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Article

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Amfiteatru Economic Journal

Provided in Cooperation with:

The Bucharest University of Economic Studies

Suggested Citation: Istudor, Nicolae; Ion, Raluca Andreea; Petrescu, Irina Elena; Hrebenciuc, Andrei (2019) : Agriculture and the twofold relationship between food security and climate change: Evidence from Romania, Amfiteatru Economic Journal, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 21, Iss. 51, pp. 285-293, <https://doi.org/10.24818/EA/2019/51/285>

This Version is available at:

<https://hdl.handle.net/10419/281443>

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AGRICULTURE AND THE TWOFOLD RELATIONSHIP BETWEEN FOOD SECURITY AND CLIMATE CHANGE. EVIDENCE FROM ROMANIA

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Please cite this article as:

Istudor, N., Ion, R.A., Petrescu, I.E. and Hrebenciuc, A., 2019. Agriculture and the Twofold Relationship between Food Security and Climate Change. Evidence from Romania. *Amfiteatru Economic*, 21(51), pp. 285-293.

DOI: 10.24818/EA/2019/51/285

Article History

Received: 28 December 2018

Revised: 12 February 2019

Accepted: 3 March 2019

Abstract

Nowadays, agriculture is facing a special challenge – to produce more food for a growing population, while reducing greenhouse gas emissions caused by food production. This piece of research is focused on the impact of agriculture on climate change, starting from the assumption that agriculture is affected by climate variability, but also it contributes to it by emitting greenhouse gases, under the restriction of less per capita land. The paper analyses the connection between agricultural emissions and agricultural output, using a simple regression model, which includes variables corresponding to agricultural production and to greenhouse gas emissions. The results of the research highlight the fact that agricultural production has direct effects on greenhouse gas emissions and, thereby, on climate change. The relevance of the research consists in rising awareness of the emergency to integrate climate change in policies and actions related to food security at all levels. Moreover, the paper contributes to the enrichment of scientific literature, because it presents empirical evidence supporting the different effects of agricultural practices on the environment in Romania, with implications for climate change, a scientific direction that has been little studied in other papers.

Keywords: food security, climate change, greenhouse gas emissions, agriculture

JEL Classification: Q180, Q54

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Introduction

Ensuring global food security for a world population of 7.6 billion people, and expected to be 9 billion by 2050, is a great challenge from the perspective of climate change. Agriculture has always been considered as the interface between environment and human activity, and, therefore, it holds the solution for two of the global problems: ensuring food security and maintaining the stable climatic context in which the population can live. In the last decades, the average global temperature has been increasing, mainly because of the accumulation of greenhouse gases in the atmosphere. Studies (FAO, 2008, p.1) show that the main causes are the burning of fossil fuels to meet the increasing energy demand, and the use of intensive practices in agriculture to meet the growing food demand.

Agriculture, as compared to other economic sectors, is the most affected by climate variability, by changing annual temperatures, abundant rainfall, droughts, extreme temperatures, changes in diseases and pests, changes in atmospheric CO₂, changes in sea levels which affect coastal areas, reducing, as such, the agricultural surfaces (Hoffmann, 2013, p. 3). Less immediate impacts are estimated to result from gradual changes in mean temperatures and rainfall which affect the suitability of land for different categories of crops and pasture (FAO, 2008, p.12), considering the increasing aridity and salinity, groundwater depletion etc. Conversely, some negative effects of agriculture upon the environment are soil chemical pollution, soil erosion, and greenhouse gas emissions (Ion, 2017). Some studies (FAO, 2016, p.4) report that 21 percent of greenhouse gas emissions come from agriculture. Other studies (IPCC, 2007a) show that agriculture contributed with 13.5 percent and forestry with 17.4 percent to greenhouse gas emissions in 2004. As FAO reported, the sources through which agriculture contributes to greenhouse gas emissions are carbon dioxide emissions related to deforestation, methane emissions from rice cultivation, methane emissions from the digestion process, nitrogen emissions from fertilizer management (FAO, 2012a, p.69).

