conferences have been held regarding these issues, however, little action has been taken. Even though the major challenge has been

[1] Goodstein, Eban S. *Economics and the Environment*, 6th edition. USA, 2011.

identified as the exceeding amount of carbon dioxide (CO_2) emissions in the atmosphere, however the ways on combating this issue are various and opinions differ.

Although the author of the present study has an attempt to discuss, research and analyze the problem of increasing CO_2 emissions and environmental degradation, however the approach is rather different from the commonly undertaken one. In particular, the author is focusing on the agriculture as the main contributor to the GHG emissions. To be exact, the different outlook that has been taken in this regard, is investigating two types of agriculture – animal based (*livestock* is the main focus) and plant based (*plant cultivation* is the main focus), which in the long run is dealing with livestock and plant production, the main cause of which is providing meat, dairy, and plant products to ensure food security. In its turn, livestock and plant production both have a certain impact on the environment, in particular, deforestation, land degradation, water depletion and pollution as well as air pollution by the major agricultural GHG associated with livestock production, in particular methane, and nitrous oxide, referred to fertilizers in plant production. Such side effects of the agricultural practices as the ones mentioned above, subsequently lead to a big contribution to climate change in a negative way. However, the questions and assumptions still rise in terms of which type of agriculture, animal-based or plant-based, is more destructive to the environment. Although there is quite a number of studies being done pointing out that animal based agriculture is more destructive than the plant based, however the doubts and uncertainty still appear in this regard. In this light, the author is aiming at testing practically the existing assumptions, therefore the following hypotheses are to be focused on.

Research hypothesis

The hypothesis that has been taken in this dissertation can be presented as follows:

- *animal based agriculture has a significantly bigger environmental impact than plant based agriculture.*

Considering the fact that animal agriculture is developed in order to cater for the animal based diet, the author is drawing a parallel between plant agriculture and vegetarian diet, and in similar vein relating to the animal based diet. In order to show how significant the effect from animal agriculture is, the author set out to investigate and eventually compare big and small meat producing countries. Therefore, there is another hypothesis arising:

- *big meat producing countries significantly contribute to the environmental degradation in comparison with small meat producing countries.*

In case of proving these hypotheses the author is likely to confirm the validity of the existing assumptions that shifting to the plant based agriculture, contributes to the environmental sustainability, through saving water, land and specifically decreasing the amount of GHG released, thus contributing to the climate change reduction. However, the author intends to draw a link between plant based food production and vegetarian diet as the two are interrelated, and point out that in case of shifting towards the vegetarian diet there will be less animal based agriculture, and assumingly more plant based one, eventually decreasing the negative environmental impact.

In order to pursue this hypothesis and show the benefits of the plant based agriculture over the animal-based one, we need to identify the amount of GHG produced through the livestock agriculture, and the amount of identical GHG produced in the crop production. In similar vein, we need to trace the land and water presumably required for the livestock production, considering the fact that there is the land not only for the pastures that is needed, but also for crop production in order to feed the livestock. In addition, the author intends to touch upon the food security in terms of whether vegetarian diet can contribute to the larger food production than the animal based diet.

It goes without saying that the idea of *food security* is one of the main incentives for agriculture. The definition of food security is based on establishing balance between the

demand and supply of food. It is worth pointing out that food demand is correlated with food consumption patterns, hence food preferences and particular diets may eventually be responsible for the agriculture development with subsequent production and eventual environmental impact. Food demand influences agricultural production and a number of studies have shown that it eventually results in polluted soil, air, and water, as well as eroded soil, and loss of biodiversity. As the population keeps growing and by 2050 it is estimated to be about 9.6 billion[2], in the direct proportion food production, with a particular focus on meat production, keeps growing as well. To point out, these are developing countries that start playing a particular role here. If this trend continues to be working as business as usual, then the planet resources, environment and overall wellbeing is going to suffer increasing losses[3].

"A statement of significance":

It is eventually critical to emphasize the importance of finding innovative and productive solutions in order to slow down the environmental degradation. In case our both hypotheses hold true and plant based agriculture (plant based food production) does contribute to the overall sustainability rather than degradation as in the case of livestock agriculture, then there is a need for the policy makers to start taking into consideration a detrimental impact from the worldly perceptions regarding the necessity of animal based food consumption in order to ensure sustainability including the food security issue.

[2] UN Press Release. Embargoed until 13 June 2013.
http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2012_Press_Release.pdf
[3] OECD. *Better policies for better lives, Towards Green Growth*. 2011
http://www.oecd.org/greengrowth/48224539.pdf

2. LITERATURE REVIEW AND CONSIDERATIONS

2.1.Agricultural pressure on the world's resources

It is crucial to note that agricultural sector particularly depends on natural resources for its production processes, which eventually contributes to environmental harm.[4]

When talking about agricultural impact on the environment it is important to focus on the greenhouse gas emissions produced by agricultural practices. The three main GHG of concern are methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). Although there are positive effects of the agricultural GHG such as being the source of the nutrients and a soil amendment to improve soil quality and productivity, however this is the negative impact which is brought attention to further.

The World Bank data provides us with the numbers regarding methane and nitrous oxide emissions in the process of agricultural activity. Agricultural methane emissions are referred to as emissions from animals, animal waste, rice production, agricultural waste burning (non-energy, on-site), as well as savannah burning. According to the provided data, agricultural methane emissions range from 0.3 to 91.1% of overall methane emissions around the world[5]. There is no direct parallel that could be drawn between the developing and developed countries' agricultural methane emissions, in other words, it is not clear-cut to state that the less developed are the countries the more agricultural methane they should be accountable for. For comparison, it is good to bring to attention the World Bank data regarding the agricultural methane emissions (% of total). It is possible to trace that those are mainly developing countries like Argentina (72.1%), Bangladesh (68.3%), Brazil (73.8%), Cambodia (60.9%), India (60.8%), Mongolia (78.1%), as well as some African countries, such as Ethiopia (70.5%),

[4] FAO. *Greening the Economy with Agriculture*. Swiss Confederation. 2012. http://www.fao.org/docrep/015/i2745e/i2745e00.pdf

[5] The World Bank Data on natural and man-made environmental resources. http://data.worldbank.org/topic/environment

Namibia (91.6%), Sudan (85.8%). However, there is also a number of developed countries that are characterized as big methane emitters, such as Australia (53%), Ireland (78.4%), Luxembourg (82.7%), New Zealand (90.3%). To this end, it is noteworthy that both developing and developed countries are responsible for the methane emissions with regards to the agriculture, which serves both as a food security source as well as the economic growth driving force.

As far as agricultural nitrous oxide emissions are concerned, most of the countries producing those GHG are also the ones that are under the biggest agriculture methane emitter umbrella. In particular, Argentina (92.2%), Australia (81.3%), Bangladesh (84%), Brazil (79.5%), India (72.8%), Ireland (91%), Mongolia (93.4%), Namibia (93.2%), New Zealand (94.9%), Sudan (86.5%), Ethiopia (86.5%) are also characterized as big nitrous oxide emitters[6]. At this point we could conclude that the countries focusing on agricultural industry whether because of the food security or economic growth reasons, are the biggest contributors of such damaging GHG as methane and nitrous oxide.

It is important to note that those are agricultural GHG from *soil management, enteric fermentation, livestock, manure management, fossil fuel consumption, forest management practices* that are affecting environment most.

As far as agricultural soil management is concerned, the use of *synthetic and organic fertilizers* particularly adds nitrogen to soils, eventually increasing natural emissions of nitrous oxide emissions (N_2O).

Regarding the enteric fermentation, this is the cattle that is responsible for a great amount of GHG emissions. Methane is usually produced as part of the typical digestive process in animals and through the enteric fermentation is resulting as a by-product emitted through

[6] The World Bank Data on natural and man-made environmental resources. The indicators relevant to the GHG. http://data.worldbank.org/topic/environment

exhaling and belching of animals[7]. Above that, the livestock affects the carbon balance of land used for pasture and feed crop, which eventually indirectly contributes to releasing large amounts of carbon into the atmosphere.

In the case of manure management it is known that manure releases GHG (in particular, CH_4) in the process of decomposition. The quantity of gases released keeps increasing, unless there are proper manure management methods implemented[8].

It is interesting to note that in terms of fossil fuel consumption, agricultural production requires those fossil fuels usage which eventually accounts for nearly eight percent of the overall emissions from agriculture[9]. That subsequently leads to CO_2 emissions through combustion of gasoline and diesel fuel.

It is common knowledge that in the agricultural sector, productivity has grown rapidly as a result of the increased use of modern inputs including irrigation water, fertilizers, pesticides, and machinery[10]. However, along with those agriculture practices one can witness a number of negative consequences, such as deforestation, water depletion, fish stock depletion, soil degradation, affecting health and leading to biodiversity losses, all of which are the results of the above mentioned practices.

It is argued, that at present there are five main groups of people with different views of the future agricultural development. Those are business as usual optimists, environmental pessimists, industrial-world-to-the-rescue group, new modernists, and the group arguing for

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[7] Food and Agriculture Organization of the United Nations. *Tackling Climate Change Through Livestock: a global assessment of emissions and mitigation opportunities.* Rome, 2013 http://www.fao.org/docrep/018/i3437e/i3437e.pdf

[8] Farm Foundation Issue Report. *Agriculture, Forestry and Greenhouse Gases.* Research provides insights for public policy. USA, September, 2005. http://www.farmfoundation.org/news/articlefiles/105-Sept05_IR_9_14%20Revison%20II.pdf

[9] Earth Save International is a California non-profit agency committed to serving individuals and families in need. Known for *Meals for Health* program. A new global warming strategy. http://www.earthsave.org/globalwarming.htm

[10] Global Harvest Initiative. GAP Report. *Measuring Global Agricultural Productivity*. 2011. http://globalharvestinitiative.org/GAP/GHI_2012_GAP_Report.pdf

sustainable intensification of agriculture[11]. While the ways those groups of people are referred to might be different, one thing unites them all, and this is the impact agriculture brings to the environment.

According to Hazell[12], development of agriculture should simultaneously contribute to four principal goals: food security, growth, poverty reduction, and sustainable natural resource management. However, there also has to be pointed out that by no means agriculture development should contribute to the environmental degradation, just on the contrary, it should provide options for the environmental sustainability and conservation. As it is pointed out in the recent FAO report on "Greening the Economy with Agriculture"[13], it is the agricultural sector that will be playing a vital role in the transition to a green economy. However, this intention is not only about good management practices that can result in decreasing GHG[13], it also comes down to changing a traditional pattern of food security provision. In particular, a typical agricultural sector would consist of crops, forestry, fisheries, and livestock. However, it should be considered, that this is the livestock that is in fact the biggest contributor to the land degradation, climate change, air pollution and water shortage, water pollution and loss of biodiversity, and, according to the FAO report, on Environmental Issues and Options[12], there should be major policies elaborated to deal with such an issue. Therefore, there is a need for a new outlook on the livestock sector, in particular, whether it could be reduced, or there might be other options alternative to this sector development. However, this point will be visited again later on in connection with the livestock as an agricultural sector.

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[11]FAO. Animal Production and Health Division. *Greenhouse Gas Emissions from the Dairy Sector. A Life Cycle Assessment.* 2010. http://www.fao.org/docrep/012/k7930e/k7930e00.pdf

[12] FAO – LEAD. *Livestock's Long Shadow. Environmental Issues and Options*. 2007. http://www.europarl.europa.eu/climatechange/doc/FAO%20report%20executive%20summary.pdf

[13] FAO. *Greening the Economy with Agriculture*. Swiss Confederation. 2012. http://www.fao.org/docrep/015/i2745e/i2745e00.pdf

There is a new priority under discussion for environmental sustainability that has emerged since the 1990s, and it stresses the importance of those agricultural practices that do not degrade the environment[12]. In the meantime it is argued there that there are two fundamentally different types of environmental problems to be associated with agriculture. The first type arises in intensive farming systems and is associated with the misuse of modern inputs, for example, irrigation water, pesticides, and fertilizers. The second type is about extensive farming systems and it is referred to rapid population growth, poverty and growth in agricultural productivity, which is insufficient to meet the increasing need for food and livelihood. It is worth pointing out here, that the first type is a subsequent result from the issues specified in the second type. The key question however is how to meet through agriculture the growing demand for food and livelihood and at the same time to be able to practice it in a sustainable and environmentally friendly manner.

It becomes more obvious that continued agricultural growth is not viewed as an option, but rather a necessity for most developing countries. Furthermore, this growth must be achieved on a sustainable basis so that not to jeopardize natural resources, and at the same time it has to be equitable in order to contribute to the alleviation of poverty and food insecurity[14].

When talking about agriculture and the impact on the environment, there is a need to focus on the tradeoffs between its growth and environmental objectives. As it has been mentioned above, along with the negative impacts of the agricultural practices there are also positive ones that need to be pointed out. In particular, some resources are renewable (trees, soil nutrients) or they might have substitutes (for example, farm trees can replace woodlands for fuel wood), which eventually signifies that they need not all to be preserved at current levels or at all points in time. However, if to compare the environmental benefits and the destructive elements of the agriculture, the balance remains far from being reached.

[14] FAO. Policy brief. *Food Security*. issue 2, June 2006. ftp://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf

It is also important to pose a question regarding the level at which environmental costs and benefits could be measured. In particular, levels of environmental degradation that may be considered acceptable to the farmers and rural communities may be totally unacceptable at the national and international levels, should the externality costs be significant. Once important international externalities are involved, international and global assessments are also required, such as impacts of agriculture on global climate change makers.

It is worth pointing out that recently organic agricultural practices have been broadly discussed. Although there is a number of mitigation strategies suggested such as modification of livestock and cropland management, in particular feed management, fertilizer use, crop selection and water management[15], however they are not able to reduce significantly the emission of the agricultural GHG per se. Another point to consider is as follows: in case of being implemented, are those measures still enough in order to sufficiently reduce the negative impact on the environment? It is of paramount importance to consider alternative ways to diminish the detrimental effect caused by agriculture, however not through mitigation options, rather through elimination of GHG from the source of emission. One of the directions to look at is livestock as playing the major part in releasing GHG through the worldwide agriculture practices.

[15] Farm Foundation Issue Report. *Agriculture, Forestry and Greenhouse Gases.* Research provides insights for public policy. USA, September, 2005. http://www.farmfoundation.org/news/articlefiles/105-Sept05_IR_9_14%20Revison%20II.pdf

2.2.Livestock as an agricultural sector: major threat to the environment

"Livestock sector is one of the two or three most significant contributors to the environmental degradation".

