**BABEŞ-BOLYAI UNIVERSITYCLUJ-NAPOCA**
**FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION**

**Phd Thesis**

# Impact of climate change on some socio-economic indicators on national and regional level. Case study: Influence of the change of meteorological parameters on crop production

**Summary**

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**Cluj-Napoca, 2011**

# Contents of the Summary

# Contents

# Keywords

Climate change
Economic impact
Yield forecasts
Change of crop production
Regional differences
National and Regional Input-Output Analysis
Adaptation options
Adaptive capacity
Territorial vulnerability
EU climate change policy

# Introduction

Investigation of climate change represents a relatively new research area. Its importance results from the fact that these changes are becoming more and more emphasized, and their impacts on different areas of life (human health, settlements etc.), on natural resources (water resources, ecosystems etc.), as well as on different sectors of economy are becoming more and more evident.

„Climate change – and its impact on how we produce and consume – is increasingly at the heart of sustainable development policy. It is, therefore, central to regional development, presenting an unprecedented challenge, but also an opportunity for Europe's regions in terms of their capacity to innovate and create new jobs." (EC, 2008b) So, climate change issues have become a major area of interest for researchers and economists.

Over the past century mean temperature in Europe increased by 0.95 ˚C, representing a faster warming than that of the global mean of Earth, which was 0.7 ˚C (EEA[1], 2004). Climate conditions became more variable. Temperatures have become more extreme and frequency of floods has increased. Economic losses caused by weather-related disasters have increased substanially in the last decades (EEA, 2004).

According to the Stern Report[2] climate change represents a unique challenge for the economy, being the biggest „market failure" that has ever existed (Stern, 2006).

Climate change actually represents a double challenge: how to reduce gas emissions that are responsible for global warming and how to adapt to the current and future climate change (EC, 2007b).

Intergovernmental Panel on Climate Change (IPCC)[3] in its Fourth Assessment Report (IPCC, 2007) presented the schematic framework of anthropogenic factors responsible for climate change formation, impacts and responses to climate change and links betwen them. This scheme represents in fact a framework for investigations concerning climate change. Clockwise links provides information regarding climate change and resulted impacts'

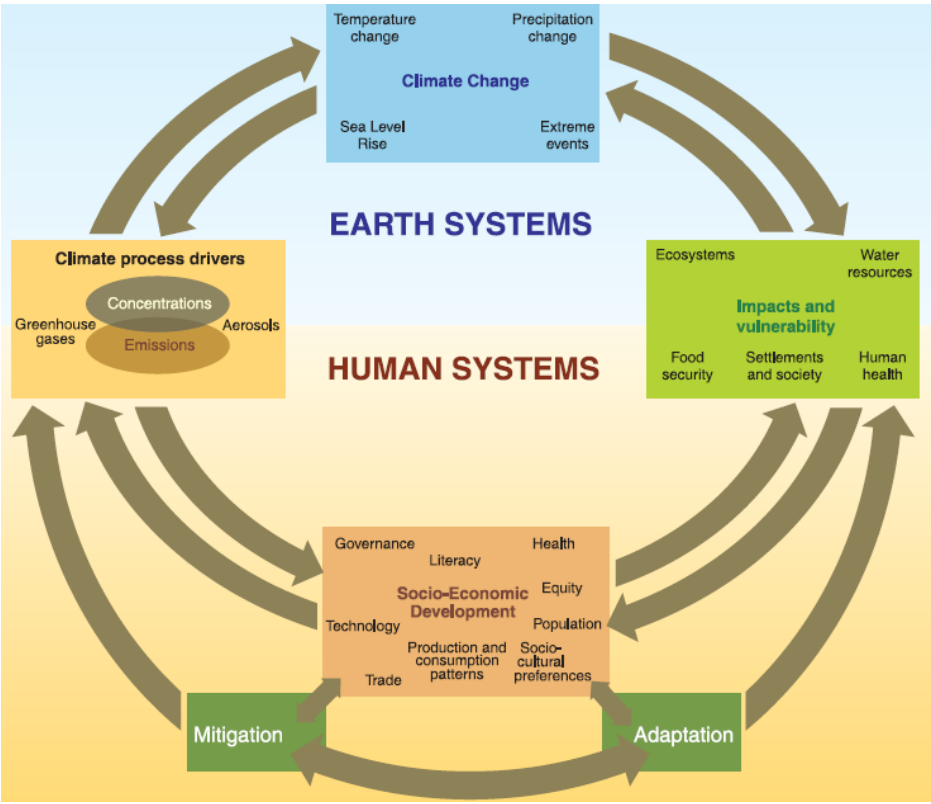
[1] European Environment Agency

[2] *Stern Review on the Economics of Climate Change* is a 700 pages report published on 30th October, 2006 written by the economist Lord Stern of Brentford for the government of UK. Report discusses impacts of climate change on global economy.

[3] IPCC was founded in 1988 by the UN. It includes thousands of researchers from all around the world. Their task is to assess existing research results and knowledge on climate change and its impacts, and to prepare comprehensive reports on a regular basis. Preparation of a report takes several years. The most recent report is the 4th Assessment Report from 2007.

assessment. In the opposite direction there can be estimated possible ways of development and global constraints regarding greenhouse gas emission, which could reduce risk of future impacts that society would like to avoid (IPCC, 2007).

*Figura 0-1*: **Schematic framework representing anthropogenic drivers, impacts of and responses to climate change, and their linkages.**




(*Source*: IPCC, 2007: 26)

My research summarized in this thesis focused on the economic impacts of climate change, on adaptation opportunities, adaptive capacity and territorial vulnerability.

Climate change is a global problem and it plays an important role in EU policies, so my research is placed on a European and global context.

My reasearch focusing on climate change had as main objective to highlight the impacts of climate change on field crop production, and thus, on the economy of the Romanian regions.

In order to achieve the primary objective of the thesis, through browsing a vast literature and especially through the use of econometric models and other quantitative methods, I searched for the answers of the following questions:

How does climate change at global, European and at the Romanian regions' level?

Which will be the impacts of climate change on agriculture and on other sectors of the economy?

How to adapt to climate change?

How can the economic impacts of climate change be quantified? Which would be the most appropriate method for my research?

Which climate change mitigation and adaptation policies do exist in the EU and at global level?

Regarding climate change issues in Romania there have been formulated the following questions:

Which climate change is expected in Romania in the next 50 years?

Which will be the impacts of climate change on Romanian crop production sector?

Which adaptation options do exist in Romanian crop production sector?

How climate change does appear in Romanian legislation and policies?

Can there regional differences in Romania regarding the impacts of climate change on crop yields be predicted?

What kind of impacts agricultural changes are going to have on the regional economy in the medium term?

What kind of regional differences do exist in Romania concerning adaptive capacity and vulnerability to climate change?

How do farmers cope with climate change impacts?

In order to achieve the goal of the thesis and to find answers to the questions above, I proposed the following partial objectives to be met during the research:

*Objective 1: Realization of a literature review on global climate change phenomena, on sectoral impacts of climate change and on general adaptation options to these changes.*

*Objective 2: Identification of methods and techniques for assessing the economic impacts of climate change, based on literature.*

*Objective 3: Analysis of EU policy objectives and measures on climate change and their role at global level.*

*Objective 4: Characterization of climate change issues in Romania based on results of some national and international research: climate change forecasts, impacts on crop production and adaptation options.*

*Objective 5: Characterization of the agricultural sector in the Romanian regions, highlighting regional differences regarding the structure of production.*

*Objective 6: Analysis of role of agriculture in the Romanian regions' economy.*

*Objective 7: Realization of forecasts regarding climate change impacts on crop production.*

*Objective 8: Realization of forecasts regarding impacts of changes in agricultural production on the regional economy in Romania for the next 10 years.*

*Objective 9: Analysis of adaptive capacity in Romanian counties and determination of territorial differences regarding vulnerability to climate change.*

*Objective 10: Ellaboration of a case study on perception of climate change by farmers in Gheorgheni Depression.*

European Commission within its framework programmes for research financed several international projects on climate change issues. One of these is the CLAVIER project - "Climate Change and Variability: Impact on Central and Eastern Europe" (2006-2009), funded within the 6th Framework Programme for research. In CLAVIER, among the 13 institutions from six European countries, there participated the BBU too. BBU research group was headed by Prof. Dr. Mária Magdolna Vincze as project director from the BBU, and I participated as a research assistant. Through the work in this project, I had the opportunity to gather experience in this field, I attended various meetings and workshops held throughout the project. I obtained climate data and methodological basis (which I developed further in the study ) used in the thesis within this project.