Regarding the magnitude of the emissions, the major contribution comes from enteric fermentation in ruminants, 40 percent, burning crop residues, 16 percent, chemical fertilizers, 12 percent, and rice cultivation, 10 percent (FAO, 2016, p.38). Nowadays, both in the United States of America and the European Union, agriculture is viewed as the main source of air pollution (Erisman et al. 2007, Bauer et al. 2016). Results from IFPRI's (International Food Policy Research Institute) studies show that, by the year 2050, under a high emissions scenario, more than 40 million more people could be at risk of undernourishment than there would be in the absence of climate change. In this context, a deep analysis of the relationship between agriculture, as support of food security, and climate change is needed. Agriculture is important for food security because it produces food for people, and because it provides the main source of livelihood for 36 percent of the world's workforce (Istudor et al., 2014; FAO, 2008, p.9).

The research answers the questions which are the connections between food security and climate change, by analysing the impact of agriculture on climate change. The case study of Romania is discussed; in pursuing this, statistical data from FAO database and World Development Indicators have been retrieved. Forty-three observations related to the factors which influence the relationship between agriculture and climate change have been introduced and analysed using a simple regression model. When choosing the variables, the agricultural potential of this country – 12,502,535 hectares of utilized agricultural area has been considered, which represents, on average, 0.68 hectares/inhabitant (National Institute of Statistics, 2016), higher as compared to the world average area of 0.19 hectares/inhabitant (FAOSTAT, 2016). In Romania, the total greenhouse gas emissions

registered an increasing trend over the period 1970-1989, when both agriculture and industry developed and delivered to the economy large quantities of products, and a decreasing trend over the period 1990-2010, when the Romanian economy has faced recession and profound changes generated by the transition to the market economy. In present times, the total greenhouse gas emissions register 121,762 kt CO₂ equivalent, the methane emissions register 25,707 kt CO₂ equivalent, and the CO₂ emissions register 70,000 kt (World Bank, 2019).

The paper is structured into five parts. After the introduction, the literature review is presented with the final goal of providing a solid scientific basis to the main research issue presented in Section 2. Section 3 presents the data and methodology, while Section 4 presents the results of the regression models and their discussions. Finally, the conclusions of the research are drawn.

1. Review of the scientific literature

There is an increasing body of evidence that points to food security and climate change relationships. One direction is that climate change was found as one significant food insecurity drivers, besides sharp and increased food prices and demographic growth (FAO, IFAD, UNICEF, WFP and WHO, 2017). The food crisis in 2008 manifested in a 50–200% increase in commodity prices, which lead 110 million people into poverty and added 44 million more to the undernourished (Nellemann et al. 2009). In 2013, worldwide, 767 million people lived in extreme poverty (World Bank, 2016). Since most poor people spend more than 50 percent of their income on food, a slight growth in agricultural products' prices can significantly affect their levels of individual food security.

The world population reached 7.6 billion people in 2018, more than doubled as compared to its level in 1960 (FAO, 2018). A recent FAO, IFAD, UNICEF, WFP and WHO report (2017, p.5) estimates that, despite significant demographic growth, the share of undernourished people in the world decreased from 14.7 percent in 2000 to 10.8 percent in 2013, but it rose again to 11 percent in 2016. Studies show that, by 2050, when the world's population will reach 9.1 billion, and food production will increase by 70 percent (FAO, 2018, p.2), climate change could interrupt progress toward ensuring the world food security (Wheeler and von Braun, 2013). Thus, any climate change event, as demonstrated by several studies that climate variability threatens food security through negative effects on crop productivity (Popescu and Ion, 2018; Bobojonov and Hassan, 2014; Wheeler and von Braun, 2013; Briner et al., 2012), endangers food security.

The other direction of studies found in literature indicates that agriculture also contributes to climate change, through greenhouse gas emissions. Reports (FAO, 2008, p.59) found that land conversion from forest to pasture or cropland, and intensive agricultural practices are significant sources of greenhouse gas emissions. Deforestation for agriculture accounted for 17.4 percent of total greenhouse gas emissions (IPCC, 2007a), while agricultural and food processing use of fossil fuels account for only 2.4 percent of greenhouse gas emissions (WRI, 2006).