Steinfield et al. [16]

As it appears from the above statement, one of the contributors to the most serious environmental problems appears to be the livestock sector. Recently the livestock as well as agriculture as a sector in general have been increasingly drawing significant attention from major global organizations, such as the United Nations Food and Agriculture organization, United Nations Environmental Program, United Nations Development Program, World Bank (when talking about the food security problem), etc. This, in its turn, signifies the growing, if not critical, importance of the livestock sector's impact on the environment, which needs no procrastination in addressing.

In similar vein, the FAO report "Livestock's long shadow: environmental issues and options"[17] claims that *livestock* production is a major contributor to the world's environmental problems, contributing about *18% to global anthropogenic GHG emissions*. This has been the most publicized finding in the FAO's reports specifically pointing out the role which animal agriculture plays with regards to the climate change. In addition, FAO asserts that the global *dairy sector* contributes with *3.0%-5.1% to total anthropogenic GHG emissions*[18].

[16] A well-fed world is a hunger relief and animal protection organization working with grassroots groups in the US. And internationally on feeding and food production programs. http://awellfedworld.org/globalwarming/longshadow

[17] Food and Agriculture Organization in the United Nations, 2006, *Livestock's Long Shadow: Environmental Issues and Options,* http://www.fao.org [Accessed on September 2013]

[18] GGELS project. European Greenhouse Gas emissions from Livestock Production Systems. LPS Regional zoning for the survey of related manure management practices. European Commission 2008.

There is the term "livestock revolution" that has been assigned to the rapid expansion of livestock production in developing countries[19]. The growth of production is generally driven by demand, which in its turn is caused by population growth, urbanization as well as income growth in developing countries. Although livestock production is growing, however such problem as world hunger still appears to be an important issue. In fact, in 2012 the United Nations Food and Agriculture organization estimated that nearly 870 million people, in other words, one in eight people in the world, were suffering from chronic undernourishment 2010-20124.

It is considered that the most important non-CO2 greenhouse gas is methane (CH4), and the number one source of methane worldwide is animal agriculture. Methane is assigned to be 21 times more powerful than CO_2. It is also noteworthy to draw a parallel in terms of GHG emissions related to the livestock sector, in particular, carbon emissions account for only about 9%, whereas nitrous oxide (N_2O), mainly from fertilizer use and all waste management systems related to the manure applied to agricultural soil, and CH4 emissions (related to fermentative digestion by ruminant livestock, residue/manure management) represent 46 and 45% respectively. In many developing countries, agriculture accounts for the majority or a major share of national GHG emissions. For example, in Australia in 2009 agricultural share in CO_2 accounted for 60%, in Pakistan up to 81%, etc. According to the HSUS, and the data from the US Department OF Agriculture (USDA) and the EPA, animal feeding operations produce approximately 500 million tons of manure every year[20]. One of the astonishing facts estimated by the EPA is that "all confined animals generate 3 times more raw waste than is generated by humans in the US". In similar vein, it is outlined in the report that "the continuous confinement

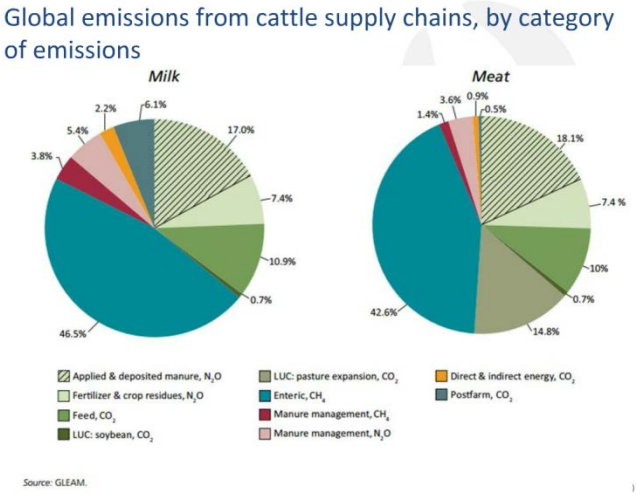
[19] U. Pica-Ciamarra, J.Otte. Pro-Poor Livestock Policy Initiative, A living from Livestock research report. The *'Livestock revolution' Rhetoric and Reality*. November 2009. http://www.fao.org/ag/againfo/programmes/en/pplpi/docarc/rep-0905_livestockrevolution.pdf

[20] The Human Society of the United States. An HSUS report: the *Impact of Industrialized Animal Agriculture on the Environment.* https://dornsife.usc.edu/assets/sites/1/docs/levan/hsus-the-impact-of-industrialized-animal-agriculture-on-the-environment.pdf

of chickens, pigs, turkeys, cattle, and other animals raised in industrialized agricultural systems jeopardizes the animals' welfare", which eventually degrades the environment. Furthermore, factory farms produce immense quantities of animal waste and byproducts, which damages water and air quality and subsequently contributes to climate change.

It is interesting to bring the following information to our attention (Table 1). In particular, where we could see the global emissions from cattle supply chain taking into consideration the category of emissions [21]

Table 1



The above table provides statistics regarding the fact that the largest share of GHG in the animal based production belongs to methane, the major source of which is enteric fermentation.

There is also a need to point out that apart from the environmental destructive impact, livestock production and subsequent consumption brings a negative health impact. In particular, there are a number of animal diseases that are associated with increasing intensity of production and concentration of animals on limited space. Many of those diseases pose a threat to human health, such as zoonotic disease, IndNippah, Avian flu, etc., eventually leading to

[21] FAO. *Tackling Climate Change through Livestock. A global assessment of emissions and mitigation opportunities.* 2013. http://www.fao.org/docrep/018/i3437e/i3437e.pdf

public health consequences[22]. On the top of all that, animal products from intensive production systems tend to have higher residue contents. However, this issue will be revisited further while discussing the necessity for a new outlook regarding the food security and human wellbeing.

When talking about animal agriculture, this is the cattle which is an important source of CH_4 in many countries because of their large population and high CH_4 rate due to their ruminant digestive system. In general, the amount of CH_4 released mainly depends on the type of digestive tract, age and weight of the animal. In this regard, ruminant livestock (e.g. *cattle, buffalo, sheep, goats*) are major sources of CH_4. As it has been mentioned above, methane emissions are produced in the process of manure management and decomposition of manure during storage and treatment. Besides that, manure along with waste management are related to the geographical concentration of livestock in areas with little or no agricultural land, which subsequently leads to high impacts on the environment including water, soil, air and biodiversity.

To support the above mentioned, it is useful to bring the following chart into discussion (Table 2).

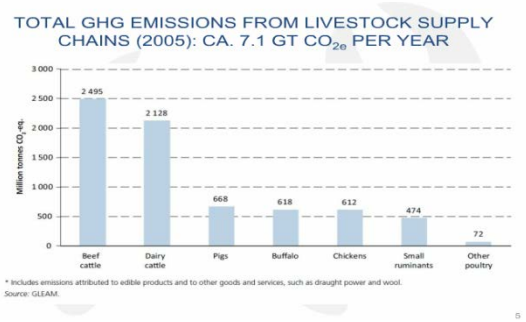


Table 2

[23]*Source: FAO 2013*

[22] UNEP Global Environmental Alert Service (GEAS). Written by Stefan Schwarzer, October 2012. https://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=92

[23] FAO. Animal Production and Health Division. Greenhouse Gas Emissions from ruminant supply chains. A global life cycle assessment. 2013. http://www.fao.org/docrep/018/i3461e/i3461e.pdf

As we can see, the biggest share of the GHG from the livestock sector belongs to the cattle, both for beef and dairy purposes. That, in turn, is aligned with the fact that this is manure management and enteric fermentation which are the main drivers of the CH_4 emissions from the livestock sector in agriculture.

While it is important to know the fact that GHG emissions are vastly released due to a number of agricultural, in particular, livestock related practices, however it is crucial to specify the emission sources themselves. According to the GGELS project, there are a few main GHG emissions sources, such as:

a) on-farm livestock rearing including enteric fermentation, manure deposition by grazing animals, manure management and application of manure to agricultural land;

b) cultivation of organic soils, and feed production including application of mineral fertilizer;

c) on-farm energy consumption related to livestock and feed production and subsequent energy consumption for the transport and feed procession. Another important aspect regarding the livestock farming is the expenses resulting in veterinary products and services.

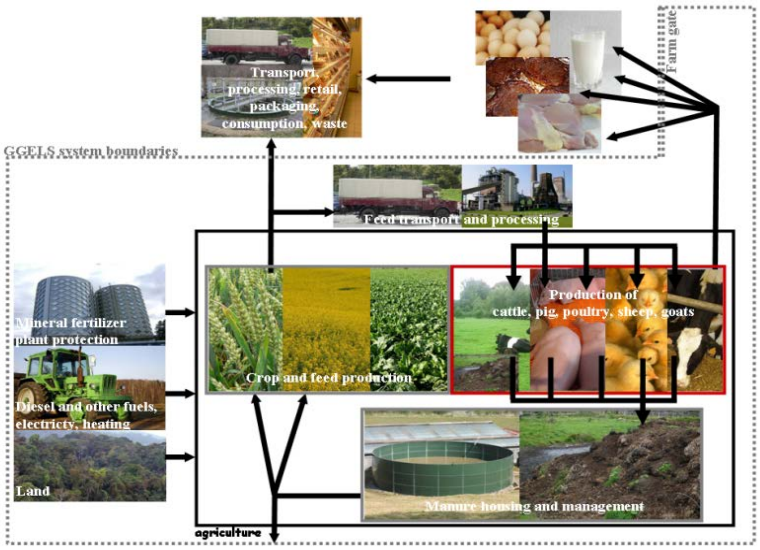
In this respect, there is a need to point out that the animal agriculture is mainly dealing with the following main food productive species: beef cattle, dairy cattle, small ruminants (sheep and goats), pigs, and poultry. And this is self-explanatory, for, the demanded and most consumed animal products are meat (beef, pork, poultry, and meat from sheep and goats), milk (cow milk and milk from sheep and goats), and eggs. Eventually, in order to produce the above mentioned products there is a chain of agricultural activities performed, that are referred to as GHG emissions (CH_4, N_2O, and CO_2) sources. These activities were identified as a result of GGELS project[18,] the final goal of which was to evaluate the livestock's sector contribution to the EU GHG emissions. In order to gain deeper understanding regarding the agricultural

activities responsible for GHG emissions, we will specify particular GHG related to each agricultural process:

- *enteric fermentation* - CH_4; livestock excretions such as manure management, depositions by grazing animals - CH_4, N_2O; *manure application to agricultural soils* - N_2O; *use of fertilizers for production of crops dedicated to animal feeding crops* - CO_2, N_2O; *cultivation of organic soils* - CO_2, N_2O; *emissions from crop residues* - N_2O; *feed transport (including imported feed)* - CO_2; *on-farm energy use (including indirect energy use by machinery and buildings)* – CO_2; emissions *of land use changes induced by livestock activities (feed production and grazing)* – CO_2; *emissions or removals from pastures, grassland and cropland* – CO_2

It is quite noticeable that those are not only directly dealing with livestock sources, like in the case of animals themselves emitting CH_4, it also the indirectly related to the livestock sources, such as use of fertilizers for better crops in order to feed animals, feed transport, etc. According to this data it is not insignificant to point out that the vast majority of agricultural sources emitting GHG are dealing particularly with livestock production and growth. The following table below could clearly specify the major GHG emissions sources in the agricultural perspective.

Table 3: Major GHG emissions sources in agriculture



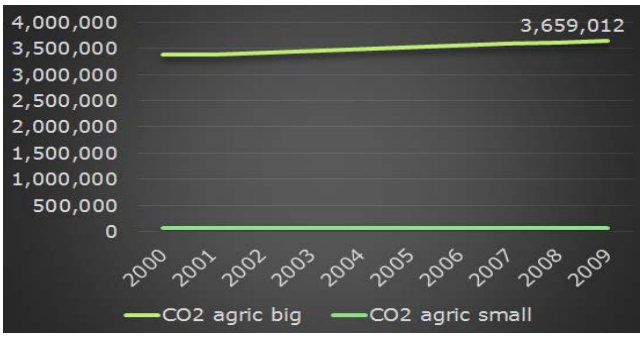
Source: Climate Emergency Institute[24]

For our purposes here it should be noted, that the above mentioned agricultural activities while producing CH_4, N_2O, and CO_2, also significantly contribute to the environment natural resources' degradation. In particular, according to the FAO report on "Greening the Economy with the Agriculture", those are agricultural land, water resources, forest, fish resources, biodiversity, energy resources that are being severely affected by the livestock sector4.

To this end, it is important to note, that the damage caused by the livestock sector is even worsened by the passiveness and ineffectiveness of existing regulations on livestock waste management. It could be explained through the absence of an effective policy framework connecting the environmental concerns and considerations of livestock production or "widespread ignorance of the cumulative environmental impact, as well as public risks and negative externalities associated with the livestock production"4.

In order to give a more clear idea on the role of meat based agriculture in the GHG increase, we will provide a chart below related to big and small meat producing countries and the amount of CO_2 equivalent they release. Further on small and big meat producing countries are described as the ones that are producing fairly small and big amounts of meat worldwide[25].

Table 4: Agricultural GHG emitted in small and big meat producing countries



[24] Climate Emergency Institute is an organization that acts to prevent global and regional climate catastrophe. *Approach to Greenhouse Gases.* http://www.climateemergencyinstitute.com/glemissions.html

[25] World Bank Data providing information regarding environment and related to it indicators, e.g. greenhouse gases.
http://data.worldbank.org/indicator#topic-6

Source: World Bank Data

As we can see above, in big meat producing countries the agricultural CO2 on average from 2000 to 2009 reaches 3,659,012 gigagrams, while small meat producers contribute to 85454 gigagrams increase of CO_2 equivalent.

2.3.Meat consumption within the food security concept

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".

World Food Summit[26]

Around 870 million people (852 million out of which are from developing countries) are estimated to have been undernourished in the period 2010-124. As of May 2006, there were 39 countries in the world that were experiencing serious food emergencies and required external assistance for facing the critical food insecurity: 25 in Africa, 11 in Asia, 2 in Latin America and 1 in Europe .