Thesis is divided into seven chapters, supplemented by an introductory chapter and a chapter containing the conclusions of the research.

# Research methodology

Literature review provided me a basis for conceptualizing the economic effects of climate change and information on the state of national and international research in this field. Economic assessment of the impact of climate change is a difficult task because it requires interdisciplinary knowledge from many fields (Roson, 2003).

Thus, for the present thesis, I had to review specific literature (books, articles, research reports and web pages) from the field of economy, agriculture, meteorology etc., in addition to the literature regarding the economic impacts of climate change.

Quantitative methods used in this thesis are: econometric modelling, input-output analysis, regionalization of the national input-output table and cluster analysis. In order to collect qualitative data on farmers' opinion on impacts of climate change I have also conducted a survey.

Programs used for calculations were as follows: Excel, STATA and SPSS. In order to illustrate regional results and to show regional differences, I have used ArcView, a program for creating maps.

Table 1 below presents the objectives pursued by the methods listed above, as well as a description of the quantitative and qualitative data used.

**Table 1: Research methods used in the thesis**

| Method | Objective | Data |
|---|---|---|
| Econometrical modelling | Yield forecasts for the most important crops in the Romanian development regions, in function of climate factors. | Yield data from the period 1975-2008 (NIS[4]-Romanian Statistical Yearbook 1976-2009 and Tempo Online Time Series)<br>Climate data from the period 1975 – 2020 (Climate models: REMO5.7-A1B and REMO5.7 ERA40 developed by Max-Planck Institute for Meteorology, Germany) |
| Input-Output Analysis | Impact assessment of the changes in the agricultural production on regional economy | National Input-Output Table from 2007 (NIS - National Accounts, 2010) |
| Regionalization of the National Input-Output Table | Regional Input-Output Tables on the level of Romanian NUTS2 regions using the GRIT method (Bonfiglio et al., 2006) | National Input-Output Table from 2007 (NIS - National Accounts, 2010)<br>Employment data from 2007 (NIS-Romanian Statistical Yearbook, 2008) |
| Cluster | Classification of counties by | Employment data, demographical |

[4] National Institute for Statistics

| | | |
|---|---|---|
| analysis | their adaptive capacity using different socio-economic factors | data, agri-environment data, data concerning infrastructure, GDP, education from 2000-2008[5] (NIS-Tempo Online Time Series) |
| Questionnaires | Knowing the subjective opinion of farmers from the Gheorgheni Depression on the impact of climate change and their options for adaptation | 24 questionnaires (own field research conducted in summer of 2010). |

[5] For GDP I used data from 2000-2005.

## Summary of chapters included in the thesis

Chapter 1 Theoretical and empirical studies and research on the impacts of climate change

Chapter 2 Techniques for assessing the economic impact of climate change

Chapter 3 European Union programmes on climate change issues

Chapter 4 Characterisation of the situation of climate change in Romania

Chapter 5 Study of regional differences regarding the impact of climate change on Romanian crop production

Chapter 6 Study on territorial differences regarding vulnerability to climate change in Romania

Chapter 7 Case study on the impact of climate change on crop production and farmers' adaptive capacity in Gheorgheni Depression

## Chapter 1 Theoretical and empirical studies and research on the impacts of climate change

The first chapter contains a literature review on basic concepts related to climate change: on-going climate change and forecasts, climate change impacts and adaptation options.

Based on reports of the International Panel on Climate Change (2001 and 2007) –the observed effects of climate change and long-term predictions of some climate parameters at global and European level are presented. The instruments of climate change forecast are also presented highlighting the importance of economic and demographic factors in predicting future climate change.

In the next step I present a summary of various studies and international research results about climate change impacts on the sectors most frequently studied in the reviewed literature. Thus, I have synthetized the research results on the impact of climate change on agriculture (crop production and livestock sector), fisheries, forestry, ecosystems, water resources, human health, human settlements, infrastructure, energy and tourism sectors in different regions. The most detailed analysis has been done for the agricultural sector, focusing on vegetal production.

Finally, I present concepts related to adaptation to climate change. Based on literature review definitions, classification of adaptation options and some characteristics regarding adaptation strategies and adaptation options are presented. There are enlisted the most important challenges concerning strengthening of the adaptive capacity, such as the improvement of climate models, especially in the case of the extreme events, implementation of "best practices" in adaptation measures by sharing information on their costs and benefits, enhancing collaboration at national and international level, etc. (EEA, 2005). International research projects on adaptation, assessment methods of adaptation options and funds available for adaptation in developing countries are also identified in this section.

## Chapter 2 Techniques for assessing the economic impact of climate change

After conceptual classifications, based on literature review, the main methods for estimating the economic impact of climate change are presented.

Subdivision 2.1 presents the general framework for estimating the economic impact of climate change and issues to be taken into account in impact assessment. According to the Metroeconomica report (2004) the estimation of the economic cost of climate change impact,

as well as the evaluation of the global monetary benefit of adaptation strategies must be made following the scheme below.

Figure 2-1**: Scheme for estimating the economic impact of climate change and global monetary benefit of adaptation strategies**

| Estimating the economic value of climate change impact | Estimation of global monetary benefit of the adaptation strategy |
|---|---|
| Economic value of climate change impact (monetary units)<br>=<br>Estimated climate change impact (physical units)<br>x<br>The economic value per unit of the impact (monetary units per physical unit) | Global monetary benefit of the adaptation strategy (monetary units)<br>=<br>"Efficiency" of adaptation strategy to mitigate exposure of the receiver(s) to climate change risks (physical units)<br>x<br>The economic value per unit of the impact avoided (monetary units per physical unit) |

(*Source*: Metroeconomica, 2004:8-9)

Subdivision 2.2 describes the methods and techniques most often used for estimating economic impact. According to the AGO report (2004) there are two basic levels of analysis that can be used to assess the net costs of climate change impact:

¬ partial equilibrium analysis - assessment of the costs of climate change impact on a single market or sector;

¬ general equilibrium analysis – it is applied when the effects of climate change on a single market result economic flows throughout the economy.

Techniques used in the case of partial equilibrium analysis are presented in the table below:

Table 2-1**: Methods for assessing the potential costs of climate change impact**

| Method | Directly observable market behaviour | Hypothetical market behavior |
|---|---|---|
| Direct market | Market Price<br>Preventive / recovery costs | Contingent evaluation |
| Indirect/surrogate market | Transport cost<br>Hedonic prices method | Modelling of contingent choices |

(*Source*: by Tietenberg (2000) from AGO, 2004:ES3)

In the case of general equilibrium analysis the following techniques are the most commonly used: Input-Output Analysis, Computable General Equilibrium Model and Integrated Assessment Models.

