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THE USE OF MULTIDIRECTIONAL ANALYSIS TO ASSESS THE IMPACT OF SELECTED PARAMETERS ON THE GHG EMISSIONS FROM THE AGRICULTURAL SECTOR IN THE EU

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Abstract:

Currently in the EU countries, efforts are undertaken to stabilize greenhouse gas concentrations in the atmosphere by limiting their anthropogenic emissions and setting up mechanisms to intensify their absorption. Agriculture is one of the areas of management that significantly affects the GHG emission. CH_4 and N_2O are the key pollutants, in fact they significantly contribute to climate change because of the high potential for global impact. These gas emissions largely depend on the volume of agricultural production and technology. One of the most important factors determining the scale of GHG production will be the livestock farming development. The undertaken studies have been trying to determine the correlation between GHG emissions in the EU and selected factors from the agricultural sector that may have an impact on this value. Moreover, the studies are based on the example of randomly selected countries, showing which factors are decisive in different regions of Europe. The study was conducted in accordance with a multidirectional analysis using the program R.

Keywords:

GHG, agriculture emission, R-Project, multidirectional analysis.

1 INTRODUCTION

The phenomenon of climate warming has a global scale, so it is necessary to take integrated efforts in the whole world. During the Kyoto conference, the rules were adopted and these require that the developed countries reduce aggregate greenhouse gas emissions. Greenhouse gas emissions in the European Union have declined in recent years. It is expected to further reduce emissions by commitment of all the EU Membership Countries.

In 2008, in the fourth consecutive year, emissions in the EU decreased to reach their lowest level since 1990. Greenhouse gas emissions in the EU- 27 now represent 11-12% of global greenhouse gas emissions and each EU citizen emits on average 10.2 t CO_2-equivalent every year [1]. Between 1990 and 2004 emissions from agriculture in OECD countries have increased (fig. 1).

Measures to reduce greenhouse gas emissions must include all sectors of economy, including agriculture. This is one of the branches of management that significantly increases the emissions of mainly CH_4 and N_2O. These gases are considerably higher than the rate of CO_2 warming, by absorbing heat 21-fold in the case of CH_4 and 310-fold in the case of N_2O more efficiently. Agriculture is responsible for nearly one fifth of total global greenhouse gas emissions. The conversion of land to agricultural use is one of the major global sources of GHG emissions [2].

An important challenge of our age is the adaptation of agriculture to changing climate conditions and to support actions that reduce these changes. Agriculture is in fact one of the areas of management that addresses the climate change the most. There is also a very complex system, which may play an important role in reducing the impact of these changes.

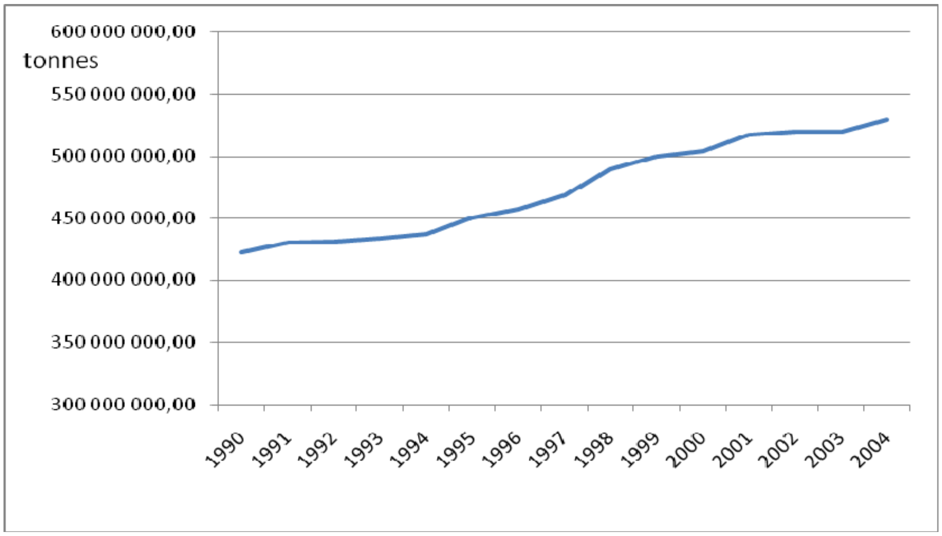

Figure 1: Total emissions GHGs in OECD countries (Tonnes CO_2 equivalent)