There are a few dimensions identified within the food security concept, such as: *food availability, food access, utilization, stability.*

According to the World Health Organization, "Food Security" comprises the following meaning:

- "All people at all times have both *physical and economic access* to enough food for an *active, healthy life";*
- "The ways in which food is produced and distributed are respectful of the *natural processes on the earth*, and thus *sustainable"*;
- "Both the consumption and production of food are governed by *social values* that are equitable as well as *moral and ethical"*;
- The food is obtained in a manner that *upholds human dignity*[27]

[26] World Health Organization: *Trade, foreign policy, diplomacy and health*. World Food Summit. 1996 http://www.who.int/trade/glossary/story028/en/

[27] World Health Organization. *Trade, Foreign Policy, Diplomacy and Health. Food security.* http://www.who.int/trade/glossary/story028/en/

In this case, if we try to look at the meat production and consumption within the above food security framework, we can instantly identify the ways where meat-based diet does *not* correspond to the food security understanding. In particular, with the world population increasing, and economic situation worsening due to the recent crisis, the access to the abundant, healthy and nutritious food from an economic point of view is quite limited. Above that, there are many countries that import meat products from big exporters, such as USA, Australia, Argentina, Brazil, etc. However, lately meat import has started shrinking in a number of countries. For example, Vietnam's meat import has increased by 15% in comparison with last year, which is explained by the concern about food safety[28]. Amidst economic uncertainty and global crisis, Singapore government suggesting eating less meat, which eventually contributes to decreased meat import[29]. As we can see, meat doesn't provide available physical and economic access in order to ensure food security in the country.

The next point to consider is sustainability and natural earth process with regards to the meat production. As it was covered earlier, livestock is the cause of such GHG as methane and nitrous oxide. According to FAO (2012)4, about 1.1 billion sheep and almost 1.4 billion cattle all together on the planet contribute to producing 37% of total methane. Considering that methane estimated to be 21 times more powerful than carbon dioxide, it is possible to maintain, that livestock is a big contributor to the climate change. Above that, the agricultural land which is about *one third of total land surface* of the Earth is being used for raising farm animals across the world, not to mention such natural resources as forests, millions of hectares of which are being cut for pastures; water depletion and water pollution, for which production of livestock is responsible. According to FAO (2012)4, agriculture is responsible about 93% for

[28]UkrAgro Consult is an organization in the Black Sea region working with the agricultural markets in the Ukraine and Black Sea region. http://www.blackseagrain.net/about-ukragroconsult/news-bsg/vietnams-meat-imports-shrink

[29]Asia News. *To combat Economic Crisis, government suggests less meat, shorter showers*. 28 January, 2009. http://www.asianews.it/news-en/To-combat-economic-crisis,-government-suggests-less-meat,-shorter-showers-14333.html

water depletion (Table 5)[30]. Livestock is playing a big role in increasing water depletion, as it requires water for drinking and servicing, product processing, as well as feed production in order to raise farm animals, not to mention that it is one of the main causes of water depletion and degradation[31].

Table 5: Water Use and Depletion by Sector

Water use and depletion by sector

Sector	Water use	Water depletion
	(..... Percentages of total .....)	
Agriculture	70	93
Domestic	10	3
Industrial	20	4

Source: Earthly Issues

To this end, land degradation, water depletion and pollution, air pollution and subsequent contribution to climate change – these are all the causes of meat production, which contradicts to one of the stressed by WHO principles of food security: production of food (in our case, meat) is respectful of *natural processes on the earth*, and thus *sustainable.*

In similar vein, food security encompasses the fact that both the consumption and production of food are governed by *social values* that are equitable as well as *moral and ethical*.However, if we take a look at the meat production, there are normally two sorts of opinions regarding meat consumption. First, it is considered to be traditional from the time being, therefore this is part of the culture and it comprises social values. However, if we shift our attention to the ethical aspect, that is where we can find contradiction between meat consumption and moral standards. We basically define ethics as doing what is right morally.

[30] The Ozone Hole Inc. is an organization dedicated to protecting the ozone layer, the climate and the Earth's environment. *Earthly issues: Water Crisis* http://www.earthlyissues.com/watercrisis.htm

[31] Schwarz, H.J. *Water and Livestock. Needs, Challenges, Management Issues*. Faculty of Agriculture and Horticulture. Livestock Ecology Section. http://amor.cms.hu-berlin.de/~h1981d0z/pdf/2006-02-kenia/kabete-lect.pdf.

However, how can we confidently say that eating animals - who feel pain and have the same senses as humans - making them live in cruel conditions, slaughtering them for the pleasure of eating meat, is ethical? This is where many discussions come into place, even though it is hardly possible to deny that producing animals for food is unethical. As we can see, a number of principles of food security, highlighted by WHO, are contradicted with the fact of meat consumption, which therefore, brings us to thinking, that there might be alternatives to it in order to ensure food security, embracing its core principles.

It is worthy to note, that agriculture itself is responsible for providing food security, and no matter whether it is meat based agriculture or the one focusing on the crop cultivation, in this or that way it will affect negatively the environment, although to a different extent. As Tom Paulison put "the planet is getting skinned", where agriculture is that catastrophe that never allows the land to heal. "The moment you out a plow to the soil, you degrade the soil"[32].

However, considering the negative impact brought by meat production across the world, there is a need for a new outlook regarding the livestock production and food pattern in general, a new direction in decision making[33]. There is also a need for new policies and techniques that will be able to redirect the livestock sector towards more sustainable development paths. In this respect, as it was mentioned earlier, policies will have to balance four main objectives that are: food security, food safety, preservation of natural resources, and poverty reduction[34].

Whatever the new food patterns might be further investigated and brought attention to, it is of crucial importance to remember, that despite the increased world food production in the last few decades, the global effort to meet MDG of reducing hunger by half by 2015 appears to

[32] Keith, L. *The Vegetarian Myth. Food, Justice, and Sustainability.* Flashpoint Press. 2009.

[33] Pierre Gerber. *Methane to Markets Partnership Expo. Livestock long shadow. Environmental Issues and options*. LEAP, FAO. 2007.

[34] Pierre Gerber. *Environmental Issues associated with Livestock production intensification in rapidly growing economies: problem statement and identification of policy needs in Asia*. LEAP, FAO, 2005.

be difficult to reach[35]. In fact, the number of people suffering from chronic hunger had increased from under 800 million in 1996 to over one billion in 2010[36]. Therefore, it is urgent to look for new solutions, new path that will eventually bring to human wellbeing, as well as environmental sustainability.

2.4. **Livestock production within food security in developing and developed countries**

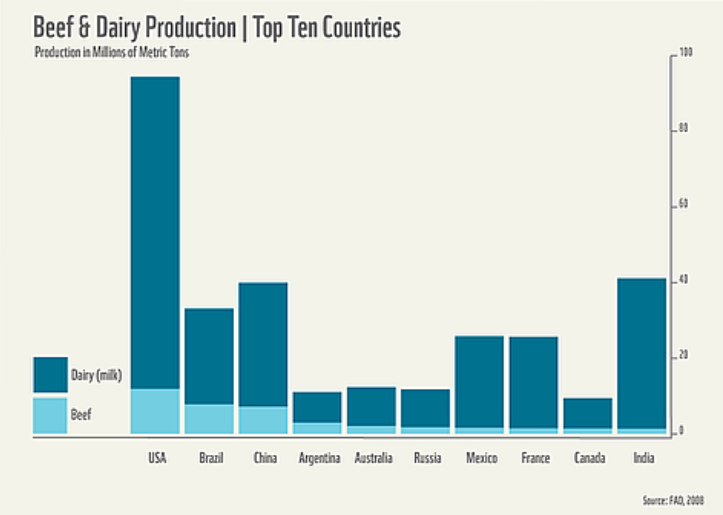
"*No water, no future; no food, no future, no energy, no future; no environment, degraded future"*

Vikram Singh Mehta[37]

When talking about food security, we have to draw attention to the fact, that some countries are producing a vast amount of food (in our particular case, food related to livestock, meat and dairy) for export, while others are mostly dependent on the import of it. According to OECD-FAO (2008)[38], the largest beef and dairy producers among the 10 top producing countries are USA, Brazil, Argentina, China, India (Table 6). In other words, the countries that are responsible for the most meat production are also responsible for dairy, as it is basically characterized by growing and producing cattle. It is worth mentioning, however, that half of those countries are developing ones, which means that for them combating environmental issues caused by livestock is much more complicated than for the developed ones.

Table 6: *Beef and Dairy production. Top ten countries.*

[35] Deepak Nayyar. UN System Task Team on the post-2015 UN Development Agenda. *The MDGs after 2015: Some reflections on the possibilities.* 2012. http://www.un.org/millenniumgoals/pdf/deepak_nayyar_Aug.pdf
[36] UNCTAD Annual Report. 2010. http://unctad.org/en/Docs/dom2011d1_en.pdf
[37] Vikram Singh Mehta. *The times of India: Man versus Nature.* Feb 14, 2011. http://articles.timesofindia.indiatimes.com/2011-02-14/edit-page/28544035_1_supply-food-security-water
[38] OECD-FAO. *Agricultural Outlook 2008-2017*. http://www.oecd.org/tad/40715381.pdf



Source: OECD-FAO (2008)

In order to give a general idea of what meat based agriculture looks like and contributes to, we suggest taking a closer look at some big meat producing countries profiles, such as USA and Brazil. In particular, it is interesting to know what is those countries' agriculture practices' contribution to ensuring food security not only in their own countries, but also worldwide. Taking into consideration that they are major players in livestock products supply throughout the world, what price *they* have to pay eventually with regards to the environmental destruction and climate change. In other words, what are those benefits and losses that they get while ensuring food security.

Brazil has played an important role in food production and trade, however the chronic food insecurity remains one of the biggest challenges in this developing country. Although, at the national level food availability in Brazil is more than sufficient to the entire population, however there is lack of access to food due to inability of poor Brazilians to afford food. Brazil is a big contributor to the following export: dry beans, maize, rice, soy beans, refined sugar and wheat. In this regard, in order to ensure the export of these commodities, there is a need for a

significant increase of fertilizers, which eventually brings an additional impact on the cost of production[39].

In the meantime, Brazil was the world's biggest exporter of meat in 2012, after coming second to Australian in 2011 and it still has resources to expand its meat industry, which is eventually expected to be growing[40]. Overall, livestock and meat production accounts for about 25% of the total GDP.

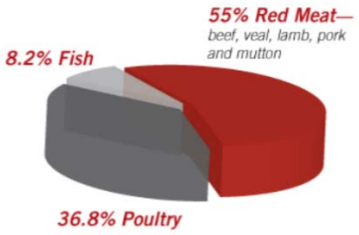
Although with the agricultural industry with its livestock and crop sectors booming, what is that price that Brazil has to pay in order to contribute to the food security around the world. To begin with, the reports in 2011 showed that the biggest *deforestation* in the region was attributed to *cattle ranches*, responsible for a massive 62% of the 277 square miles, compared with just 5% attributed to the agriculture[41]. According to the IEA data, Brazil in 2010 was the fifth in the world regarding the methane emissions[42]. Regarding the agricultural N_2O emissions, Brazil scored forth in the world. This brings us to the conclusion that Brazil is sacrificing its Amazon forests, is subject to large GHG emissions. In addition, Brazil holds 12% of the planter fresh water, however its high percent (61%) goes just to the agriculture sector[43].

As far as food security issues in the USA are concerned, an estimated 85.1% of American households were food secure in 2011, while 14.9% were food insecure, out of which 5.7% were characterized by a very low food security[44]. The meat and poultry industry is the largest segment in the U.S. agriculture. From the Table below one can see the average animal

[39]Do Amoral, W.A., Peduto, A. *Trade Knowledge Network Policy report. Food Security: The Brazilian Case.* 2010. http://www.iisd.org/sites/default/files/pdf/food_security_brazil.pdf
[40] Tavener, B. *Brazil Retakes Meat Export Lead: Daily.* The Rio Times. April 30, 2013. http://riotimesonline.com/brazil-news/rio-business/brazil-retakes-meat-exports-leader-title/#
[41] Croix, S. *Amazon Deforestation by Cattle Ranchers: Daily*. The Rio Times, Sep.3, 2011. http://riotimesonline.com/brazil-news/rio-politics/amazon-deforestation-by-cattle-ranchers-daily/
[42] Index Mundi. *Methane Emissions – Country Ranking*. 2010.
[42]http://www.indexmundi.com/facts/indicators/EN.ATM.METH.KT.CE/rankings
[43] The Water Blog: *The Water Challenges in Brazil,* June 8, 2012. http://www.waterblog.suez-environnement.com/en/2012/06/08/water-challenges-in-brazil/
[44]Alisha, J., Nord, M., et al. *Economic Researcg Service. Household Food Security in the United States in 2011.* United States Department of Agriculture (USDA), Sep 2012. http://www.ers.usda.gov/publications/err-economic-research-report/err141.aspx

consumption pattern with its 55% given to beef, lamb, veal, and pork[45]. Overall, livestock and seafood alone contribute about $200 billion to the economy each year[46].

Table 7: *Distribution by Meat, Fish and Poultry products.*



Source: American Meat Institute

Although the US plays an important role in feeding its country as well as the world, its environmental degradation is increasing. Significant damage to soil and water, growing amount of GHG emissions in the atmosphere (7% of total CO_2 emissions attributed to agriculture in 2009), and this is just a portion of the real picture. The US agricultural land used to produce meat accounts for 56%, while the percentage of the topsoil loss associated with raising livestock is 85%[47]. According to the US EPA, nitrate is the most widespread agricultural contaminant of drinking water wells, and nearly 2% of the US population, about 1.5 million people, is exposed to elevated nitrate levels from drinking water wells. About 77% of total water in the Central America goes to the agricultural sector, which has a significant relation to the USA[46].

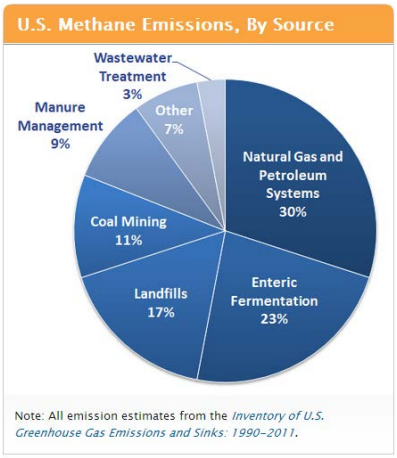
[45] American Meat Institute. The *Voice of the Meat and Poultry Industry for more than a century. The US Meat Industry at a glance.* 2011. http://www.meatami.com/ht/d/sp/i/47465/pid/47465

[46] United States Environmental Protection Agency (EPA). Agriculture *and Food Supply. Climate Impacts on Agriculture and Food Supply.* 2011. http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html#content

[47] U.S. EPA. Potential Environmental Impacts on Animal Feeding Operations. 2012 http://www.epa.gov/agriculture/ag101/impacts.html

With regards to the methane emissions, US was the forth in the world in 2010, while in agricultural nitrous oxide emissions it scored second[48]. It goes without saying that the biggest part in methane emissions belongs to the agricultural sector in the USA, in particular such areas as enteric fermentation and manure management, which both account for 32%[46](Table 8).