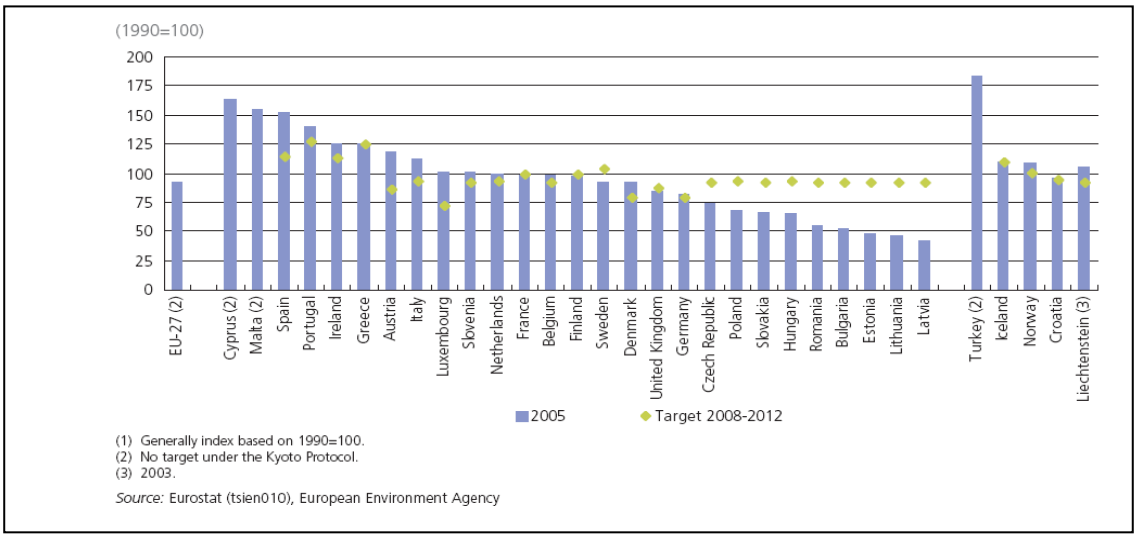
## Chapter 3 European Union programmes on climate change issues

In this chapter climate change policy of the European Union are presented. There have been identified events and documents at EU level and at global level that have played an important role in mitigating the impact of climate change or in adaptation to climate change.

Climate change policy is a part of the Community environment policy, having as main instrument the 6th Environmental Action Programme for the period 2002-2012, entitled "Our Future, Our Choice" (presented in Subdivision 3.1).

Subdivision 3.2 refers to the EU objectives and implemented measures and to the EU's role in climate change mitigation, by presenting events and important documents. Presentation of events, which played an important role in formation of EU climate change policy, begins with year 1991, when the first Community Strategy regarding limitation of the $CO_2$ emission and improvement of energy efficiency was outlined and ends with the Copenhagen Agreement.

*Figure 3-2*: **Green House Gas emission in the EU (%)**




*(Source*: Eurostat Yearbook, 2009: 419, Fig. 12.1)

Subdivision 3.3 presents in detail the two most important EU documents on adaptation to climate change: the Green Paper "Adapting to climate change in Europe - options for EU action" published in 2007 and the White Paper "Adapting to climate change: Towards a European framework for action" published in 2009.

## Chapter 4 Characterisation of the situation of climate change in Romania

Based on various national and international studies, Chapter 4 focuses on climate change in Romania. In subdivision 4.1 forecasts of meteorological factors for the next 40 years in Romania at county level, based on REMO5.7 – A1B climate model developed by the Max-Planck Institute for Meteorlogy from Germany, are presented. Climatic factors analyzed are the annual and seasonal temperature and precipitation. I illustrated the territories mostly affected by climate change on some maps.

Subdivision 4.2 presents some research results from literature (Cuculeanu et al., 1999, Cuculeanu et al., 2002, CECILIA project, report of Ministry of Environment and Water Management, 2005 etc.) on the impact of climate change on crop production in Romania, mainly on wheat and maize production in the southern and southeastern part of the country. For the rest of the country there are few research results.

In subdivision 4.3 I present the adaptation options applicable in the Romanian agriculture. Adaptation measures can be divided into two broad categories: adaptation measures for risk mitigation in agriculture (agro-technical measures) and adaptation measures for risk transfer (financial measures): some of these have already been applied in Romania.

Subdivision 4.4 describes the policy and legislation in Romania regarding climate change. The importance of human impact on climate was recognized in 1992 in Rio de Janeiro and Romania was one of the countries which signed the United Nations Framework Convention on Climate Change - UNFCCC, ratified by Law no. 24/1994. In 1997 Romania ratified the Kyoto Protocol, assuming a commitment to reduce its green house gases emissions for the period 2008-2012 by 8%, compared to the base year 1990, in order to harmonize with EU measures to reduce green house gas emissions (ANPM, 2009). Another event that has influenced the Romanian policy on climate change was the EU accession of Romania, after which many new elements were implemented in the legislation from the field.

## Chapter 5 Study of regional differences regarding climate change impact on Romanian crop production

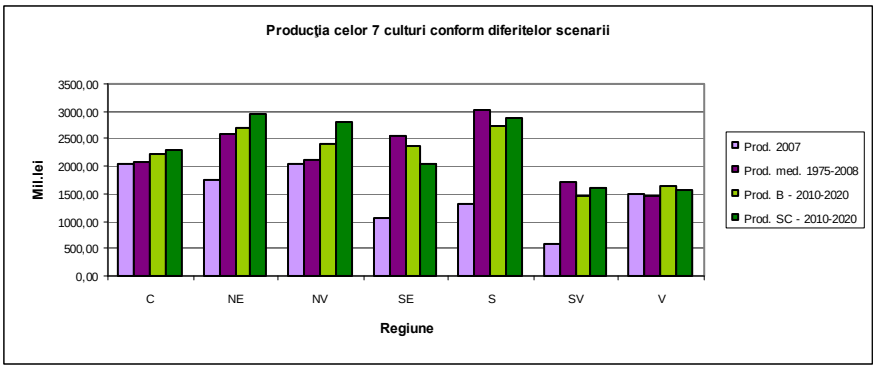
In Chapter 5 I present a comprehensive study on the impact of climate change on crop production, revealing regional differences. I effectuated yield forecast for the most important crops in Romania for the next 10 years. Based on these results I estimated changes occurring in crop production and agricultural production of the regions. Using regionalized Input-Output

Models I quantified the changes which will be produced in the economy of the regions in 2015, as compared to 2007.

In the first part of the study (subdivision 5.1) I present the characteristics of the structure and evolution of the agricultural production in the Romanian NUTS2 regions, in order to highlight regional differences. I analysed the following aspects: the structure of agricultural production, the structure of agricultural land use, the structure of the cultivated area, yield changes of the most important crops in the period 1975-2008 (wheat, maize, barley, potato, lucerne, clover, sunflower). I took into account the evolution of technological and agri-environment indicators - in order to evaluate the agricultural sector's performance in different regions and to receive a partial response to yield variations-, such as agricultural area irrigated, soil erosion control works, use of fertilisers and use of pesticides.

Subdivision 5.2 presents yield forecasts based on climatic factors for the most important crops in the Romanian development regions, for the next 10 years. I described the methodology and the econometrical models used for yield forecasts. I calculated the change in yields in the period 2010-2020 compared to the average of the period 1975-2008 and I estimated the change in the agricultural sector's output at regional level.

*Figure 5-3:* **Production of the seven crops according to different scenarios ***




(Source: own calculations based on NIS– Tempo Online Time Series and on the results of the econometrical model)

*using current prices from 2007, B – baseline scenario, SC – climate scenario.

In subdivision 5.3 I analyzed the economic impact of the changes in regional agricultural production. The methods applied are Input-Output Analysis and regionalization of the national Input-Output Table. Based on regional IO tables I analyzed the structure of the regions' total output, highlighting the role of the agricultural sector. I calculated two types of multipliers (forward and backward) for each region: these are used in the assessment of each individual sector's potential to generate effects throughout the economy. In the next step I

simulated climate change impacts on regional economy for year 2015, using regional IO tables built for 2015, based on tables from 2007.

Using output and income multipliers I calculated changes in total output and income – due to the changes in crop production caused by climate change – on the level of the regions. In the last part of the chapter I calculated the changes in the structure of regional output from resources, respectively from uses side.