It is expected that in the agricultural sector one of the most important factors determining the scale of GHG production, will be the development of livestock farming. Intensive livestock production has always been and has a heavy burden on the environment because it interacts with all ecosystems.

In recent years, EU Members have significantly reduced greenhouse gas emissions, through inter alia reduction in the use of chemical fertilizers, modern cultivation of agricultural land, more efficient farming techniques, as well as by reducing the livestock population. Further improvement is expected to reduce these dangerous emissions. However, the lasting solution to the problem of emissions from farming will require a comprehensive approach to land use and farming.

Compassion in World Farming believes that the EU Member States and other developed countries with high income, should reduce production and consumption of meat and milk by 1/3 by 2020, compared to today's levels, and at least 60% by 2050 [3].

37% of total anthropogenic emissions of CH_4 come from livestock production [4]. In industrialized countries, about 15% to 18% of all greenhouse gases emitted into the atmosphere accounts for CH_4. As it is well known, the source of CH_4 emissions is largely agricultural and actually some of the main groups in this sector. First of all, it is the emission derived from ruminant enteric fermentation and secondly, emissions from livestock manure.

Among the two main greenhouse gases: CO_2 and CH_4 the third important one is N_2O. Anthropogenic source of N_2O emissions are mainly the processes of nitrification and denitrification of organic nitrogen in fertilizers and animal faeces and land use - the use of fertilizers and the natural storage of sewage sludge. In industrialized countries, the share of N_2O in the greenhouse effect is 6%. In the atmosphere it can last for about 120-150 years. A significant part of N_2O emissions come from agricultural sector. Nitrous oxide is the largest source of greenhouse gas emissions from agriculture, which globally accounts for 38% of the total emissions [5]. Emissions associated with cattle and pigs husbandry are as much as 65% of all anthropogenic emissions of this compound. Since the beginning of the industrial revolution, the N_2O concentration in the atmosphere has risen by about 16%, and thus strengthening the greenhouse gas effect from 4 to 6%. Between 1960 and 2000, the efficiency of nitrogen use for cereal production decreased from 80 to 30% [6]. Nonetheless, according to the Food and Agriculture Organization, it is expected to further increase in N_2O emissions from the agricultural sector by about 35-60% by 2030 [7]. Areas for improvement include increased use of no-till cropping, agro-forestry, and integrated crop and animal farming, as well as decreased use of external inputs in food and agriculture [8].

2 EXPERIMENTAL

The research aimed at finding a correlation between selected parameters and greenhouse gas emissions in EU countries. It showed what parameters decide on emissions in selected European countries according to the analyzed data for these selected European countries.

For the test, the factors mainly associated with GHG emissions from the agricultural sector were considered:

- Arable and permanent crop area,

- Pasture area,

- Livestock production: cattle, sheep, pigs and poultry.

The level of detail of analysis is dictated by the amount of available statistical data. Data obtained from the databases of the FAO and the OECD that and covered the period 1990-2002 [7,9].

The study is based on the multidirectional analysis, which allowed the inclusion of information on the relation between the explanatory variables. Analysis was performed using the statistical program R-Project.