Table 8[49]: US Methane Emissions by Source



Source: EPA (2011)

While ensuring food security for more than 300 million people, as well as feeding other countries globally when exporting, the country's agriculture becomes a major user of ground and surface water in the US, accounting for approximately 80% of the Nation's consumptive water[50]. Interesting to note, however, that the areas under the highest risk are particularly referring to the ones, including the agricultural belts[51].

In short, the issues brought by one of the largest US sectors, namely agriculture, are many and they are critical that need to be addressed without any delay.

[48] Index Mundi. *Agricultural Nitrous Oxide Emissions – Country Ranking*. 2010. http://www.indexmundi.com/facts/indicators/EN.ATM.NOXE.AG.KT.CE/rankings

[49] EPA. Overview of Greenhouse Gases: Methane Emissions. 2011. http://epa.gov/climatechange/ghgemissions/gases/ch4.html

[50] USDA. *Irrigation and Water Use.* 7 June, 2013. http://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use.aspx#.U00QQ1WSyvV

[51] Wyler, G. *All Around the US, Risks of Water Crisis are Much Bigger than People Realize*. Business Insider, May 22, 2013. http://www.businessinsider.com/us-drought-water-scarcity-2013-5?IR=T&

We have seen the actual picture with regards to food security and livestock environmental impact of some countries that are considered as big meat producer players on the world arena. However, it is interesting to trace whether the environmental degradation is caused to a large extent by livestock agriculture in particular. For this reason, there is a need to take a look at the countries that are referred to as small meat producers. Further in the research we will be analyzing both small and big meat producing countries, and eventually will be able to see and conclude whether the fact of the countries with developed meat and dairy industries correlates with a negative impact on the overall environmental situation within those countries. In the following chapter on methodological approach there will be more light shed on the problem under discussion.

As we have seen, the countries that are considered big meat producers are subject to dramatic environmental issues not only within their own territories, but also contributing to the world environmental degradation (in case of water issues and GHG emissions, contributing to climate change). In order to ensure sustainable growth in the respected countries as well as in the world, there have to be changes implemented right from the source of the issues. In this particular case, even though agricultural sector, namely livestock production, seems to be booming, however it still is not able to fully address the food security issues. Above that, the way it is practiced in is significantly damaging the environment, while diminishing and polluting natural resources and affecting climate change. Are there any rational alternatives that could be suggested in order to address all those issues? One of the suggested solutions is shifting towards a vegetarian lifestyle that could contribute not only environmental sustainability, but also improve the malnutrition and hunger across the world.

2.5.Vegetarianism as a rational approach towards environmental sustainability

"There will be not enough water available on current croplands to produce food for the expected 9 billion population in 2050 if we follow current trends of food consumption…"

International Water Management Institute[52]

Some of the world's leading water scientists emphasize that global food shortages are likely to make the world's population to switch towards a vegetarian diet over the next 40 years[53]. Assuming the fact that animal based agriculture does contribute to the environmental degradation (further this will be analyzed in a more practical way), one of the ways to lessen such kind of impact is shifting to a plant based agriculture. Again, in the following chapter we will be able to trace whether plant based agriculture is less destructive than the animal based one. Assuming that it is, it would be interesting to bring the point of vegetarianism to closer attention.

According to Oxfam International[54], an animal diet consumes five to ten more water than a vegetarian diet, while about a third of the world's arable land is used to grow crops just to feed animals. As the UN report states, there must be an increase in food production by 70% by mid-century, which will eventually place significant pressure on natural resources, when at the same time water resources have to be allocated to satisfy global energy demand and to generate electricity for the 1.3 billion people currently without it[55].

As FAO[56] predicts, there will be a significant increase in the world population over the next decades, which will subsequently lead to bigger food demand as mentioned earlier.

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[52]John Vidal. *International Water Institute. Food shortages could force world into vegetarianism*. The Guardian, 26 August, 2012. http://www.theguardian.com/global-development/2012/aug/26/food-shortages-world-vegetarianism

[53] Lee Rannals. *Food Shortages may lead to global vegetarianism.* Red Orbit., 27 August, 2012. http://www.redorbit.com/news/science/1112682556/

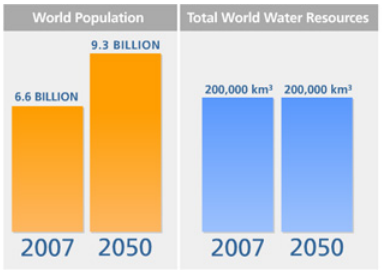
[54] Oxfam International, confederation of 17 organizations to find solutions to poverty and injustice. http://www.oxfam.org/

[55]Dan Karney. United Nations Report: *World Urged to Vegan Diet*. Center for Business and Public Policy. Jan 27, 2012. http://businesspublicpolicy.com/?p=2188

[56] FAO. *Global Hunger Down, but millions are still chronically hungry*. 2013. http://www.fao.org/news/story/en/item/198105/icode/

However, natural resources are less likely to increase, on the contrary, they are either to stay on the same level as of today, or more likely to be decreasing in the opposite proportion with the growth of the population.

Table 9 [57]: *World Population and World Water Resources comparison*



Source: FAO (2009)

As the Internation Panel of Sustainable Resource Management[58] points out, agricultural production accounts for 70% of global fresh water production, 38% of land use, and 19% of the world's total GHG emissions.

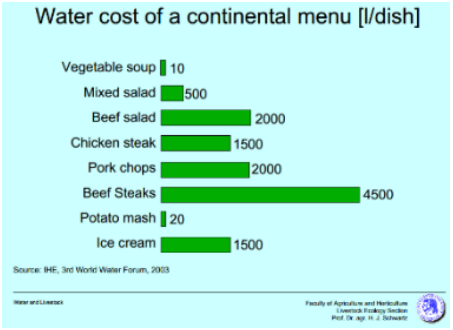
It is noteworthy, that stock free farming, in other words, plant agriculture, provides a number of advantages to developing countries regarding their food security. In general, humans are able to be fed more efficiently on plant-based diet, for, they require less water, land and crops to produce in comparison with the meat-based diet. Indeed, all the grains, crops fed nowadays to the livestock, can be allocated to those poor countries, where the food is the number one issue. It is noteworthy, that livestock production uses up to 43% of the world's cereal and uses up to 85% of the world's soy4.

Another point to consider regarding the plant-based diet, is that it reduces the risk of conflict over scarce water and grazing land[59].

[57] FAO (2009). *How to feed the world in 2050.* http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf
[58] UNEP, International Resource Panel. http://www.unep.org/resourcepanel/
[59] Louise Gray. *Eat less meat to save the planet – UN*. The Telegraph. June 2, 2010. http://www.telegraph.co.uk/earth/earthnews/7797594/Eat-less-meat-to-save-the-planet-UN.html

As Table 10 demonstrates, vegetables do require significantly less water in comparison to meat production and preparation.

Table 10[60]: Water Cost of Continental Menu



Source: Schwartz: Water and Livestock

According to Chapagain and Hoekstra (2011)[61] producing any kind of livestock product generally requires more water per kilogram of product. For example, to produce 1 kg of cheese on needs to 5000-5500 kg of water, and for 1 kg of beef on average around 16000 kg of water.

The inefficiency of production of plant and animal based food goes even further. For example, about 85 % of the world's soybean crop is processed into meal, and virtually most of that meal is used in order to feed animals. Soybeans are one of the major components of the plant based diet. Therefore, instead of feeding the 85% of the cultivated soybeans to the livestock, it could have been fed to people, especially in those vulnerable countries where malnutrition and hunger are the burning issues.

It is known that there are obviously fertilizers required for the crop production as well, however, part of the chemical fertilizers, in this regard, could in fact be substituted by manure, thus substantially decreasing environmental impacts on land and water, eventually making the farming practices even more sustainable. Following up with farming, it is important to note that

[60] Schwarz, H.J. *Water and Livestock. Needs, Challenges, Management Issues.* http://amor.cms.hu-berlin.de/~h1981d0z/pdf/2006-02-kenia/kabete-lect.pdf. Accessed July, 2013

[61] Hoekstra, A.Y., Chapagain, A.K., et al. *The Water Footprint Assessment Manual: Setting the Global Standard*, Earthscan, London, UK, 2011.

stock-free farming is suitable for small-scale, low income farming, and at the same time it doesn't require extensive machinery use[62].

It is important to point out that there are also a number of diseases associated with animal products consumption, such as heart diseases, cancer, diabetes, obesity[i].

There have been a number of studies done regarding the livestock issue and its possible solutions. One of the well-known reports "Livestock's Long Shadow" by FAO (2007) clearly outlines that livestock sector is one of the most significant contributors to the crucial environmental problems, such as land degradation, climate change, air pollution, water shortage as well as water pollution, and subsequent loss of biodiversity. In similar vein, UN points out that a global shift towards a vegan diet is vital to save the world from hunger, fuel poverty and the detrimental impacts of climate change[63]. From the social and ethical perspective, eating soybeans and vegetable can save millions of lives of living creatures.

Having outlined major benefits of the plant-based diet, it is important to note, that even if it does bring long term benefits to the environment and society overall, however there are many accompanying issues along with the benefits. In particular, from the economic perspective this is the contribution to GDP that is being made from the animal production, and at the same time the employment that is provided within the agriculture. Therefore, there is a need for careful and extensive planning to be done in global collaboration, since in the long run it deals with the global concerns of hunger, environment degradation and economic instability. However, one should keep in mind when talking about policy recommendations, environmental policies that **plant-based diet** is able to balance major four objectives: food security, food safety, natural resources, and poverty reduction.

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[62] FAO. *Advantages and Disadvantages of CA.* Agriculture and Consumer Protection Department. Conservation Agriculture (CA): 2013. http://www.fao.org/ag/ca/1c.html

[63] Felicity Carus. *UN urges global move to meat and dairy-free diet.* The Guardian, 2 June, 2010. http://www.theguardian.com/environment/2010/jun/02/un-report-meat-free-diet

It is important to emphasize that there is a need for a new outlook regarding the livestock production and food pattern in general, a new direction in decision making is required regarding livestock development and economic planning to obtain reliable information about the structural evolution in the livestock sector and its implications.

Here it should be noted that new policies and techniques should be elaborated in order to redirect the livestock sector towards more sustainable development paths. In this respect policies will have to balance four main objectives that are: food security, food safety, preservation of natural resources, and poverty reduction[64].

Although recently there has been a lot of discussion regarding the livestock impact on the environment, however there have been mainly suggestions with regards to improvement of the livestock production technologies, etc. The previous policies that have been suggested include: development of livestock waste recycling and discharge standards based on the polluter pay principle; reduction of subsidies for chemical fertilizers use and fostering of safe manure recycling; development of public awareness of the longer term social welfare issues and the more immediate public health risks associated with current manure management practices. However, an important point to consider here is that all those policies and practices are rather reflecting the adaptation approach. For, in the long run, livestock will keep producing the waste which requires us to adapt to it with least deteriorating consequences possible. The discussion however, comes down to the point that there should be a *mitigation* approach worked out, in other words, a new strategy that will be able to cut down negative externalities right at source. Another point to consider is that whether there could be a possibility to view the source of emissions from a different perspective and analyze whether there could be any alternatives to this source. To this end, when talking about policy recommendations, environmental policies regarding this issue, it is worth considering that plant based diet or

[64] World Food Summit. *Rome Declaration on Food Security. 1996.* http://www.fao.org/docrep/003/w3613e/w3613e00.HTM

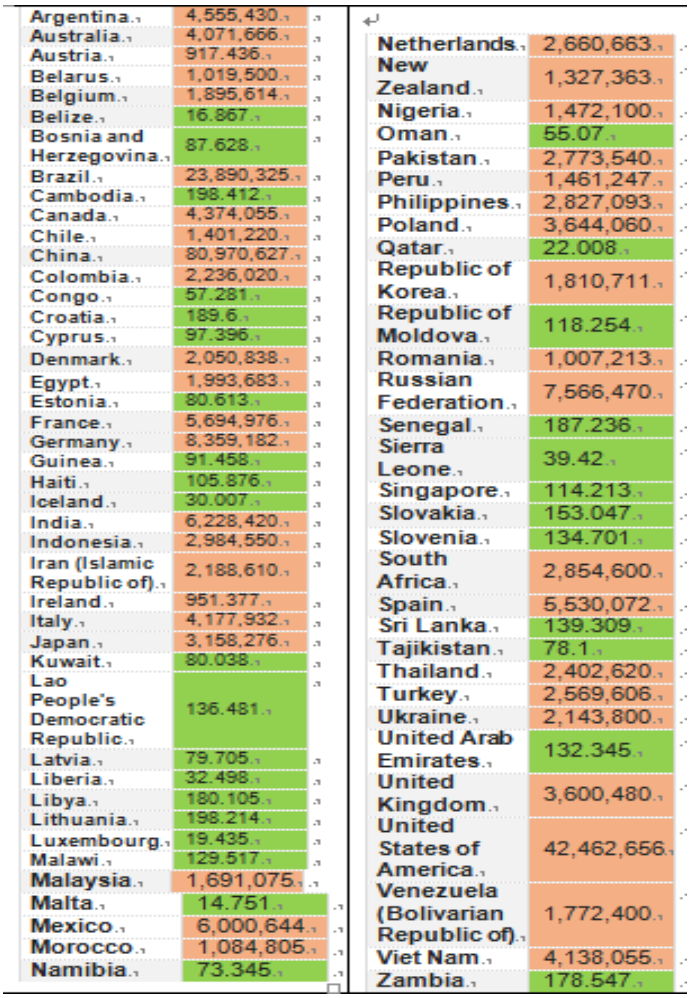
vegetable oriented cultivation are able to balance those 4 objectives: *food security, food safety, natural resources, and poverty reduction*. Further, through conducting our investigation, we will be able to show the connection between non-meat production and working towards attaining the above mentioned objectives

3. METHODOLOGY

As the primary goal of this research was to show the difference between the animal and plant based agriculture, and subsequently a vegetarian life style, therefore there is a need to incorporate a specific method that will be able to provide us with particular numbers related to the problem under discussion, considering that, we set out to conduct an empirical research from the very beginning in order to be able to trace and analyze obtained evidence in a quantitative form.