*Table 5-2:* **Changes in regional output and income in 2015 compared to 2007**

| Region | Scenario | | BL | | FL | |
|---|---|---|---|---|---|---|
| | | | Mil. lei | Share in forecasted regional value (%) | Mil. lei | Share in forecasted regional value (%) |
| NW | B | O | 9922.49 | 3.8 | 18171.54 | 6.95 |
| | | V | 1274.2 | 3.07 | 2368.23 | 5.71 |
| | SC | O | 10782.87 | 4.11 | 19747.18 | 7.53 |
| | | V | 1384.69 | 3.33 | 2573.57 | 6.18 |
| C | B | O | 5255.54 | 2.01 | 4840.95 | 1.85 |
| | | V | 673.64 | 1.67 | 630.9 | 1.56 |
| | SC | O | 5343.82 | 2.05 | 4922.27 | 1.88 |
| | | V | 684.96 | 1.7 | 641.5 | 1.59 |
| NE | B | O | 15813.15 | 7.44 | 16617.17 | 7.82 |
| | | V | 2042.11 | 5.52 | 2165.65 | 5.86 |
| | SC | O | 16530.18 | 7.75 | 17370.65 | 8.14 |
| | | V | 2134.71 | 5.76 | 2263.85 | 6.11 |
| SE | B | O | 11444.47 | 5 | 11863.36 | 5.18 |
| | | V | 1474.75 | 3.99 | 1546.1 | 4.19 |
| | SC | O | 10613.7 | 4.65 | 11002.18 | 4.82 |
| | | V | 1367.69 | 3.71 | 1433.87 | 3.89 |
| S | B | O | 14282.9 | 5.3 | 15501.67 | 5.76 |
| | | V | 1829.92 | 4.63 | 2020.27 | 5.11 |
| | SC | O | 14714.96 | 5.45 | 15970.59 | 5.92 |
| | | V | 1885.28 | 4.76 | 2081.38 | 5.26 |
| SW | B | O | 11820.06 | 6.81 | 12065.43 | 6.95 |
| | | V | 1522.32 | 5.58 | 1572.44 | 5.76 |
| | SC | O | 12392.55 | 7.11 | 12649.8 | 7.26 |
| | | V | 1596.05 | 5.83 | 1648.6 | 6.02 |
| W | B | O | 5297.53 | 2.3 | 4874.93 | 2.12 |
| | | V | 675.97 | 1.98 | 635.33 | 1.86 |
| | SC | O | 5124.92 | 2.23 | 4716.08 | 2.05 |
| | | V | 653.94 | 1.92 | 614.63 | 1.8 |

*Source:* own calculations

*B – baseline scenario, SC – climate scenario, BL – Backward Linkage, FL – Forward Linkage, O – output, V – income.

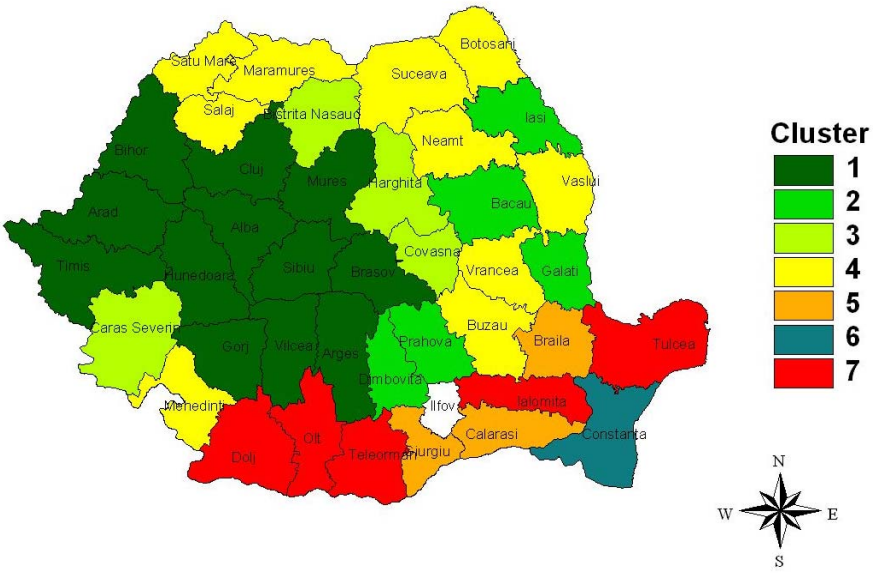
## Chapter 6 Study on territorial differences regarding vulnerability to climate change in Romania

Chapter 6 discusses issues related to territorial vulnerability. After the presentation of the most important concepts regarding vulnerability, using the research results from the previous chapters, I have characterized territorial vulnerability to climate change in different parts of Romania.

Subdivisions 6.1 and 6.2 present the concepts related to vulnerability to climate change and adaptive capacity. Subdivision 6.3 describes various methods used by researchers for vulnerability assessment, and in subdivision 6.4 there are presented the indicators for vulnerability and adaptive capacity assessment used in literature.

Based on some indicators recommended by the literature, I carried out a cluster analysis of the Romanian counties by their adaptive capacity (subdivision 6.7).

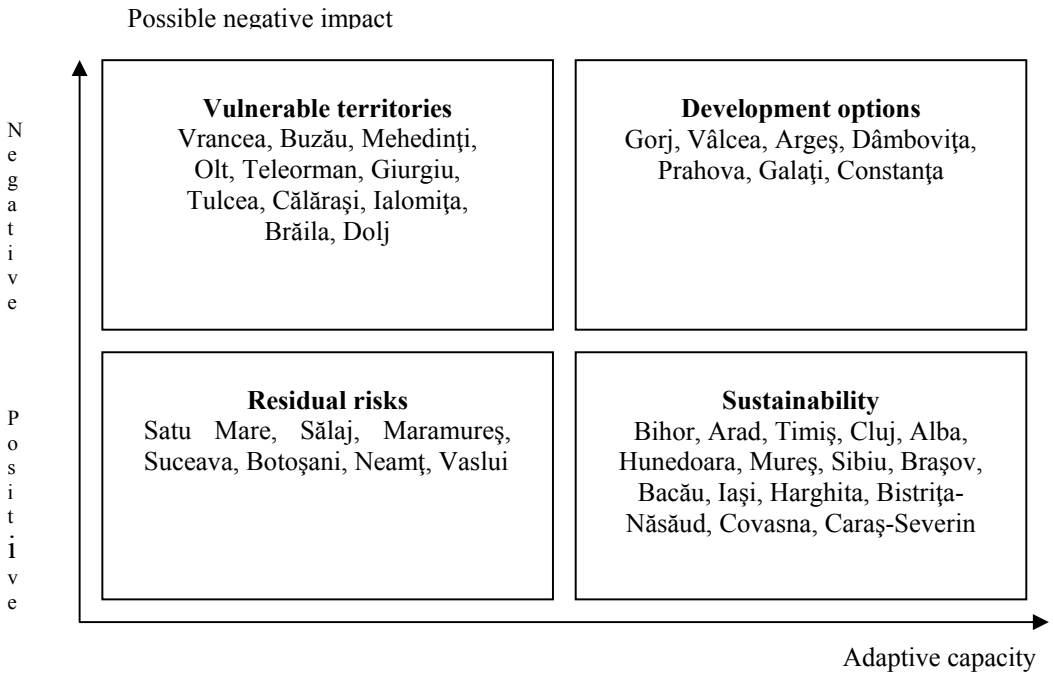
*Figure 6-4*: **Cluster analysis of Romanian counties by their adaptive capacity**




Source: own edition.

Through the classification of Romanian counties by size and direction of the potential effects of climate change (subdivision 6.6) and their classification by adaptive capacity (based on Downing and Patwardhan, 2003), I have classified counties also by their vulnerability to climate change (subdivision 6.8).