3 RESULTS AND DISCUSSION

Based on the multidirectional analysis, simultaneously influences of several factors were examined on the dependent variable. The analysis was used to determine the factors most associated with GHG emissions from agriculture. Calculated value statistics refer to the critical value of F-Snedecor distribution for an assumed significance level and number of degrees of freedom.

a) UE

```
Analysis of Variance Table

Response: X.totalGHGs
              Df     Sum Sq    Mean Sq F value    Pr(>F)    
sheep          1 3.9787e+16 3.9787e+16 540.586 < 2.2e-16 ***
pigs           1 2.0069e+15 2.0069e+15  27.268 8.453e-07 ***
chickens       1 4.0552e+16 4.0552e+16 550.984 < 2.2e-16 ***
cattle         1 9.4625e+15 9.4625e+15 128.567 < 2.2e-16 ***
Pasturearea    1 1.6390e+16 1.6390e+16 222.697 < 2.2e-16 ***
Croparea       1 1.2670e+16 1.2670e+16 172.152 < 2.2e-16 ***
Residuals    110 8.0960e+15 7.3600e+13                      
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
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b) Germany

```
Analysis of Variance Table

Response: X.totalGHGs
            Df     Sum Sq    Mean Sq F value    Pr(>F)    
sheep        1 1.2897e+14 1.2897e+14 92.4462 2.77e-05 ***
pigs         1 2.7051e+11 2.7051e+11  0.1939   0.6730    
chickens     1 4.0981e+12 4.0981e+12  2.9376   0.1303    
Pasturearea  1 1.9727e+12 1.9727e+12  1.4140   0.2732    
Croparea     1 6.1004e+11 6.1004e+11  0.4373   0.5296    
Residuals    7 9.7655e+12 1.3951e+12                      
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

c) Finland

```
Analysis of Variance Table

Response: X.totalGHGs
            Df     Sum Sq    Mean Sq F value   Pr(>F)   
sheep        1 3.6069e+11 3.6069e+11 15.3242 0.007851 **
pigs         1 4.1856e+11 4.1856e+11 17.7829 0.005580 **
chickens     1 2.5871e+09 2.5871e+09  0.1099 0.751514   
cattle       1 4.7127e+11 4.7127e+11 20.0225 0.004216 **
Pasturearea  1 2.3697e+10 2.3697e+10  1.0068 0.354405   
Croparea     1 6.9256e+10 6.9256e+10  2.9424 0.137102   
Residuals    6 1.4122e+11 2.3537e+10                    
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

d) Italy

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Analysis of Variance Table

Response: X.totalGHGs
            Df     Sum Sq    Mean Sq F value  Pr(>F)  
sheep        1 4.3394e+12 4.3394e+12 11.7501 0.01401 *
pigs         1 1.6667e+08 1.6667e+08  0.0005 0.98374  
chickens     1 8.9747e+10 8.9747e+10  0.2430 0.63956  
cattle       1 1.0547e+12 1.0547e+12  2.8558 0.14200  
Pasturearea  1 4.8768e+07 4.8768e+07  0.0001 0.99120  
Croparea     1 1.2236e+12 1.2236e+12  3.3131 0.11859  
Residuals    6 2.2159e+12 3.6931e+11                  
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

e) Spain

```
Analysis of Variance Table

Response: X.totalGHGs
            Df     Sum Sq    Mean Sq F value    Pr(>F)
sheep        1 5.6054e+11 5.6054e+11  0.2980 0.6048383
pigs         1 9.9893e+13 9.9893e+13 53.1029 0.0003402 ***
chickens     1 1.7575e+13 1.7575e+13  9.3430 0.0223213 *
cattle       1 1.1512e+13 1.1512e+13  6.1199 0.0482062 *
Pasturearea  1 9.6078e+11 9.6078e+11  0.5107 0.5016623
Croparea     1 1.1001e+12 1.1001e+12  0.5848 0.4734243
Residuals    6 1.1287e+13 1.8811e+12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