As a result, we have incorporated a statistical method of regression analysis in order to estimate relationships among variables. So that to estimate which type of agriculture may be more detrimental in terms of GHG emissions, we have selected such variable as equivalent of *agricultural CO_2 emissions* as a dependent one, while trying to identify those variables that could have a potential impact on decrease or increase of CO_2 emissions. It is important to point out that GHG emissions from agricultural practices mainly consist of methane (CH_4), nitrogen oxide (N_2O), and carbon dioxide (CO_2). However, in order to bring our calculations and a subsequent quantitative analysis to a unified system, we have chosen to convert all the investigated agriculture related GHG into *CO_2 equivalent*. Further, in order to identify whether animal based agriculture particularly contributes to CO_2 emissions, we have selected a number of countries that are considered to be *big meat producers*, as well as a number of countries that are accounted for *small meat producers*. First, we have compiled data on the meat production around the world (from *World Bank dataset*), which later helped us to identify the countries, where meat production is considered to be *above* and *below* average. In this way, 41 countries have been picked as big meat producing countries, while 32 countries have been identified as small meat producers.

Table 11: List of the big and small meat producing countries



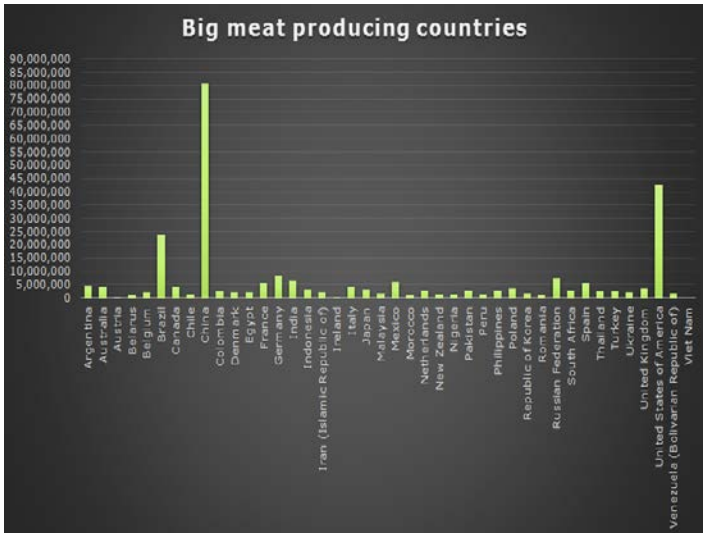
Argentina	4,555,430	Netherlands	2,660,663
Australia	4,071,666	New Zealand	1,327,363
Austria	917.436	Nigeria	1,472,100
Belarus	1,019,500	Oman	55.07
Belgium	1,895,614	Pakistan	2,773,540
Belize	16.867	Peru	1,461,247
Bosnia and Herzegovina	87.628	Philippines	2,827,093
Brazil	23,890,325	Poland	3,644,060
Cambodia	198.412	Qatar	22.008
Canada	4,374,055	Republic of Korea	1,810,711
Chile	1,401,220	Republic of Moldova	118.254
China	80,970,627	Romania	1,007,213
Colombia	2,236,020	Russian Federation	7,566,470
Congo	57.281	Senegal	187.236
Croatia	189.6	Sierra Leone	39.42
Cyprus	97.396	Singapore	114.213
Denmark	2,050,838	Slovakia	153.047
Egypt	1,993,683	Slovenia	134.701
Estonia	80.613	South Africa	2,854,600
France	5,694,976	Spain	5,530,072
Germany	8,359,182	Sri Lanka	139.309
Guinea	91.458	Tajikistan	78.1
Haiti	105.876	Thailand	2,402,620
Iceland	30.007	Turkey	2,569,606
India	6,228,420	Ukraine	2,143,800
Indonesia	2,984,550	United Arab Emirates	132.345
Iran (Islamic Republic of)	2,188,610	United Kingdom	3,600,480
Ireland	951.377	United States of America	42,462,656
Italy	4,177,932	Venezuela (Bolivarian Republic of)	1,772,400
Japan	3,158,276	Viet Nam	4,138,055
Kuwait	80.038	Zambia	178.547
Lao People's Democratic Republic	136.481		
Latvia	79.705		
Liberia	32.498		
Libya	180.105		
Lithuania	198.214		
Luxembourg	19.435		
Malawi	129.517		
Malaysia	1,691,075		
Malta	14.751		
Mexico	6,000,644		
Morocco	1,084,805		
Namibia	73.345		

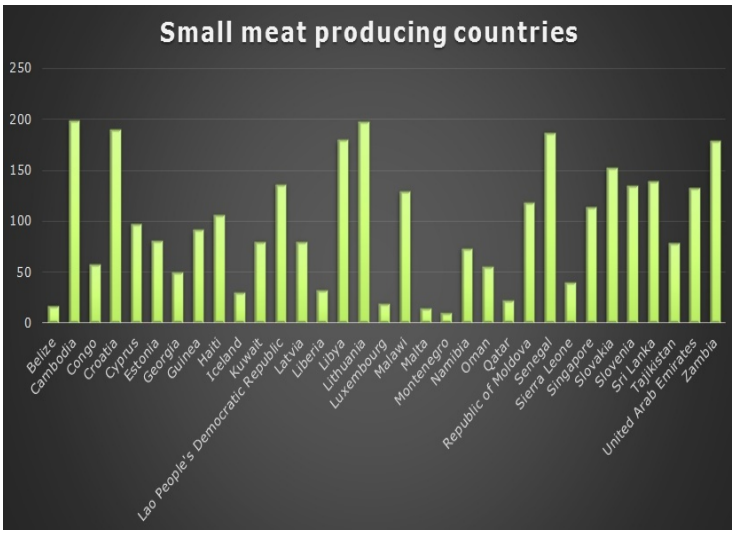
Source: World Bank Dataset

The above table provides the information on all the selected for analysis meat producing countries. Different colors differentiate the countries according to the amount of animal based products they produce, with the *red color* standing for big production going up to *80,970,627* ton/year and the lowest *917,436* ton/year, while the *green color* symbolizes small meat producing countries with the highest meat production resulting in *198,412* ton/year, and the lowest *10,250* ton/year. The present data is related to the year of 2011, the last year according to the FAO statistics, when the information about all countries was available. Below we have provided charts on big and small meat producers in order to get a more clear idea on the *big gap* between meat production in both sets of countries. Another important fact to mention is

that we have used the time period from *2000 to 2009* in order to be able to compile a *panel data* which will enable us to capture observations not only at a specific point of time but over the years

Tables 12, 13: Small and big meat producing countries





There was a thorough process of finding the variables directly related to animal based and plant based agriculture. First, it was mainly the Food and Agriculture (FAO) database that was used for obtaining most of the data, as it deals directly with food production and contains extensive data on agricultural practices as well as environmental impact from those practices. We have also successfully used the World Bank data in order to obtain data on CO2 emissions in different countries, as well as their population, GDP, and general meat production throughout the world.

Since we are mainly dealing with animal and plant based agriculture, therefore we were first considering the factors that are particularly dealing with these two types of agriculture. In the first case those the amount of each kind of livestock on pastures (*in heads*), the amount of the products produced from the livestock (*in tons*), as well as the CO2 equivalent from the agricultural activities dealing with animal production (*in gigagrams*), such as CO2 from manure management, enteric fermentation, etc. In case of plant based agriculture we took the

amount of vegetables and cereals produced in each country, as well as the amount of CO_2 from plant based related agricultural activities such as CO_2 from *rice cultivation, burning crop residues, fertilizers' application*. However, once we are talking about conducting regression, we have to make sure that the variables we are taking are independent. Therefore taking types of livestock in heads, as well as using production from this livestock and the CO_2 emissions released from the cultivation and subsequent production are not independent from each other factors. Eventually, prior to running a regression we have identified 10 important independent variables as shown below:

Table 14: 10 independent variables

Ten independent variables	**Description**	**Source**
Cattle livestock (heads)	The amount of cattle in heads used as livestock for further meat Production	FAO
Sheep and goat livestock (heads)	The amount of sheep and goat in heads combined used as livestock for further meat Production	FAO
Pigs livestock (heads)	The amount of pigs in heads used as livestock for further meat production	FAO
Poultry livestock (1000 heads)	The amount of chicken and other poultry in 1000 heads used as livestock for further meat production	FAO
Cereal	The amount of cereal in tones produced as Crops	FAO
Vegetables	The amount of vegetables in tons	FAO
Pasture land area	The land area in 1000HA used for livestock pastures	FAO

Livestock production price index	Livestock production index shows agricultural production for each year. Production indexes are calculated from the underlying values in international dollars, normalized to the base period 2000-2009	World Bank
Crop production price index	Crop production index shows agricultural production for each year. Production indexes are calculated from the underlying values in int. dollars, normalized to the base period (2000-2009)	World Bank
Fertilizers' Consumption	Fertilizers consumed in kg per HA	FAO

Source: FAO, World Bank

While conducting a regression analysis, we followed a model for a *simple and multiple regression*, such as $\mathbf{Y = \alpha + \beta X_1 + \varepsilon,}$ where **Y** is CO_2 agricultural, **X** and eventually $\mathbf{X_2}$, …, $\mathbf{X_n}$, when working with a multiple regression model, stand for independent variable which are shown below as a sum output before the regression analysis itself. We have done the regression for both sets of countries –*big meat producers* and *small meat producers*, separately. However, in order to estimate the relation between both of those groups of countries, as well as indicate the presence of the CO_2 increase in big meat producing countries, we have incorporated a dummy variable, where small meat producers take the value of 0, in comparison with the big meat producers that take the value of 1. Using the following model,

$$\mathbf{YCO2\ agr_{it} = \alpha + \beta(big\ meat\ producing\ country\ dummy_{it}) + \varepsilon}$$

we will be able to identify whether the CO_2 emissions in big meat producing countries significantly differ from the ones in small meat producers, and if so, by how much that difference is. This will eventually help us to prove or reject the second hypothesis that *small meat producing countries are less CO_2 intensive*.

Another important thing to bring to the attention is that in order to be more objective and specific in the obtained results, we have not only used CO_2 agricultural as a dependent variable,

but also incorporated a concept of land area, as it is important to keep in mind that all the selected 73 countries are different with regards to the country area size. To confirm the initial regression results we are later using all livestock types as a single variable, which will give us a more general picture on which those factors are, referred to plant or animals agriculture, that are particularly causing CO_2 emissions increase.

4. ANALYSIS

When we are talking about CO_2 emissions, in particular, in agriculture, we have a number of different factors that are correlating with the GHG emissions, whether increasing or decreasing them. In our particular case, we need to identify those ones that contribute to the increase of CO_2 emissions in the investigated countries. It is worth pointing out, that in the analysis itself we intend to focus directly on the agricultural CO_2, as they are particularly the ones that constitute about 29% (according to the numbers we have identified through existing data) of the total CO_2 emissions among all 41 biggest meat producing countries all over the world. Although in some countries agricultural CO_2 share goes up to 80% of overall CO_2, however it is rather important to take the average among those countries.

Our analysis will consist of several parts. To begin with, we have two hypotheses to look at. The first hypothesis is regarding the fact that among meat and plant based agriculture this is particularly livestock (meat based agriculture) that contributes to agricultural CO_2 increase in the atmosphere compare to the cereal and vegetable cultivation. In this regard, we will be first dealing with big meat producing countries by running a regression to trace, what those particular agricultural practices are that cause CO_2 growth. Agricultural practices are represented by a number of independent variables, such as types of livestock – cattle, sheep and goat, pigs, poultry, cereal and vegetable production, pasture land area, livestock and crop production price index, fertilizers. The detailed information data was presented earlier in the previous chapter.

It is likely that both types of agriculture contribute to CO_2 emissions, however, the question for us to consider is which type of agriculture is more CO_2 intensive. Further, we will focus on small meat producing countries to see whether there would be the same interrelation between meat and plant agriculture and CO_2 emissions. It is important to note, that in both

cases we are considering not only agricultural CO_2 equivalent emissions as a dependent variable, but also their behavior with regards to the country land.

The table below represents the two dependent variables we intend to incorporate in the further analysis:

Table 15: Two dependent variables

Two dependent variables	**Description**	**Source**
Agricultural CO_2	The CO_2emissions from the agricultural sector calculated in tons	FAO
Agricultural CO_2/land	The CO_2emissions from the agricultural sector calculated in tons divided by the land area in order to see the intensity of the CO_2per HA of land	FAO / World Bank

Source: FAO, World Bank

The other hypothesis for us to look into is that big meat producing countries are more CO_2 intensive than small meat producers. In this case again we will be dealing with big and small meat producing countries combined and their agricultural CO_2 emissions.

What we need to identify, however, is weather the share of agricultural CO_2 emissions from big meat producers is bigger than the one from small producers, in particular the fact that those CO_2 intensive agricultural practices are less contributing to CO_2 emissions in the second set of countries. We will eventually run a regression including all 73 countries incorporating the concept of a *dummy variable*. To be exact, the countries that are considered to be big meat producers will be referred to as “1”, while the opposite set of countries will be decoded as “0”. We will further see a general picture of different agricultural practices’ contribution to the CO_2 emissions with regards to big and small meat producers *combined*.

Thus, working on the first hypothesis, when running the first regression with CO_2 agricultural to be a dependent variable, we are presented with the following results: almost all

statistically significant indicators are the ones related to animal production. In particular, *livestock price index* is statistically significant with p-value 0.000, as well as number of *cattle* is similarly statistically significant. Along with those indicators there is also application of *fertilizers* which is significant with p-value 0.000. The variables that are *not statistically significant* are the ones dealing with the *plant agriculture*, to be exact, *crop price index* with p-value 0.925, *cereal production* and *vegetable production* with p-values 0.128 and 0.591 respectively.

In order to show how elastic our dependent variable CO_2 is with regards to 1% change of each of the independent variables as well as to put all variables into one scale, we have implied the *log* concept in a multiple regression.