2. Research methodology

The results of the research described in the literature review section drive to the need of investigating the links between food security and climate change and the impact of agriculture to climate change. The hypothesis tested in this paper is: Food security and

climate change are interconnected, and, in the attempt to ensure food security for a growing population, agricultural production is expected to increase, so are agricultural emissions, contributing, as such, to climate change anew.

In the methodological approach we take into consideration the two research directions mentioned above, and the option is for a quantitative research carried out by the observation method and the statistical data analysis (secondary data) that covers the national and international or global level. In order to verify the proposed hypothesis, simple linear regression was used, with the variables observed, namely those corresponding to agricultural production and those that determine climate change (total greenhouse gas emissions, methane emissions and CO₂ emissions). These variables become dependent or independent, depending on the direction and intensity of reciprocal influences.

From a methodological point of view, the data processing and analysis took into account the fact that agricultural emissions are dominated by CH₄, and that CO₂ emissions are considered as indirect emissions, such as inputs and energy consumption (FAO, 2012a, p. 68). In the present study, CO₂ emissions were considered because, according to previous research, their effect could be significant, depending on farm management systems (West and Marland, 2002). The emission level is expressed in kilotons CO₂ equivalent. The data are taken from the World Development Indicators database for the period 1970-2012 and are presented in figure no. 1. A linear downward trend is observed, showing that the levels of total greenhouse gas emissions, methane and CO₂ have decreased over the period 1970-2012. On average, the total greenhouse gas emissions level is 196,075.8 kt CO₂ equivalent, the methane gas level is 32,856.1 kt, and the CO₂ emissions level is 140,587.1 kt per year.

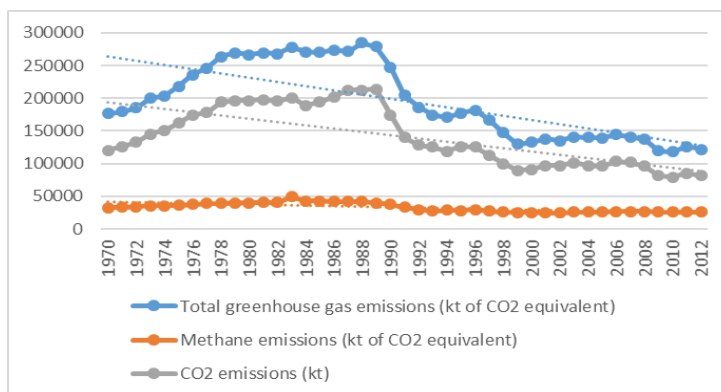


Figure no. 1: Dynamic of the total greenhouse gas emissions, methane emissions and CO₂ emissions, in Romania, 1970-2012 (kt of CO₂ equivalent)

Source: authors' calculations based on data retrieved from World Bank, 2019

The relationships of dependence between the variables are analysed with SPSS 22, using the simple regression model. The confidence interval is 95%, and the maximum error level is $\pm 3\%$. Forty-three observations have been introduced, for the period 1970-2012. The first step is to verify whether there is a dependency relationship between dependent variables, the levels of emissions, and independent variable, the agricultural output, by calculating the correlation coefficients. Simple regression models have been used to find out the intensity of the dependency between the levels of emissions and the agricultural output (Table no. 1).

Table no. 1: The influence of the value of the agricultural production (VAP) on the levels of the total greenhouse gas emissions (TGGE), methane emissions (ME) and CO₂ emissions (CO₂)

Variables	R Square	Coefficients of regression function	Standard error	Sig.
Total greenhouse gas emissions (TGGE)	0.363	0.603	0.007	0.000
Methane emissions (ME)	0.337	0.580	0.001	0.000
CO ₂ emissions (CO ₂)	0.350	0.592	0.006	0.000

3. Results and discussions

Data processing using regression models (table no. 1) shows that the results are statistically significant since the values of Sig. are below 0.05. Weak correlations have been found between the values of the agricultural production and the levels of the total greenhouse gas emissions ($R^2=0.363$), methane emissions ($R^2=0.337$) and CO₂ emissions ($R^2=0.350$), since the values of R Square are below 0.5. This means that the emissions are influenced by other factors, not only by the level of the agricultural output. Besides agriculture, carbon dioxide is released into the atmosphere from deforestation, fossil fuel use in transportation, building heating and the manufacture of cement and other goods. Methane emissions are released as a result of human activities related not only to agriculture, but also to landfills, and also from natural processes that occur in wetlands (IPCC, 2007b).