Figure 6-5: ***Classification of counties by their vulnerability***




(*Source:* own edition)

## Chapter 7 Case study on climate change impact on crop production and adaptive capacity in Gheorgheni Depression

Chapter 7 presents the results of a survey I carried out among farmers from the Gheorgheni Depression. This survey also has a „verification" role, because it refers to the experience of farmers on climate change impact and adaptation options, which were determined in the previous parts of the thesis.

Subdivision 7.1 presents the investigated area, the Gheorgheni Depression, which is among the territories with the lowest agricultural potential from Romania, mainly because of its unfavourable climate conditions. In the same time, according to the REMO 5.7 climate model, in Harghita county temperature increase is expected in the next 40 years, so theoretically the conditions for crop production will become more favourable.

The questionnaire used for the survey is divided into three parts. The first part refers to the farms studied: the size of the farms, plants cultivated, agricultural technologies applied, changes in crop yields, causes of changes etc. (subdivision 7.2). The second part (subdivision 7.3) refers to the perception of farmers on the impact of climate change and it contains questions on climatic factors (identified by farmers as being the most important), the main information sources on weather, the observed changes in climatic factors in the previous years, the description of the direct economic impact of climate change and/or extreme events

on the farm in the past and estimation of future impacts, the changes farmers intend to make in the structure of the cultivated area, the description of cases where adverse agro-climatic conditions appeared and the way how farmers reacted, the factors that will mostly influence the development of agriculture in the next 10-20 years in Gheorgheni Depression etc.

The third part of the questionnaire (subdivision 7.4) identifies adaptation options which could be undertaken by farmers, as well as the farmers' needs for a more appropriate adaptation. The questions cover the following aspects: measures farmers could take in order to adapt to climate change, the needs of the farmers to take measures to adapt to the potential effects of climate change for the next 3-5, 10 and 20 years and over, whether climate change should be considered in long-term national, local and farm-level agricultural strategies, and the studies which would be interesting for farmers.

# Conclusions

Research on climate change, on its effects, as well as on adaptation options became particularly important only in the last 10-15 years. Climate change forecasts predict significant risks in many fields and in many locations by the end of this century. So investigations on economic impacts of climate change represent an important challenge for reasearchers. Conclusions of my research undertaken in this thesis are presented below.

*Objective 1: Realization of a literature review on global climate change phenomena, on sectoral impacts of climate change and on general adaptation options to these changes.*

**Climate change**

According to the Fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC, 2007) the Earth's surface mean temperature has risen by 0.76 ° C compared to 1850. Warming in the last 50 years is caused with very high probability by the greenhouse gas emissions resulted from human activities as burning fossil fuels (coal, oil, gas), forest destruction and degradation and others.

Climate models used for climate forecasts are characterized by high uncertainty. According to the latest report of IPCC (2007), which contains the findings of the most important models, global temperature will increase by 1.1 – 6.4 ºC by the end of this century.

Warming will be greater in higher northern latitudes and it will be lower over the South Ocean (near Antarctica) and the northern part of North Atlantic. At global level extreme events, such as heat waves and heavy rainfalls, will become more frequent.

Climate change has significant effects on economy, but simultaneously economic activities also influence intensification of climate change.

**Impacts**

According to literature climate change impacts on the following sectors and fields are considered as being the most important: agriculture (crop production, livestock, forestry, fishing) / food production, biodiversity, water, human health, infrastructure and human settlements, energy and tourism. Chapter 1 summarizes - based on the literature - the international research results regarding these sectors.

Crop production is directly affected by temperature and precipitation, extreme climatic events (floods, droughts, storms, etc.) and increased concentration of $CO_2$ in the air. Difference between climate models and crop estimation methods used by different researchers led to different results on the forecasts regarding the changes in the agricultural production in

different regions of the world. For example, by the end of this century some scientists predict an overall decrease of 26% of global crop production, while others forecast only a drop of 0.07% (Reilly et al., 1998).

**Adaptation**

Anticipation of impacts and adaptation represents a challenge for every nation, and it requires action on all levels, both in the public and private spheres (Burton, 2006). The most important challenges which should help the adaptation process are the following: improvement of climate models, implementation of „good practices" in adaptation measures, strengthening the coordination and cooperation at national and international level in order to ensure consistency of adaptation measures with policy goals and appropriate allocation of resources (EEA, 2005).

*Objective 2: Identification of methods and techniques for assessing the economic impacts of climate change, based on literature.*

Chapter 2 presents methods and techniques for assessing economic impacts of climate change. The main studies cited in this chapter are the AGO (2004) and Metroeconomica (2004) reports. According to these documents in case of future impact assessment it is recommended the utilization of a *dinamic baseline scenario* in order to describe future without climate change. According to this scenario the socio-economic, physical, environmental and other conditions – which are relevant regarding the sector or region analyzed – are changing also in the absense of climate change. Climate change should be included in this framework. Taking into consideration this recommandation, in the case study presented in chapter 5 for assessing economic impacts, there were created two scenarios, out of which one is the baseline scenario and the other one the scenario which includes impacts of climate change.

Techniques used in the literature to assess the economic impacts of climate change can be divided into two groups: techniques used for partial equilibrium analysis respectively for general equilibrium analysis.

Application of the techniques from the first category is based on the assumption that climate change impacts on a particular market won't have significant indirect impacts on prices of goods and services in the macroeconomic flows.

According to Kates et al. (1985), impacts of climate change are too broad to be limited to one industry or region, so their analysis requires a general equilibrium approach. In the case

of the general equilibrium analysis, inter-sectoral reallocation of resources that occurs as a consequence of climate change can be taken into consideration. Using this type of analysis there can be investigated impacts on input-output structure of the economy, which can not be captured by partial equilibrium analysis. According to Perrels et al. (2004) climate change primarily affects production, but - among others - employment too, so incomes may change therefore due to the changes in conditions of production and competitiveness of various sectors and countries. Thus, in my empirical research (Chapter 5), these impacts on these two aspects - production and incomes – are going to be analyzed in details.

The most important techniques in the case of general equilibrium analysis are the *Input-Output Analysis* (IOA) and the *Computable General Equilibrium models* (CGE). Strengths of IOA and CGE models are: delimitation of sectors sensitive to climate change; comprehensive management of resource flows; ability to follow the multiplier effects; socio-economic dimensions, which provide the ability to perform analysis of impacts' distribution etc. IOA's major weakness is the lack of standard statistical properties, its static character and the assumption that the changes induced by climate factors are determined solely by technical side of production. At the same time, easiness of application and detailed form of input-output models can compensate disadvantages mentioned above (Rose et al., Kates et al., 1985, Semerak et al., 2010). Thus, I decided to use the IOA for my research.

*Objective 3: Analysis of EU policy objectives and measures on climate change and their role on global level.*

Climate change policy is a part of the Community's environmental policy, having as main instrument *The 6th Environmental Action Programme* (2002-2012). It identified four priority areas of the environmental policy, out of which one is the climate change.

EU activities related to climate change can be divided into two categories: actions to mitigate climate change and actions to adapt to climate change.

In the first category we mention the Kyoto Protocol adopted in 1997 at the United Nations Framework Convention on Climate Change conference of UN[6] under which each country which signed the Protocol assumed that will reduce its greenhouse gases emission by a certain percentage in the period between 2008-2012 compared to 1990, so that the total emission of countries to fall by 5% below the emission levels from 1990. Percentage established for Romania was 8%. After Kyoto there appeared a lot of initiatives, measures and

[6] United Nations

regulations at EU level to moderate climate change, but currently there exist only a unilateral commitment according to which EU is committed to reduce its GHG emissions by at least 20% by 2020 compared to 1990 whether an international agreement will be established or not.