Table 16: Elasticity of CO2 agricultural from independent variables

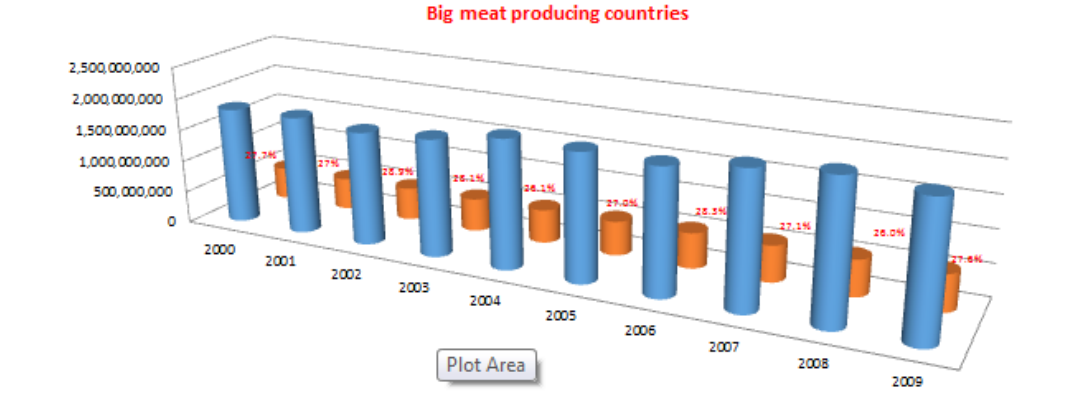
```
. xtreg  lco2agrton llvstockpriceindex lcroppriceindex lcattle lshgoat lpigs lp
> try1000 lfrtzr lcreal lvegble lpstre1000, fe

Fixed-effects (within) regression               Number of obs      =       410
Group variable: ctry1                           Number of groups   =        41

R-sq:  within  = 0.3830                         Obs per group: min =        10
       between = 0.5079                                        avg =      10.0
       overall = 0.5068                                        max =        10

                                                F(10,359)          =     22.29
corr(u_i, Xb)  = 0.4382                         Prob > F           =    0.0000

------------------------------------------------------------------------------
   lco2agrton |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
llvstockpr~x |   .1787297   .0367083     4.87   0.000     .1065394    .2509199
lcropprice~x |   .0036028   .0382239     0.09   0.925    -.0715681    .0787738
     lcattle |   .0532671   .0135698     3.93   0.000     .0265808    .0799533
     lshgoat |   .0325751    .014838     2.20   0.029     .0033947    .0617554
       lpigs |   .0505007   .0174282     2.90   0.004     .0162264    .0847749
    lptry1000 |   .0189867   .0130874     1.45   0.148    -.0067509    .0447244
      lfrtzr |   .0524524     .01301     4.03   0.000      .026867    .0780379
      lcreal |   .0165683   .0108464     1.53   0.128    -.0047621    .0378988
     lvegble |   .0178799    .033205     0.54   0.591    -.0474209    .0831806
  lpstre1000 |   .0614139   .0414512     1.48   0.139    -.0201038    .1429317
       _cons |   13.07349   .7274739    17.97   0.000     11.64284    14.50413
--------------+---------------------------------------------------------------
     sigma_u |  .84692245
     sigma_e |  .04341205
         rho |  .99737944   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(40, 359) =   398.74                 Prob > F = 0.0000
```

As we can see from the above regression output, with 1% increase in *cattle production* the agricultural, CO_2 emissions will *rise by .053*. In the case of other types of livestock the results are as follows: with *1% increase* of *sheep and goat amount*, CO_2 rises by *.032%* and accordingly, *pigs* amount increase by 1% causes CO_2 *increase by .050%*. It is important to specify here, that *fertilizers' application*, according to the regression output, is similar in its

effect on CO_2 increase from the *cattle* and *pig production*. In particular, the fertilizers' increase by 1% will subsequently affect CO_2 emissions *by .052*, which is in line with the cattle (.053) and pigs production (.050). And it is quite obvious, as one should bear in mind, that livestock based agriculture is not necessarily limited by just animal production, as for their growth there is a need for crop feed as well. Therefore, on the top of crop production itself with the purpose of feeding the population, there is a significant share of crops produced that is used as animal feed. To be more exact, among developed big meat producing countries, on average there is *27%* of all crop production that goes to the livestock. Therefore, it is quite difficult to conclude that plant production contributes as great as meat production to the CO_2 emissions.

The graphs below (Table 17 and Table 18) provide us with details on the total crop amount that was produced in big meat producing countries each year starting from 2000 up to 2009, as well as the total amount of crops that was fed to animals each of those years.

Table 17: Share of the grown cereal used as livestock feed (big meat producing countries)



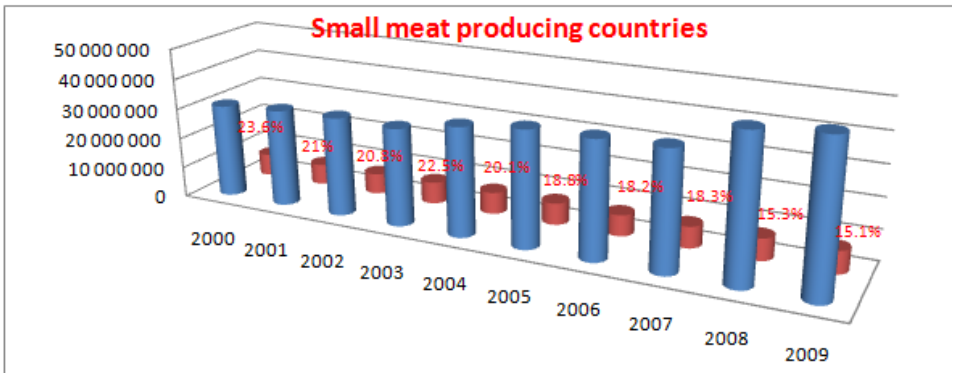
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
cereal production (tonnes)	1,818,705,965	1836185033	1759862065	1815534930	1985460422	1957801793	1923289607	2067207578	2147568463	2045510257
cereal fed to produce beef	508954820.4	497107357.1	510345613.2	511464537.8	520144174.7	529714884	546038940	561003233	559728008.6	564852071.7

The percentage of crop share ranges from 26 to 28% through the 10 years, which tells us that there could be a significant extra amount of plant products produced, subsequently more fertilizers applied, which eventually brings a higher increase of agricultural CO_2 share.

Therefore, while taking into consideration the results of the regression output, there is a need to pay attention to what might be the potential cause of particular results.

In similar vein we notice the correlation between the general crop production and the part of it used as animal feed in small meat producing countries.

Table 18: *Share of the grown cereal used as livestock feed (small meat producing countries)*



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
cereal production (tonnes)	30 664	3187475	3235468	3188776	3548299	3774897	3794781	3839798	4661544	4835456
cereal fed to produce beef	7247477	6758675	6754833	7179306	7132249	7119091	6920188	7022790	7157133	7335280

It is interesting to note as well, that we have taken price indexes for both livestock and crop production in order to see, how the price change on the respective products may influence the agricultural CO_2. What appears throughout the regression is that the *livestock price index* is the *most significant* independent variable, where t-value is 0.000 and p-value is 4.87 which is higher than the one of other variables. The *crop price index* on the contrary is *the lowest* with p-value up to 0.925 and t-value 0.09.

There are also such variables as the amount of *land used for pastures* as well as the *poultry* amount. This theoretically has two explanations. First of all, the measurement for both of these variables was taken in 1000 heads (for poultry) and 1000 HA (for pasture land), when the rest

of the variables such as other types of livestock are used as a full number in millions. The other reason for a low significance level poultry-variable might be the fact, that poultry is actually accounted for a small (comparing to ruminant livestock) contribution to the CO_2 emissions.

Taking all this into consideration we can state with confidence regarding our first hypothesis, that animal based agriculture is more CO_2 intensive than plant based agriculture. We have seen it through regressing agricultural CO_2 as a dependent variable with regards to 10 other independent variables that respectively are associated with animal or plant production. Obviously, we have not considered the whole wide range of variables such as meat produced from the livestock, other types of technologies used in the process of producing meat including transportation from pastures for slaughterhouses, slaughter machines, etc. However, it is believed that the most GHG intensive attributes have been included, such as livestock itself as it is responsible for CH_4 emissions, as well as fertilizers application, and grain, cereal and vegetables cultivation.

We have seen through the regression analysis the impact that is made on CO_2 emissions from different livestock in details, in particular, from cattle, sheep and goat, pigs and poultry cattle. Among all these types of livestock it is the cattle that has a great impact on the CO_2 increase. However, it is of importance to see the overall picture in terms of what is that particular factor among meat and plant based agriculture to affect the GHG.

Table 19: Agricultural CO_2 *related to animal and plant agriculture (big meat producers)*

```
. xtreg  lco2agrton llvstockpriceindex lcroppriceindex llivestkthead lfrtzr lcre
> al lvegble lpstre1000, fe

Fixed-effects (within) regression               Number of obs      =       410
Group variable: ctry1                           Number of groups   =        41

R-sq:  within  = 0.4900                         Obs per group: min =        10
       between = 0.8223                                        avg =      10.0
       overall = 0.8200                                        max =        10

                                                F(7,362)           =     49.69
corr(u_i, Xb)  = 0.7558                         Prob > F           =    0.0000

------------------------------------------------------------------------------
  lco2agrton |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
llvstockpr~x |   .1245794   .0322343     3.86   0.000     .0611895    .1879693
lcropprice~x |    .017519   .0344569     0.51   0.611    -.0502419    .0852798
llivestkth~d |   .3235685   .0303425    10.66   0.000     .2638988    .3832382
      lfrtzr |   .0525756    .011603     4.53   0.000     .0297577    .0753934
       lcreal |   .0183821   .0097851     1.88   0.061    -.0008606    .0376248
     lvegble |   .0315847   .0296723     1.06   0.288     -.026767    .0899364
  lpstre1000 |   .0160148   .0354982     0.45   0.652    -.0537939    .0858234
       _cons |   10.10983   .7175277    14.09   0.000     8.698785    11.52088
-------------+----------------------------------------------------------------
     sigma_u |  .70109608
     sigma_e |  .03930564
         rho |  .99686677   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(40, 362) =   944.42                 Prob > F = 0.0000
```

As we can see from the above output, the livestock factor is the one that has the biggest t-value, more than twice as big as the fertilizers factor. To be more exact, we have livestock price index, livestock amount, and fertilizers that are highly statistically significant. Among these independent variables, with one *1% growth in livestock* production price index we there is *.124% increase in agricultural* CO_2, while *1% increase in fertilizers'* consumption *raises* CO_2 *emissions by .05%*. However, once the *livestock amount grows by 1%*, there is a subsequent *.323% increase in the* CO_2 emissions. This regression shows us that when it comes to the animal based agriculture compare to plant based, it is particularly the former one that highly contributes to the CO_2 emissions.

Overall, the above data has already given some implication to highlight that in big meat producing countries on average this is the livestock based agriculture that contributes to the agricultural CO_2 growth, which subsequently increases the total GHG emissions. However, there is still another aspect that is better to be taken into consideration, to be exact, the CO_2 emissions per unit, in our case HA, of land.

Table 20: CO2 emissions per unit of land (big meat producers)

```
. xtreg lco2land llvstockpriceindex lcroppriceindex lcattle lshgoat lpigs lptry
> 1000 lfrtzr lcreal lvegble lpstre1000, fe

Fixed-effects (within) regression               Number of obs      =       410
Group variable: ctry1                           Number of groups   =        41

R-sq:  within  = 0.4203                         Obs per group: min =        10
       between = 0.0271                                        avg =      10.0
       overall = 0.0260                                        max =        10

                                                F(10,359)          =     26.03
corr(u_i, Xb)  = -0.5049                        Prob > F           =    0.0000

------------------------------------------------------------------------------
     lco2land |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
llvstockpr~x |    .1751951   .034473     5.08   0.000     .1074007    .2429896
lcropprice~x |   -.0072421   .0358964   -0.20   0.840    -.0778357    .0633515
     lcattle |    .0597217   .0127435    4.69   0.000     .0346604     .084783
     lshgoat |     .03367   .0139345    2.42   0.016     .0062666    .0610735
       lpigs |    .0508405    .016367    3.11   0.002     .0186533    .0830277
  lptry1000 |    .0222334   .0122905    1.81   0.071    -.001937     .0464038
     lfrtzr |    .0555109   .0122178    4.54   0.000     .0314834    .0795384
     lcreal |    .0170332   .0101859    1.67   0.095    -.0029984    .0370647
     lvegble |    .0217792   .0311831    0.70   0.485    -.0395453    .0831036
  lpstre1000 |    .0620333   .0389272    1.59   0.112    -.0145207    .1385872
       _cons |    1.741691   .6831765    2.55   0.011     .3981608    3.085222
--------------+---------------------------------------------------------------
     sigma_u |  1.1453283
     sigma_e |   .0407686
         rho |   .99873456   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(40, 359) =  5105.67                 Prob > F = 0.0000
```

What we are able to trace here is that such variables as *livestock price index, cattle production, sheep and goat, pigs, fertilizers* are statistically *significant*. Again, the poultry is less significant in the outcome of regression, however it is important to remember that the data on it has been taken in 1000 heads, as well as the pasture land in 1000 ha.

The average tendency of CO_2 concentration per HA of land seems to be as follows: with 1% of cattle livestock increase, the emissions per HA go up .059%, in case of pigs - .050 and fertilizers contribute to increase of CO_2 per HA of land by .055%. Such an outcome gives information and basis to conclude that among most of the GHG increasing agricultural practices, particularly CO_2 intensive are livestock production (ruminants specifically), as well as fertilizers application to the soil. As far as related to plant agriculture activities, cultivation of cereals and vegetables, the regression output doesn't provide any significant result regarding those practices. It is important to highlight, that these results have been obtained while comparing both types of agriculture – livestock and plant – in order to see which one is more destructive in terms of GHG emissions.

To continue, it is important to run a similar regression with regards to small meat producing countries and see whether there would be the same correlation among the factors contributing to the CO_2 increase.

Small meat producing countries

Considering that these are small meat producing countries, major types of livestock are produced in much smaller amounts and therefore may be standing out as less statistically significant variables in the overall regression.

However we still can see that the *most significant* independent variables are *cattle* and *fertilizers*, as well as *price indexes* for both types of agriculture, with p-values 0.000 in all cases. Less significant is the production of pigs with p-value 0.044 and vegetable cultivation with 0.017 p-value. The rest of the variables came out as not statistically significant.