f) France

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Analysis of Variance Table

Response: X.totalGHGs
            Df     Sum Sq    Mean Sq F value  Pr(>F)
sheep        1 2.0634e+13 2.0634e+13 13.4481 0.01049 *
pigs         1 1.2665e+13 1.2665e+13  8.2545 0.02831 *
chickens     1 7.8836e+11 7.8836e+11  0.5138 0.50043
cattle       1 1.3504e+13 1.3504e+13  8.8011 0.02507 *
Pasturearea  1 2.7109e+12 2.7109e+12  1.7668 0.23208
Croparea     1 3.7146e+12 3.7146e+12  2.4209 0.17073
Residuals    6 9.2061e+12 1.5343e+12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

g) Hungary

```
Analysis of Variance Table

Response: X.totalGHGs
            Df     Sum Sq    Mean Sq F value    Pr(>F)
sheep        1 2.0512e+13 2.0512e+13 69.3209 0.0001629 ***
pigs         1 1.1185e+13 1.1185e+13 37.7995 0.0008484 ***
chickens     1 5.1754e+12 5.1754e+12 17.4906 0.0057994 **
cattle       1 9.0875e+09 9.0875e+09  0.0307 0.8666492
Pasturearea  1 1.0753e+11 1.0753e+11  0.3634 0.5686844
Croparea     1 1.9268e+11 1.9268e+11  0.6512 0.4504847
Residuals    6 1.7754e+12 2.9590e+11
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

h) Ireland

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Analysis of Variance Table

Response: X.totalGHGs
             Df     Sum Sq    Mean Sq F value  Pr(>F)
sheep         1 5.4550e+10 5.4550e+10  0.1490 0.71281
pigs          1 2.2983e+12 2.2983e+12  6.2774 0.04619 *
chickens      1 5.4879e+11 5.4879e+11  1.4989 0.26672
cattle        1 1.0411e+11 1.0411e+11  0.2844 0.61302
Pasturearea   1 1.9526e+10 1.9526e+10  0.0533 0.82504
Croparea      1 8.4252e+10 8.4252e+10  0.2301 0.64842
Residuals     6 2.1967e+12 3.6612e+11
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

i) Poland

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Analysis of Variance Table

Response: X.totalGHGs
             Df     Sum Sq    Mean Sq F value  Pr(>F)
sheep         1 2.7565e+13 2.7565e+13 11.5197 0.01460 *
pigs          1 1.2802e+13 1.2802e+13  5.3498 0.06002 .
chickens      1 6.1847e+12 6.1847e+12  2.5846 0.15903
cattle        1 1.2718e+13 1.2718e+13  5.3150 0.06065 .
Pasturearea   1 1.0807e+12 1.0807e+12  0.4516 0.52659
Croparea      1 8.4227e+12 8.4227e+12  3.5199 0.10974
Residuals     6 1.4357e+13 2.3929e+12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 2: Multidirectional analysis of variance results for the EU and selected European countries.

For the F-Snedecor distribution, critical value at significance level $\alpha = 0.05$ amounts to 540.586 - for the factor "sheep", 27.268 - for the "pigs", 550.984 - for the "chickens", 128.567 - for the size of „cattle", 222.697 – for "pasture area" and 172, 152 for "crop area."The calculated value of the empirical statistical testing of variables corresponding p-value less than the assumed a significance level for all variables (fig. 2.a). For chosen European countries, it is observed that different factors appear to be more or less statistically significant (fig. 2). Generally, it can be noted that the livestock production in each case is a factor affecting for emissions.

4 CONCLUSIONS

Multidirectional analysis has the important advantage that takes into account the interdependence of many tested variables. The results showed that all of the analyzed variables were highly statistically significant for the overall emissions from EU countries. In the analysis of individually chosen countries, other factors with different intensity affected the tested variable, but it should be noted that in each case these were parameters associated with animal husbandry. Probably in those countries where the analysis identified only one factor (eg. Italy, Ireland), the emission is influenced by other variables, which were not taken into account. It is concluded that in fact in the future, the volume of livestock production will be an important factor influencing the emission of GHG from the agricultural sector.

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