In order to limit global average temperature increase below 2 °C, in March 2007, at European Council Heads of State and Government of EU Member States have offered to set a new target: to reduce emissions by 30%. The condition was that under a future global agreement, other developed and developing countries with high GHG emission to undertake to reduce their emissions according to their responsibilities and their capacity. This agreement should come into force in early 2013 when the current commitment period, the obligations of Kyoto protocol will expire. Negotiations to establish a new agreement continue and it is hoped that the parties will reach consensus quickly.

Regarding the adaptation to climate change EC has two key documents: Green Paper "Adapting to climate change in Europe - options for EU action" from 2007 and White Paper "Adapting to climate change: Towards a European framework for action" from 2009.

*Objective 4: Characterization of climate change issues in Romania based on results of some national and international researches: climate change forecasts, impacts on crop production and adaptation options.*

**Climate change**

Climate model used in this thesis (REMO5.7 - A1B) forecasts a 1.5 ° C average temperature increase and a 3.8% precipitation decrease for Romania during the period 2021-2050 compared to 1961-1990. The highest temperature increases will appear in the South, Southeast and Southwest regions, generally in autumn and winter months. Highest precipitation decrease will appear also in these regions, especially in the summer months (in some counties reaching a decrease of almost 30%).

**Impacts**

In subchapter 4.2 I collected crop forecast results for Romania which appear in different studies and articles. According to the EU Green Paper on adaptation to climate change (2007), crop production in Romania will benefit from climate change by the end of this century. Forecasts show a crop production growth of 15-30% in Transylvania, Dobrogea and Moldova. In the southern part of the country, however, a change between -5% and +10% is projected.

Cuculeanu et al. (1999) estimated the effect of doubled atmospheric $CO_2$ concentration on wheat and maize yields in 5 locations in the southeast part of the country, for a by 3.9 - 4.4 °C average temperature increase. According to his research wheat yields will increase by 2%-34%, non-irrigated and irrigated maize yields are expected to change by -17 % - +119%. Within the CECILIA project there were forecasted changes of wheat and maize yields caused by climate change for the period 2020 - 2050 compared to 1961 - 1990 in six locations of the Southeast region. According to this research wheat yields are going to increase by 8.5% - 58.9%, while maize yields will drop by 1.7% - 33.4% (Mateescu and Alexandru, 2009).

Although wheat yield increases are forecasted in the southern part of the country, scientists generally add that extreme events shall be considered as significant risk factors, especially in the south of the country. According to the *NEPA*[7]*'s Annual Report on State of Environment in Romania - 2007*[8] (ANPM, 2008b) drought affected areas have expanded in the last decades in Romania, the most vulnerable territories being those from the southeast part of the country. Droughts and floods will lead to economic losses in agriculture. According to the report of of Ministry of Environment and Water Management (MMGA, 2005) realized under the UNFCCC, in Romania the highest vulnerability of crops occurs in the Plain of Muntenia and in Dobrogea, and the lowest vulnerability appears in central and northern parts of the country.

**Adaptation**

Adaptation strategies to reduce risk implications arising from climate change and extreme events can be grouped into three broad categories: risk mitigation, risk transfer and management of residual risks.

The first category includes those agri-technological activities that can mitigate crop production risks caused by climate change, such as: changing altitude of production areas, plant diversification, changing the sowing period, changes in fertilizer use, changes in irrigation systems, cultivation of new hybrids, changes in land management, changes in the activities taken against disease and insects, changing the plant density, mechanization, information about weather and climate systems and so on. All of these measures can be applied in Romania.

The second category – adaptation measures for risk transfer – includes mainly financial measures, such as futures contracts for combating the price or production risk,

[7] National Environmental Protection Agency
[8] *Raportul Anual Privind Starea Mediului în România - anul 2007* al ANPM

wether derivatives, insurances for reducing production risk and so on. Currently, in Romania only *traditional insurance* of agricultural production is available from this category, but there is another type of insurance that could also be applied: the *index based insurance*, according to which compensations are based on some indexes, which are related to climatic factors (e.g. if precipitations during the period insured are below a pre-determined level, regardless of crop yields, the insurer will pay), and not on farm production.

**Legislation**

The most important milestones regarding the formation of the Romanian law on climate change are the following: in 1992 in Rio de Janeiro Romania was one of the countries that signed the UNFCCC. In 1996, there was established the *National Commission on Climate Change*, whose work is coordinated by the Ministry of Environment and Sustainable Development. In 1997, Romania has ratified the Kyoto Protocol, assuming the commitments to reduce its green house gas emissions by 8% in the period between 2008 and 2012 compared to the base year 1990 (ANPM, 2009). In 2005, Romania's *National Strategy on Climate Change (NSCC)* was ellaborated, which defined policies in meeting international obligations under the UNFCCC and the Kyoto Protocol, as well as Romania's national priorities regarding climate change. In 2008 the *National Allocation Plan* was approved, which established the number of green house gases emission allowances for the period 2008-2012 (ANPM, 2009, ARPM Bacău, 2009).

In order to fulfill the commitments undertaken at European and international level under the Kyoto Protocol, in 2008, the development of the *National Strategy and Action Plan on Climate Change* has begun. Also in 2008, there was developed the first Romanian guide on adapting to climate change *(Ghid al României privind adaptarea la efectele schimbărilor climatice)* (ARPM Bacău, 2009, ANPM, 2009*)*.

According to NEPA publications, future actions on climate change in Romania will be the following: implementation of directives from the EC's "Energy - Climate Change Package", revision of NSCC 2009-2012 in order to fulfill Romania's obligations concerning UNFCCC and the Kyoto Protocol (Proorocu, 2010).

*Objective 5: Characterization of the agricultural sector in the Romanian regions, highlighting regional differences.*

In Romanian development regions (excepting the Bucharest region, which was excluded from the analysis due to its almost negligible share in the country's agricultural production), share of crop production in agricultural production (ranging between 55% - 65%) exceeds the share of livestock production and share of agricultural services taken together. Share of agricultural area in total area varies between 56% and 69% in the Romanian regions and its structure shows regional differences. For example, share of arable land in South-Muntenia, Southeast and Southwest Oltenia regions in 2007 was 73.8% - 78.5%, while in Center and Northwest regions it was much lower (40% and 49%).

Wheat, maize, barley, potato, sunflower, lucerne and clover are the most important crops in Romania, together occupying about 75% of the arable land in each development region, but their share varies significantly from one region to another. Wheat and maize are the most important crops in each region, but their share shows significant regional differences. Share of sunflower is significant in the Southeast, South - Muntenia and Southwest Oltenia regions, while in other regions it has very low weight. Shares of potato, lucerne and clover are more significant in the Northwest, Center, Northeast and West regions.

Crop yields also show significant regional differences, which arise from factors such as climatic conditions, geographical location, topography, soil type, level of economic development and others. Based on some calculations I noticed that generally South, Southesat and Southwest regions are characterized by the highest yield variability in the last 35 years. Cause of these high differences is that these areas are the most favourable for crop production, but they are also the most affected regions by natural hazards, especially by drought. For example, generally in the period 1975-2008 maize yields were the highest in the South and Southeast regions (3.34 t/ha, resp. 3.39 t/ha) and the lowest in Northeast and West regions (2.73 t/ha, resp 2.89 t/ha). At the same time variation coefficient of maize yields was the highest in Southeast and Southwest regions (39 %, resp. 37%) and the lowest in Northeast and West regions (20%, resp. 21%).

In order to evaluate the performance of the agricultural sector in development regions regarding the applied agricultural techniques, I used technical and agri-environment indicators. These analyses helped me to explain partially yield trends in some regions. Share of irrigated agricultural area in total agricultural area is much higher in the South (50%), Southeast (50%) and Southwest regions (30%) than in the other regions (in Northeast region it is below 10%, in other regions is below 5%). Share of area reclamed with soil

erosion control works is highest in Northeast region (30%), followed by Northwest region (20%) and at the last places are West and South regions (5-10%).