Table 21: CO_2 *emissions related to independent variables (small meat producers)*

```
. xtreg  lco2agrton llvstockpriceindex lcroppriceindex lcattle lshgoat lpigs lp
> try1000 lfrtzr lcreal lvegble lpstre1000, fe

Fixed-effects (within) regression               Number of obs      =       320
Group variable: ctry1                           Number of groups   =        32

R-sq:  within  = 0.5746                         Obs per group: min =        10
       between = 0.4668                                        avg =      10.0
       overall = 0.4682                                        max =        10

                                                F(10,278)          =     37.55
corr(u_i, Xb)  = 0.1628                         Prob > F           =    0.0000

------------------------------------------------------------------------------
  lco2agrton |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
llvstockpr~x |   .3290546   .0851768     3.86   0.000     .1613812    .4967281
lcropprice~x |   .2189289   .0513773     4.26   0.000      .117791    .3200668
     lcattle |   .2166572   .0517973     4.18   0.000     .1146925    .3186219
     lshgoat |   .0636069   .0448287     1.42   0.157    -.0246399    .1518538
       lpigs |   .0744216   .0367427     2.03   0.044     .0020923    .1467509
   lptry1000 |   .0398999   .0444854     0.90   0.371     -.047671    .1274709
      lfrtzr |   .0519379   .0051631    10.06   0.000     .0417742    .0621016
      lcreal |     .00848   .0110527     0.77   0.444    -.0132777    .0302377
     lvegble |  -.0912914   .0380367    -2.40   0.017    -.1661679    -.016415
  lpstre1000 |  -.0005447   .0484909    -0.01   0.991    -.0960008    .0949113
       _cons |   7.928198   .8361418     9.48   0.000     6.282224    9.574171
-------------+----------------------------------------------------------------
     sigma_u |  .95246804
     sigma_e |   .1205156
         rho |  .98424248   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(31, 278) =   110.39                 Prob > F = 0.0000
```

It is shown that with 1% increase in livestock price index, the CO_2 agricultural goes up by .329%, and this appears to be the highest growth among other independent variables. It is interesting to note that the next 2 variables that contribute to the CO_2 emissions the most, are crop production index as well as cattle, which both with 1% growth contribute to the

agricultural CO_2 increase by .218 and .216% respectively. It is also important to highlight that the other two statistically significant variables that affect the GHG emissions in the agricultural sector, are such livestock as *pigs*, and *fertilizers*, which goes without saying, are an important practice within either type of agriculture as well as one of the most significant contributors to the CO2 increase.

Of peculiar importance it is to bring attention to the fact that both in big meat and small producing countries we are able to trace a statistical significance of almost the same variables. In particular, livestock production including cattle, pigs as well as the livestock price index are significant, however, in terms of cattle production, it is affecting CO_2 emissions in comparison with the big meat producers. And it is obvious, since during the 10 year period small meat producing countries produced 31 times less meat than big meat producers. As far as fertilizers are concerned, their impact is relevantly similar in both groups of countries, to be exact, their application increase by 1% affected the total agricultural CO_2 emissions by approximately .052% in both cases. However, paying attention to the fact that the plant based production in small countries is 66 times less in the 10 year period, it is important to note that similarity between the fertilizers' contribution in both sets of countries. It can also be explained by the fact that in our paper small meat producing countries are mainly developing or least developed countries. Therefore the fertilizers' quality applied there could be much worse and the overall impact on the CO_2 emissions even more detrimental.

It is worth pointing out that the vegetable production in the case of small meat producers became statistically significant compare to the other set of countries, and its change by 1% contributes to the CO_2 increase by .091% which even bigger than the *pig* production. This could be justified by the fact that in small meat producing countries, a total output of vegan products, including cereals and vegetables throughout the period 2000-2009 came out as almost 4 times bigger than the output of the animal based products (products made of livestock),

whereas in the case of big meat producers this difference came out as almost 8 times bigger (Appendix, Table 26, 27). Having mentioned that, it is interesting to note that even though the cereal and vegetable production combined accounted for almost 8 times bigger than the amount of animal production in big meat producing countries, yet the contribution to the agricultural CO_2 of *just* **cattle** increase by 1% is **3.31** times *bigger* than the contribution of *overall* **cereal** production increase by 1%. As far as the *vegetable* production goes, in *big meat producing* countries it remains even *insignificant*.

As in the case with big meat producing countries, it is interesting to trace the behavior of livestock in general with regards to the CO_2 increase in comparison with other agricultural factors (Appendix, Table 22).

Again, we are able to observe a number of statistically significant variables, in particular, livestock price index as well as crop production price index, livestock amount and fertilizers. Among all of them the highest t-value is observed in fertilizers and livestock. To be more exact, with *1% change in fertilizers*, the growth in CO_2 *emissions goes up to .053%*, however *1% increase* in the amount of *livestock* on farms and pastures, the level of CO_2 *rises up to .55%*, which is much higher than from fertilizers. For the sake of comparison, in the case of *livestock and crop price indexes*, CO2 increase by *.169 and .152%* respectively.

The obtained results are quite similar with the ones in big meat producing countries, with the only difference that crop production index became statistically significant in the small countries, as well as that the fertilizers factor's t-value is also bigger than in the case of big meat producing countries. However, it is interesting to see the situation of the CO_2 emissions with regards to the land area.

Table 23: CO_2 *emissions per unit of land (small meat producers)*

```
. xtreg lco2land llvstockpriceindex lcroppriceindex lcattle lshgoat lpigs lptry
> 1000 lfrtzr lcreal lvegble lpstre1000, fe

Fixed-effects (within) regression               Number of obs      =       320
Group variable: ctry1                           Number of groups   =        32

R-sq:  within  = 0.5725                         Obs per group: min =        10
       between = 0.0116                                        avg =      10.0
       overall = 0.0149                                        max =        10

                                                F(10,278)          =     37.23
corr(u_i, Xb)  = -0.3710                        Prob > F           =    0.0000

------------------------------------------------------------------------------
    lco2land |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
llvstockpr~x |   .3219157   .0846885     3.80   0.000     .1552036    .4886278
lcropprice~x |   .2130127   .0510827     4.17   0.000     .1124546    .3135707
     lcattle |    .215252   .0515003     4.18   0.000     .1138719    .3166322
     lshgoat |   .0682743   .0445717     1.53   0.127    -.0194666    .1560152
       lpigs |   .0712657   .0365321     1.95   0.052    -.0006489    .1431803
   lptry1000 |   .0413073   .0442303     0.93   0.351    -.0457615    .1283762
     lfrtzr  |   .0519134   .0051335    10.11   0.000      .041808    .0620189
      lcreal |   .0063432   .0109894     0.58   0.564    -.0152897    .0279761
     lvegble |  -.0880784   .0378186    -2.33   0.021    -.1625256   -.0136313
  lpstre1000 |   .0027008   .0482129     0.06   0.955    -.0922079    .0976096
       _cons |  -.7032433   .8313478    -0.85   0.398     -2.33978    .9332931
-------------+----------------------------------------------------------------
     sigma_u |  1.4898968
     sigma_e |  .11982462
         rho |  .99357342   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

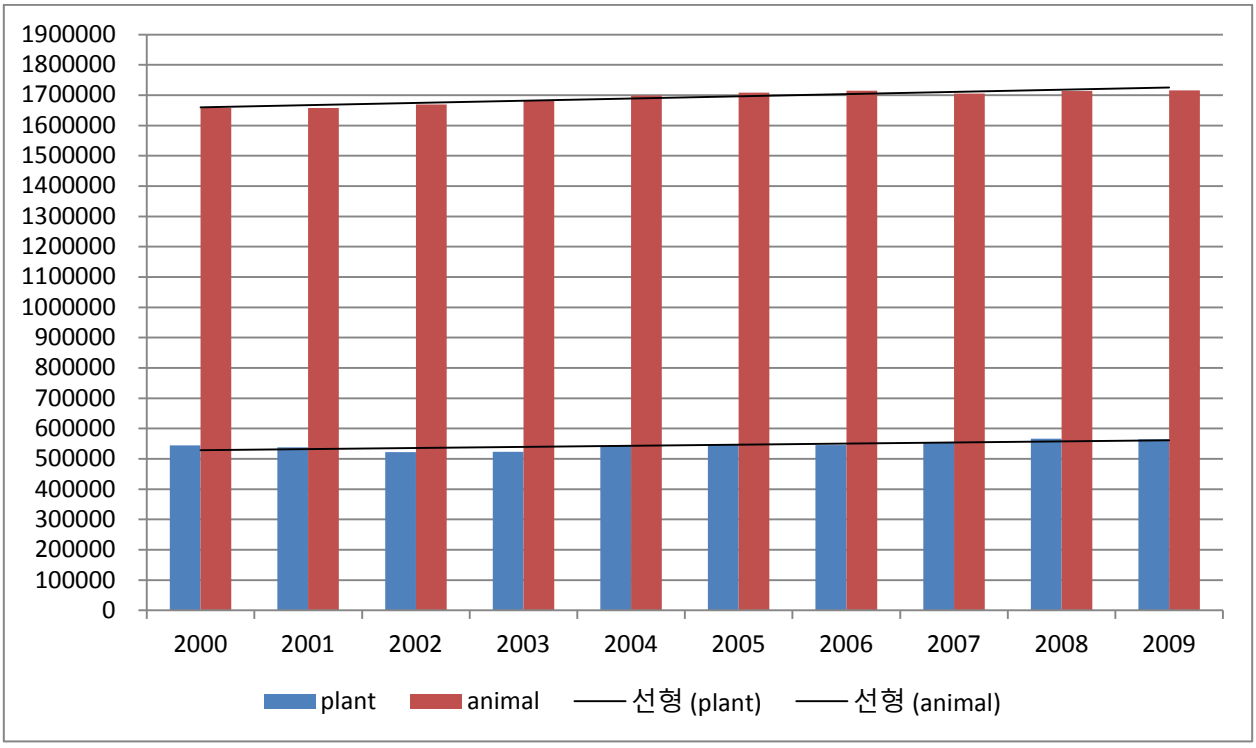
A particular pattern that has become typical throughout our analysis here shows that such variables as ruminant (cattle) production, fertilizers and prices indexes for livestock as well as crop production in this came out to be statistically significant. To be exact, with 1% increase of cattle on pastures there is .215% increase of CO_2 per HA of land, when in big meat producing countries this contribution was about .059%. Such a difference could be referred to the fact that, as mentioned earlier, small meat producers are not only developing countries, but they also appear to be much smaller in terms of land area. Therefore the cattle increase means that there might be more intensive cattle population per HA of land.

As far as fertilizers contribution is concerned, it comes about .051% each time fertilizers increase by 1%, while in big meat producing countries the similar contribution accounts for .055% increase of CO2 per HA.

Concerning the price indexes related to livestock and crop production, with 1% increase there is .321 and .213% increase of CO_2 per HA of land. It could also be noted that with the demand increase for both meat and crop production there is price increase, subsequently through the quantity demanded increasing and eventually provided, we are able to see the CO_2 emissions growth.

It is important to bring a very interesting insight regarding the overall amount of animal and plant based production in both big and small meat producing countries and the relevant amount of agricultural GHG released. According to the compiled data (Appendix, Table 26, Table 27) plant based food exceeds animal based food almost *four* times in small meat producing countries, and *nine* times in big meat producing countries. However, the GHG emission share from animal and plant based agriculture shows that the former type contributes significantly more to the GHG emissions in comparison with the latter one (Table 24).

Table 24: *Emission share from animal and plant based agriculture.*



Source: World Bank and FAO

Hypothesis 2: *big meat producing countries are more CO2 intensive than small meat producers.*

Having seen that this is particularly animal based agriculture rather than plant based one that contributes to the agricultural CO_2 emissions increase, we are able to conclude that meat consumption is more environmentally detrimental than plant consumption. However it is still

interesting to see whether we could confirm this preliminary conclusion through comparing big and small meat producing countries. To be more precise, it is of importance to incorporate a *dummy variable* and to see the exact difference in the CO_2 increase between the big and small meat producers.

Eventually it comes out as a result that on average among 73 countries, both big and small meat producers, the agricultural CO_2 is ***6.924782.*** However, once the cattle production increases by 1%, CO_2 goes up by ***.2338%,*** however is this is a big meat producing country, then it even adds up ***1.372466.*** Again, this is a good way to be able to clearly see which one of the agricultural factors has a bigger impact on the CO_2 emissions.

Every independent variable, except for the *vegetable production*, came out statistically significant with particular high significance levels from *cattle, pasture land and fertilizers*.

Table 25: Dummy variable - big and small meat producing countries

```
. xtreg lco2agrton llvstockpriceindex lcroppriceindex lcattle lshgoat lpigs lptr
> y1000 lfrtzr lcreal lvegble lpstre1000 dummy

Random-effects GLS regression                   Number of obs      =       730
Group variable: ctry1                           Number of groups   =        73

R-sq:  within  = 0.4731                         Obs per group: min =        10
       between = 0.9175                                        avg =      10.0
       overall = 0.9159                                        max =        10

Random effects u_i ~ Gaussian                   Wald chi2(11)      =   1941.26
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
  lco2agrton |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
llvstockpr~x |   .1826195   .0438379     4.17   0.000     .0966988    .2685401
lcropprice~x |   .1036737   .0341216     3.04   0.002     .0367965    .1705508
     lcattle |   .2338726   .0212962    10.98   0.000     .1921329    .2756123
     lshgoat |    .045736   .0163054     2.80   0.005     .0137781     .077694
       lpigs |   .0443659   .0100819     4.40   0.000     .0246057    .0641262
   lptry1000 |   .0860642   .0198519     4.34   0.000     .0471551    .1249732
      lfrtzr |   .0508335   .0040557    12.53   0.000     .0428844    .0587825
      lcreal |   .0317848   .0074676     4.26   0.000     .0171486    .0464211
     lvegble |   .0188515   .0234445     0.80   0.421    -.0270989    .0648019
  lpstre1000 |   .0848552   .0169508     5.01   0.000     .0516322    .1180781
       dummy |   1.372466   .1572697     8.73   0.000     1.064223    1.680709
       _cons |   6.924782   .3247066    21.33   0.000     6.288369    7.561195
-------------+----------------------------------------------------------------
     sigma_u |  .40335071
     sigma_e |  .08901016
         rho |  .95356313   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

It is interesting to see the pattern with the dummy variable, however it is also important to take all livestock animals as one variable, which eventually will simply allow us to obtain a general picture of the CO_2 behavior with regards to every major factor in agriculture. What eventually comes out as a result, is that the overall amount of livestock has the biggest t-value,

as well as the dummy variable is 1.17 which allows us to conclude that when it comes to big meat producing countries, their CO_2 emissions are significantly bigger which makes big meat producing countries more CO_2 intensive. One of the major contributors to that, as we have witnessed, is livestock based agriculture (Appendix, Table 25).

5. CONCLUSIONS

In this paper the author made an attempt to research deeper the environmental sustainability aspect, in particular, when it comes to agricultural practices and whether they have a negative impact on the environment. The emphasis was made on the two types of agriculture – animal based and plant based, and to which extent both of them have an environmental impact, as well as which type brings a significantly bigger negative environmental impact.

Besides covering the major aspects associated with the agriculture and environment, such as the pressure on natural resources, food security within the frame of livestock and plant agriculture, as well as the GHG emissions released from both agricultural types, the author considers plant based food production and subsequently vegetarian food patterns as the way to find a balance between agriculture and environment, as well as natural resource sustainability and food security. Particular attention was focused on vegetarianism as a way to bridge the gap between the sustainable food consumption and the environment.