The relationship between the value of the agricultural production (VAP) and the levels of the total greenhouse gas emissions (TGGE) shows that 1-unit change in the value of the agricultural production leads to 0.603 units' changes in the same direction in the level of the total greenhouse gas emissions, under a standard error of 0.007. F-statistics is 0.000019 resulting a significant probability and a valid model. The correlogram (figure no. 2) shows that the current dataset has a positive trend, indicating a positive influence of the value of the agricultural production on the total greenhouse gas emissions.

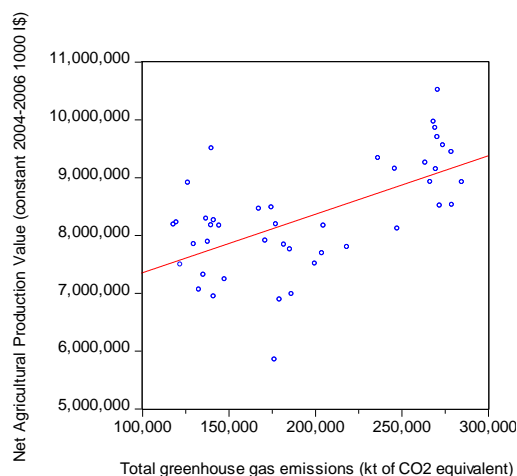


Figure no. 2: The correlation between the net agricultural production value and the level of total greenhouse gas emissions

The relationship between the value of the agricultural production (VAP) and the levels of the methane emissions (ME) shows that changes by 1-unit in the value of the agricultural production lead to 0.580 change in the same direction in the level of the methane emissions, under a standard error of 0.001. F-statistics is 0.000045, resulting a significant probability and a valid model. The correlogram (figure no. 3) shows that the current dataset has a positive trend, indicating a positive influence.

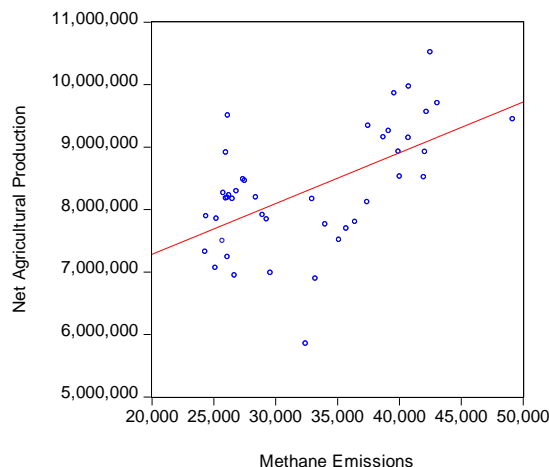


Figure no. 3: The correlation between the net agricultural production value and the level of methane emissions

The relationship between the value of the agricultural production (VAP) and the levels of the CO₂ emissions (CO₂) shows that 1-unit change in the value of the agricultural production leads to 0.592 units' changes in the same direction in the level of the CO₂ emissions. F-statistics is 0.000029, meaning that the model is valid. The correlogram (figure no. 4) shows that the current dataset has a positive trend.