It can be noticed that share of areas where chemical and natural fertilisers were applied is the highest again in the Southeast, South and Southwest (60%-70%) regions and the lowest in Center and Northwest regions (35%-50%). Share of surfaces where there were applied pesticides is the highest in the South, Southeast, Southwest and West (30%-40%) regions, while in the other three regions this share were below 20%.

Consumption of fertilizers and pesticides has dramatically decreased after the collapse of agricultural cooperatives in 1990. Between 1990 and 2008 it can be observed a significant overall decline in development regions, which led to negative impacts on yields. Highest decreases appeared in South, Southeast and Southwest region.

*Objective 6: Analysis of role of agriculture in the Romanian regions'economy*

According to Hughes (1995) IO analysis can be used particularly to characterize the structure of national or regional economy and to estimate the secondary effects that may arise from the change in the activity of a sector. In Romania, National Institute of Statistics publishes annually an input-output table at national level. Using GRIT method taken from the REAPBALK (EC-FP5) and the CLAVIER (EC-FP6) projects, I regionalized the most recent national IO table (from 2007) for each development region of Romania (Subchapter 5.3.1).

Analyzing the economic structure of regions based on regional IO tables (which include 10 aggregated sectors) we can conclude the followings: in each region *Manufacturing* sector has the highest importance regarding the production of goods and services. Its share in total regional production is ranging from 39% in the Southwest region up to 60% in the Center region. Highest share of *Agriculture, hunting and sylviculture, Fishery and Pisciculture* sector in production of goods and services appears in Northeast (12%) and Southwest (10%) regions. The lowest share in regional production in each region do have the following sectors: *Trade* together with *Hotels and restaurants* (2.3%) and *Public administration and defence* together with *Education* and *Health and social assitence* (1%).

Analyzing the structure of agricultural output (together with *Forestry, Hunting, Fishing and Pisciculture*) from the resources' side, there can be observed that share of primary inputs is higher than share of the intermediate inputs, and it ranges between 59% (in West region) and 67% (in the Northeast region). Greater part of the total agricultural branch production is consumed by the final demand and not by the intermediate consumption. Share

of final demand in total output varies between 56% (in West and Center regions) and 66% (in the Northeast region). So, any changes which appear in production of this sector may directly affect people's welfare.

Calculating backward and forward linkage coefficients I observed the following: sectors with highest potential to generate regional outputs generally in the development regions are *Manufacturing*, *Mining and quarrying*, *Trade* together with *Hotels and restaurants* and *Real estate tranzactions, renting services and services activities mainly rendered to enterprises, and other collective, social and personal services* and *Electric and thermal energy, gas and water* sectors. Sectors with highest potential to generate regional income are *Trade* together with *Hotels*. However, they will also be affected by climate change impacts on agriculture, through their connections – which are reflected in RIOT[9] too – with this sector.

*Objective 7: Realization of forecats regarding climate change impacts on crop production*

In order to effectuate yield forecasts for the most important crops for the period 2010-2020 and to simulate economic impacts of changes in crop production, I applied the methodology used in CLAVIER project and I upgraded it.

Considering the period between 1975 – 2008 as reference period and making yield forecasts for the period 2010 - 2020, it can be observed that in general – at the majority of the crops – there will appear positive changes in the Northwest, Northeast, Center and West regions, but in the southern part of the country, in South-Muntenia, Southwest Oltenia and Southeast, generally, yields will be lower.

According to the baseline scenario (when I did not take into consideration climate factors, only the tendency of the yields were determined) an upward tendency appears in the case of wheat, maize and barley yields in the Northwest, Northeast, Center and West regions. In the next ten years in these regions wheat yields will increase by over 10%, maize yields by 20-30% and barley yields by 2-6%. Situation will be reversed in the case of South, Southeast and Southwest regions, where general downward trends appear in the case of the above mentined crop yields. In the period 2010-2020, wheat yields will fall by 1-14%, maize yields by 9-26% and barley yields by 9-24%, compared to 1975-2008. Potato yields, excepting the Northwest and Northeast regions, are characterized by an increasing trend, with a value of 3-

[9] Regional Input-Output Table

17%. In case of lucerne it appears a growing trend in the Northeast, Center and West regions. In other regions yields will decline. Clover yields can be characterized by a negative trend in the Northwest region and by positive trend in the West, Northeast and Center regions. Sunflower is characterized by negative trend in the South, Southeast and Southwest regions, while in the Northwest region a positive trend appears.

Situation will change if we take into consideration deviations of yields from the trendline due to the climate change. The significant regional differences regarding yield changes are obvious. For example: according to the climate scenario in 2010-2020 wheat and maize yields will be above the average of the period 1975 - 2008 in the Northwest, Northeast, Center and West regions (with 3-26% in the case of wheat and with 5-35% in the case of maize) and significant yield decreases will appear in the other regions (in the Southeast and Sothwest regions maize yields will decrease by almost 20%, in South and South-East regions wheat yields will decrease by 10%). Potato yields show a significant increase in the Northwest (by 35%) and Center (by 30%) regions, while in the Southwest region they will decrease almost 18%.

I assumed that the share of crop production and animal production, and size and structure of the cultivated area in development regions remain unchanged, and I assumed furthermore that the only effective variable is the yield of the 7 analyzed cultures. Then, I compared production of these crops and agricultural production (both at regional level and in monetary terms[10]) from 2007 (the year we have the most recent regional IO table from) to those estimated for year 2015[11] (for which I have created regional IO tables).

The *baseline scenario* foresees an increase of 9-17% in production of the 7 crops in Center, West and Northwest regions, which represents an increase of 2.8 - 4.7% in regional agricultural production. Climate scenario predicts a 3% -35 % in increase in output of the 7 crops, which represents a 1% – 9.6 % increase in the output of the sector. In the case of South, Southwest and Southeast regions, according to both scenarios, output of the 7 crops will be much higher, representing a 10% – 20% increase of the agricultural branch production.

These results can be explained by the fact that 2007 was an extremely bad year in the case of the South, Southwest and Southeast regions (yield of some crops was 10 times lower than in previous years).

[10] Using current prices from 2007

[11] I used crop yields as the average of yields from the period 2010 – 2020. This is explained by the fact that it is not recommended to use yearly climate data, because in the case of model data it has to be used the mean of minimum 10 years. So, if we want to obtain yield forecasts for 2015, we have to take the mean of the above mentioned period.

So, I made a further comparison, using average yields from the period 1975 - 2008, the other conditions being similar.

In this case there appear more moderate changes. According to the *baseline scenario* in the South, Southwest and Southeast regions production of the 7 crops will decrease by 7-15%, which represents a 2-6% a decrease in regional agricultural production. In the other regions production of the selected crops will increase by 4-14%, which means an increase of 1-4% in regional agricultural production.

According to the *climate scenario* the highest increase in the production of the 7 crops and in regional agricultural production will occure in the Northwest (31.5% resp. 8.7%) and Northeast regions (13% resp. 3.7%). There will appear increases also in the Center (11.4% and 4.5%) and West regions (6% and 1.6%). Significant decreases will occur in the Southeast (20.7% for selected crops, 6.6% of total production) and more moderate declines in Southwest (6.2% and 1.9%) and South regions (4.3% and 1.4%).

*Objective 8: Realization of forecasts regarding impacts of changes in agricultural production on the regional economy in Romania in the next 10 years.*

Forecasts on impacts of changes in agricultural production on regional economy in Romania for 2015 were made using regional input-output tables. In order to introduce forecasted changes in regional agricultural production in IO tables I have applied the methodology used in the CLAVIER project. Regional IO tables (with 10 x 10 sectors) were multiplied by a „shock vector" (having dimension: 1 x 10 for rows, and 10 x 1 for columns). Elements of this „shock vector" show changes forecasted in the agricultural output from 2007 to 2015. After this operation I obtained regional IO tables for 2015, including new values of elements of intermediate consumption, the final consumption and final payments (subchapter 5.3.3). Based on these tables I reached the following conclusions.