Although there have been speculations and studies previously that plant based agriculture might be more sustainable, however to clear the uncertainty and prove the idea that it really does generate benefits in dealing with the above mentioned issues, the author has compared the countries that are considered to be big and small meat producers, including the plant production in both of those country sets. Throughout the paper we have covered and identified the following:

- plant based food production exceeds animal based food production almost four times in small meat producing countries, and about nine times in big meat producing countries (Appendix, Table 26-27).
- in the meantime, the emission share from animal and plant based agriculture is totally the opposite, in particular, GHG emissions are almost 4 times bigger from the livestock based agriculture in comparison with the other type.

- another important point to mention, referring rather to the food security issue, is the fact that about 19-27% (small and big meat producing countries) share of total plant based food is fed to the livestock.
- In terms of land, among the investigated 73 countries, about 6% of land is used for cereal or plant based food production, while about 25% of land is used for pasture (Appendix, Table 28).
- Inefficiency in terms of resource consumption – the amount of water, energy used to produce 1 kg of animal and plant based food, again related to the food security (Appendix, Table 29).
- Animal based food is bringing a detrimental impact to health causing a number of diseases, such as heart disease, cancer, diabetes, obesity, etc. Meanwhile, plant based diet contributes to low cholesterol levels, low blood pressure, lower body mass, etc.
- There is a very important ethical aspect that also divides radically plant and animal based agriculture – around 50 billion animals are slaughtered for meat consumption by humans yearly,

We have successfully conducted a regression analysis in order to test the following *two hypotheses*:

- Animal based agriculture has a bigger environmental impact than plant based agriculture.
- Big meat producing countries are larger contributors to the environmental degradation than small meat producing countries.

In the course of the regression we have come to the following outcomes:

- Among most of increasing agricultural practices, particularly CO_2 intensive are livestock production ones (ruminants specifically), as well as fertilizers application to the soil;
- Both in big and small meat producing countries we traced a statistical significance of almost the same variables – cattle, pig livestock, fertilizers, and livestock price index).

- Animal related agricultural activities contribute to bigger CO_2 emissions in comparison with the plant related agricultural activities. In particular, livestock (cattle, pigs, sheep, and goat), pasture land, are more significant than cereal and vegetable production.
- On average among the 73 investigated countries with the livestock production increase by 1%, CO_2 equivalent goes up by .2338%, however if this is a big meat producing country, it even adds up 1.372. It leads us to conclude that big meat producing countries are more CO_2 intensive.
- One of the major contributors to the above is livestock based agriculture.

The above results of the present research are able to prove the two hypotheses we had set out to test at the beginning which eventually confirms the previous assumptions and claims that animal based food production is more destructive to the environment.

However, it is of significant importance to highlight the *limitations* of the present study. In particular, the aspect of food security has been touched upon briefly, therefore it is hard to give a definite conclusion that plant based diet will contribute to the better food security. In the further research there will be a need to trace the whole food supply chain in order to confidently state the benefits of plant based food production and subsequent vegetarian food consumption patterns with regards to the hunger issues. In similar vein goes the fact of natural resources used to fit the plant food production. To be exact, if the majority of population goes vegetarian subsequently leading towards the drastic increase of plant production, how big would the land and water consumption be in comparison with the previous animal based food production. These are specific points that could be rather characterized as a gap in existing studies and need to be addressed in the further research.

If we want a sustainable world, we have to be willing to examine the powerful relationship behind the traditional agriculture, food patterns, habits, and the planet wellbeing. It has been accepted during generations, and perceived as a norm that animal products are crucial to be consumed if we are to live, and live a healthy life. However, with fast growth of the world

population, subsequent malnutrition and hunger, natural resources rapid depletion and destruction, and devastating climate change, it might be the time for the better solutions serving as alternatives to the conventional perceptions of the agricultural practices and subsequent food consumption patterns.

APPENDICES

Table 22: *Agricultural CO2 related to animal and plant agriculture (small meat producers)*

```
. xtreg  lco2agrton llvstockpriceindex lcroppriceindex llivestkthead lfrtzr lcre
> al lvegble lpstre1000, fe

Fixed-effects (within) regression               Number of obs      =       320
Group variable: ctry1                           Number of groups   =        32

R-sq:  within  = 0.6519                         Obs per group: min =        10
       between = 0.6474                                        avg =      10.0
       overall = 0.6398                                        max =        10

                                                F(7,281)           =     75.17
corr(u_i, Xb)  = 0.5079                         Prob > F           =    0.0000

------------------------------------------------------------------------------
  lco2agrton |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
llvstockpr~x |   .1694588   .0694994     2.44   0.015     .0326533    .3062643
lcropprice~x |   .1523325   .0462869     3.29   0.001     .0612194    .2434456
llivestkth~d |   .5516889   .0558858     9.87   0.000     .4416808    .6616969
      lfrtzr |   .0534839   .0046129    11.59   0.000     .0444037    .0625641
      lcreal |  -.0021455   .0098425    -0.22   0.828    -.0215198    .0172289
     lvegble |  -.0444176   .0332018    -1.34   0.182    -.1097734    .0209382
  lpstre1000 |  -.0333544   .0423856    -0.79   0.432    -.1167879    .0500792
       _cons |   5.468092   .7213888     7.58   0.000      4.04808    6.888104
-------------+----------------------------------------------------------------
     sigma_u |  .89644143
     sigma_e |  .10844114
         rho |  .98557768   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(31, 281) =   223.75                 Prob > F = 0.0000
```

Table 25: *Dummy variable – big and small meat producing countries*

B.

```
. xtreg  lco2agrton llvstockpriceindex lcroppriceindex llivestkthead lfrtzr lcre
> al lvegble lpstre1000 dummy

Random-effects GLS regression                   Number of obs      =       730
Group variable: ctry1                           Number of groups   =        73

R-sq:  within  = 0.6105                         Obs per group: min =        10
       between = 0.9234                                        avg =      10.0
       overall = 0.9223                                        max =        10

Random effects u_i ~ Gaussian                   Wald chi2(8)       =   2074.84
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
  lco2agrton |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
llvstockpr~x |   .0754259   .0361655     2.09   0.037     .0045429     .146309
lcropprice~x |   .0862526   .0288514     2.99   0.003     .0297048    .1428003
llivestkth~d |   .5892721   .0290957    20.25   0.000     .5322455    .6462987
      lfrtzr |   .0530166   .0033871    15.65   0.000      .046378    .0596552
      lcreal |   .0177182   .0064374     2.75   0.006     .0051011    .0303353
     lvegble |   .0182607   .0197837     0.92   0.356    -.0205146    .0570361
  lpstre1000 |    .039331   .0168431     2.34   0.020      .006319     .072343
       dummy |   1.171872   .1622686     7.22   0.000     .8538318    1.489913
       _cons |   4.243113   .3749641    11.32   0.000     3.508197    4.978029
-------------+----------------------------------------------------------------
     sigma_u |  .48977088
     sigma_e |  .07856568
         rho |  .97491317   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Table and graph 26: *Animal and plant based food – big meat producing countries*

year	animal products tonnes (1000)	vegan products tonnes (1000)
2000	795920.7054	2515508.031
2001	805079.8757	2560494.34
2002	827234.4665	2506101.08
2003	846760.8347	2589905.358
2004	863750.1063	2764883.863
2005	889246.6305	2759824.39
2006	916442.4721	2757219.649
2007	940445.5684	2929971.901
2008	964039.5851	3070672.78
2009	981133.279	2958328.565

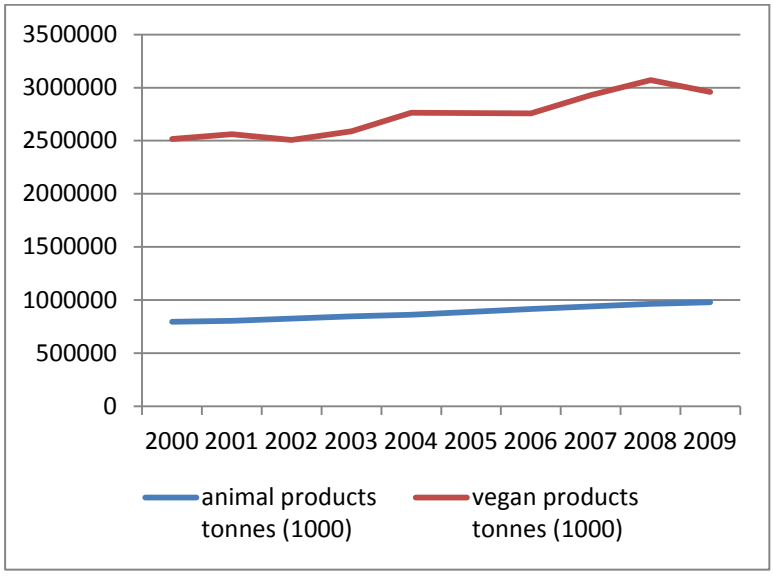


Table and graph 27: *Animal and plant based food – small meat producing countries*

year	animal products tonnes (1000)	vegan products tonnes (1000)
2000	11217.83742	41829
2001	11524.82452	40711
2002	11806.99732	41599
2003	11890.42745	41483
2004	12222.59637	45304
2005	12662.64969	47632
2006	12759.27649	47769
2007	13079.50805	48058
2008	13149.78523	56497
2009	13050.34673	59086

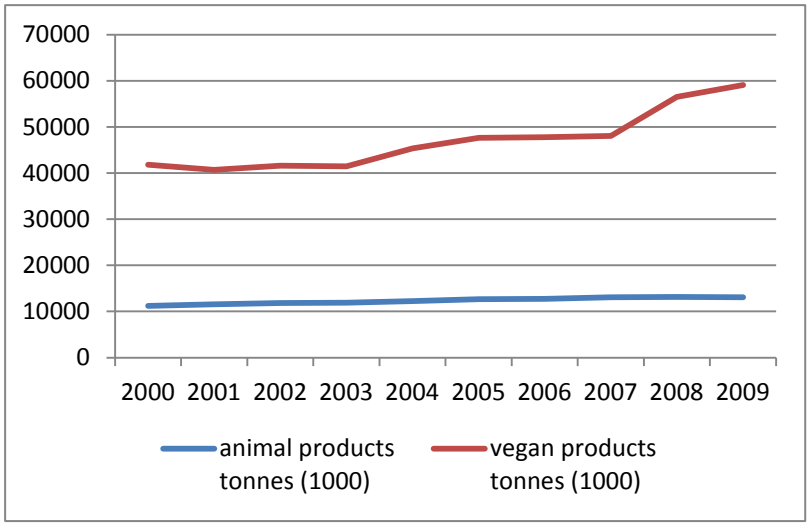


Table 28: *Land used for cereal and pasture*

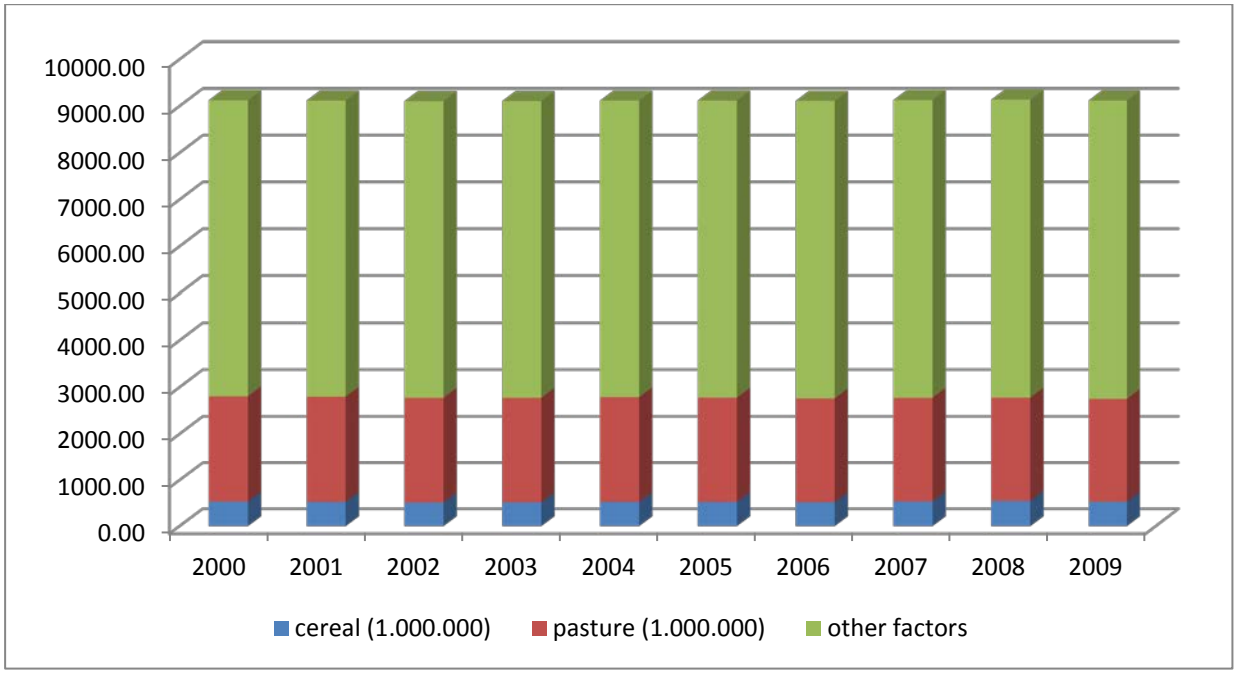


Table 29*: Inefficiency in resource consumption* (Source: UNDESA, Food and Agriculture, 2012)

Resource	Quantity	Yields
Land	1 hectare	185 kg of beef
	1 hectare	13,000 kg of potatoes
Water	500 liters	1 kg of corn (maize)
	15,500 liters	1 kg of beef
Energy	2 calories	1 calorie of soy protein
	40 calories	1 calorie of beef protein
Grains	6–20 kg	1 kg of beef

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About the author

I have been interested in the Environmental sustainability issues for the past four years. I had previously completed my first Master's degree in International Hospitality and Tourism Leadership from the University of Wales, and had worked on thesis dealing with Sustainable tourism. I gradually developed interest for investigating further the environmental challenges faced today including the climate change, global warming, nature resource depletion, and possible ways to face these challenges. Since I became vegan four years ago, I have been particularly interested in the vegetarian benefits for people, and the planet on the whole, not to mention the animals' freedom. This has brought me eventually to do my second Master's degree in Public Policy, but with the concentration in Environmental Policy, which was able to shed more light on the current burning issues in the environmental area. Combining both my personal interests in vegetarianism and deep concern about the present global issues, I tried to look at them from a different perspective, which eventually came out to be the current research. I aspire to continue work in the present area, as well as bring out and contribute further research with preferably innovative ideas to combat current global challenges.