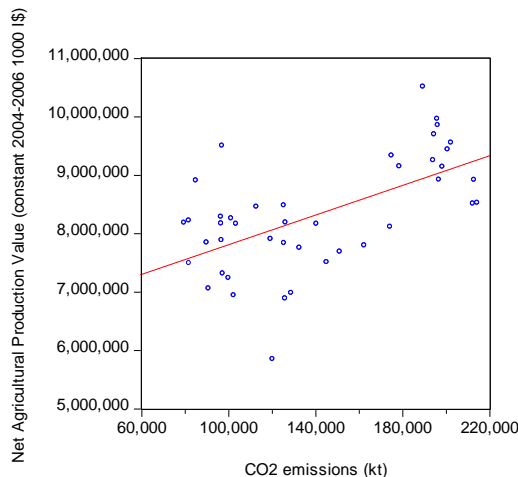


Figure no. 4: The correlation between the net agricultural production value and the level of CO₂ emissions

The results indicate that agriculture has a direct impact on climate change, but its intensity is low to medium, because the coefficients of correlations between the value of the agricultural production and the levels of emissions are below 0.5. The findings confirm the hypothesis that food security and climate change are interconnected and they are consistent to results of numerous reports and papers (IPCC, 2007a, 2007b; FAO, 2008, 2012a, 2012b, 2016). These point to the fact that climate change is affecting agriculture and food security, which will make the challenge of achieving food security more difficult (FAO, 2016). Agricultural production and food systems are particularly sensitive to climate and are major sources of GHG emissions (FAO, IFAD, UNICEF, WFP and WHO, 2018). Richards et al. (2015) found that the agricultural emissions are contributing an average of 35% of emissions in developing countries and 12% in developed countries.

Analysing the specific influence or marginal contribution of some of the observed variables (of the 43 observations made) the following were found:

- There is a strong link between agricultural carbon emissions and the conversion of forests into cultivated or grazing land, the necessary action being to reduce deforestation;
- There is a strong relationship between intensive crops and livestock farming and greenhouse gas emissions in general (GHG). Thus, carbon emissions can be reduced by streamlining agricultural practices, energy used in livestock farming and mechanized agriculture, and reducing the common practice of burning agricultural residues after harvesting, also mentioned in international reports;
- There is a medium intensity relationship between management practices that lead to increased organic carbon storage in the soil and livestock breeding. In order to meet the growing demand for food, there are solutions to improve yield growth on already grown land and to reduce the food losses between farmers and consumers, aspects confirmed in a certain form in other studies conducted internationally (FAO, 2012a, p.70; Burney et al., 2010). Under these circumstances, we believe that the solution is to increase productivity (intensive methods), not to expand agricultural land (extensive methods). Moreover, manure could be used to produce bioenergy and fertilizers, which again contributes to the reduction of methane emissions.

The results of the 43 observations of the research converge towards the idea of sustainable agriculture practices: precision agriculture, no-tillage farming, integrated nutrient management, rice growing under aerobic conditions without water retention, application of farm management models and methods to reduce greenhouse gas emissions etc., some of which are confirmed by recent research (Lal, 2013).

Conclusions

The paper investigated the complex relationship between food security and climate change, trying to identify and to explain the direction and intensity of the agriculture impact on climate change. It was found that agriculture contributes to climate change through emitting greenhouse gases, the main sources being deforestation, methane emissions from rice cultivation and from the digestion process of animals, and nitrogen emissions from fertilizers. The intensity of the impact is low to medium, considering that the values of the coefficients of correlation between the value of the agricultural production and the level of the greenhouse gas emissions are around 0.35. The econometric models resulting from the simple regression analysis of variables show that the change in the value of agricultural production by one unit leads to changes of 0.603 units in total greenhouse gas emissions,

0.580 units in methane emissions and 0.592 units in level CO₂ emissions in the same direction. Withal, it has been found that agriculture can help mitigate climate change by reducing emissions and avoiding extra carbon loss in the soil. Moreover, it has been concluded that changing food patterns and reducing food loss and waste can help mitigate climate change and thereby ensure food security.

From a conceptual point of view, research contributes to the fact that a regression model is used to analyse the intensity of the relationship between factors contributing to climate change and the level of agricultural production. From an operational point of view, it is expected that the research results will contribute to raising the awareness of the importance of integrating these factors into policy and initiative arguments at all levels, starting with individuals, local communities and extending up to national and even global organizations.

The general conclusion is that agricultural practices require change, but farmers and food producers cannot adapt themselves successfully to climate change, which is also recognized at international level (FAO, 2012a, p.15). Consequently, adaptation to climate change will require not only changes in farmers' agricultural practices but also in the actions of other actors in the agro-food chain.

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