Based on calculations I observed that the largest increase regarding the share of agricultural production in regional output in 2015 compared to 2007 will occur in the South, Southeast, Southwest and Northeast regions. Cause of this fact is, at first that 2007 was a very bad year in terms of crop production in the regions mentioned above.

Due to the modifications in final demand of the agricultural sector caused by climate change it will appear a 2.05 - 7.75% increase in total output of the development regions in 2015 compared to 2007. The highest changes occur in the Northeast (7.75% in the case of output and 5.76% in the case of incomes) and Southwest (7.11% in output and 5.83% in

incomes) regions. The smallest changes occur in the Center (2.05% resp. 1.70%) and West regions (2.23% resp. 1.92%).

Regarding the changes in primary inputs of the agricultural sector caused by the climate change, the highest increases occur in the Northeast (8.14% in the case of output, and 6.11% in the case of incomes) and Northwest (7.53% resp. 6.18%) regions. The lowest changes appear in Center (1.88% resp. 1.59%) and West (2.05% resp. 1.80%) regions.

According to the climate scenario there can be observed a (-2%, +2%) change in the structure of total output and in the structure of incomes in 2015 compared to 2007 in each region. Increase of the share of the agricultural sector in total regional output will range between 0.04% (in West region) and 1.93% (in Southwest region).

Analyzing changes regarding the share of the sectors in total incomes from 2007 to 2015 the following changes can be noticed: share of agriculture will increase in each region, lowest increase appears in West region (0.03 %) and highest one in Southwest region (1.63 %).

Analyzing changes in structure of sectoral consumption and resources, it can be observed that in Romanian regions agriculture will need with 0.1 - 2% more resources in 2015 than it did in 2007. Simultaneously, demand for agricultural products will increase by 0.2 - 2%. Highest increases will occure again in the South, Southeast, Southwest and Northeast regions.

Based on reginal IO table from 2015 I recalculated forward and backward output and income multipliers. Changes from 2007 to 2015 are almost negligible in each region.

The above presented results show that climate change can generate significant impacts on regional goods' and services' production and welfare through its impacts on crop production. Due to climatic conditions, one year may be unfavourable for a region in terms of crop production, and at the same time it may be favourable for the other one. However, summing up impacts on national level we can conclude - wrongly - that the analyzed year is a normal year in terms of crop production. I highlight that in assessing climate change impact regional differences can not be neglected. I mention that numerical results based on modeling need to be addressed with some reservations, due to the incertainties in climate change estimations.

First of all, it has to be noted that climate change represents only one dimension of potential future impacts on regional economy. Favourable and unfavourable climatic effects in some regions must be considered with caution. There are several factors that may aggravate

or even completely change the optimistic vision related to the climate scenario used. These factors range from the technological factors (modernization of production techniques, application of good practices etc.) to the global aspects (financial crisis, food security, trade and so on) (CLAVIER document, 2009).

On one hand, even if the region is not very well specialized in farming activity, lack of agricultural potential could be solved by importing goods from outside of the region or from abroad, in order to reach the equilibrium of demand-supply. On the other hand, if agricultural production significantly increase due to the climate change, it is unlikely that - because of the increased supply –this could bring considerably higher revenue for farmers. Another aspect which has to be taken into account in economic impact and vulnerability assessment, and which was not analyzed in this study, is the the behaviour of farmers after application of the Common Agricultural Policy instruments, which may significantly influence farmers' decisions (CLAVIER document, 2009).

Secondly, I am aware of the restrictions of the IO methodology, as they were presented in Chapter 2. However, limitations can be counteracted by the simplicity and empirical character of the model.

*Objective 9: Analysis of adaptive capacity in Romanian counties and determination of territorial differences regarding vulnerability to climate change.*

Attenuation of negative effects and use of positive ones is promoted by an endogenous factor owned by each county: the adaptive capacity, ability to cope with climate change impacts. This is determined by multiple dimensions of economic, socio-demographic, infrastructure and education related etc. characteristics. Subchapter 6.7 contains results of cluster analysis of the Romanian counties based on the following indicators (recommended by the literature) for adaptive acapacity assessment: population density, share of population with higher education level in total population, employment rate of labor resources, dependency ratio, GDP per capita, road density, share of agricultural area reclamed with soil erosion control works, share of irrigated agricultural area.

As a result of the cluster analysis I concluded that the vast majority of the Transylvanian counties (excepting Maramureş, Satu Mare and Sălaj counties) and six counties from the southern, southwestern and southeastern parts of the country, as well as three counties from Moldova can be characterized by higher adaptive capacity than the rest of the country. Most of the counties from the southern, southeastern and southwestern parts of the

country can be characterized by rather low ability to cope with the adverse effects of climate change.

In principle, adaptive capacity building can be done by changes produced in national policies and programmes (improved access to resources, poverty alleviation, mitigating inequality, improving educational and communication systems and infrastructure development) which can not be easily achieved in practice (Smit-Benhin, 2004). Adaptive capacity refers also to the ability to benefit from positive impacts of climate change. Thus, support of territories which according to the estimations will benefit from the effects of climate change is as important as support of territories characterized by lower adaptive capacity.

Assessment of the potential effects of climate change and of adaptive capacity helps to estimate regional vulnerability (IPCC, 2001), with other words, to identify territories, which, regarding the changes produced in crop production due to the climate change, will be the most endangered.

Based on crop yields forecasts, determination of the dependence level of the counties from the agricultural sector (share of agriculture in county's GVA production and share of agricultural employment), as well as results of cluster analysis on adaptive capacity I observed the following aspects: in Romania in the next 10 years the following counties will probably be most endangered by climate change: Vrancea, Buzău, Mehedinţi, Olt, Teleorman, Giurgiu, Tulcea, Călăraşi, Ialomiţa, Brăila and Dolj. The following counties will be in the best situation, being characterized by increasing yields and relatively high adaptive capacity: Bihor, Arad, Timiş, Cluj, Alba, Hunedoara, Mureş, Sibiu, Braşov, Bacău, Iaşi, Harghita, Bistriţa-Năsăud, Covasna and Caraş-Severin.

*Objective 10: Realization of a case study on perception of climate change by farmers in Gheorgheni Depression*

Chapter 7 contains a study on perception of climate change and its effects on crop production in an area where climate change will very likely have positive impacts in the future. 24 farmers were asked.

Main conclusion of the investigations is as follows: farmers assign great importance to climate change, but they are not quite aware regarding the adaptation opportunities, for example, many of them are not willing to cultivate other plants than those traditional ones, or to use other, more efficient production technologies because of lack of money.

Farmers see difficulties related to agricultural production as a whole, and often they do not separate the effects of climate change by other effects caused by economic and political problems, and they do not have the necessary knowledge or they are not able to take adaptation measures to cope with climate change.

Farmers must deal with other major problems related to the Romanian agricultural system: the lack of agro-food markets where they should sell their products and other disadvantages which primarily binds from the relatively small size of the farms. Organization of some training and information courses for farmers on both climate change impacts and adaptation options, as well as on other aspects concerning the accessing of funds or creation of associations, would represent a major help.

Climate change will probably have significant effects on global and on Romanian economy during this century. In Romania, the agricultural sector, which plays an important role in the national economy, is one of the most seriously affected sectors, but it is characterized by large regional differences that can not be negligible at decision making levels.

I am aware that there are several techniques for assessment of economic impacts of climate change, not only the one used in the thesis (Input-Output Analysis), and that impact assessment is influenced by the high uncertainty of climate forecasts. However, I consider that research conducted and presented in this thesis is a contribution to elucidating the economic impact of climate change. Highlighting regional differences, which implies not only national-level, but also local-level approach to the issue, constitutes a special result.

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