Resilient Society

Multidisciplinary Contributions from Economic, Law, Policy, Engineering, Agriculture and Life Sciences Fields

Editors:
Alexandru Ozunu, Ioan Alin Nistor, Dacinia Crina Petrescu, Philippe Burny, Ruxandra-Mălina Petrescu-Mag

Book Series: Environment and Human Action

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Les Presses agronomiques de Gembloux, Belgium
&
Bioflux, Romania

2017

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CIP Desciption of the National Library of Romania

Descrierea CIP a Bibliotecii Naţionale a României
Resilient Society : multidisciplinary contributions from economic, law, policy, engineering, agricultural and life sciences fields / ed. and coord.: Alexandru Ozunu, Ioan Alin Nistor, Dacinia Crina Petrescu, ... - Cluj-Napoca : Bioflux ; Gembloux : Les Presses Agronomiques de Gembloux, 2017
Conţine bibliografie
ISBN 978-606-8887-08-1
ISBN 978-2-87016-148-7

I. Ozunu, Alexandru (ed.) (coord.)
II. Nistor, Ioan Alin (ed.) (coord.)
III. Petrescu, Dacinia Crina (ed.) (coord.)

0

Les Presses agronomiques de Gembloux
http://www.pressesagro.be/
pressesagro.gembloux@ulg.ac.be

ISBN: 978-2-87016-148-7 (printed format)

Bioflux
http://www.editura.bioflux.com.ro/
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ISBN: 978-606-8887-08-1 (printed format)
ISBN: 978-606-8887-07-4 (online format)

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Editors and authors are grateful to Dr. Eleonore Beckers (Les Presses Agronomiques de Gembloux) for her assistance in editing the manuscript.

Cover: Dacinia Crina Petrescu (Photo: Jetties and tetrapods for beach protection, Black Sea, Romania)

The book “Resilient Society. Multidisciplinary contributions from economic, law, policy, engineering, agricultural and life sciences fields” is part of the book series Environment and Human Action. Editors and coordinators of the series: Ruxandra Mălina Petrescu-Mag and Dacinia Crina Petrescu.

The publication of this book was possible due to the bilateral cooperation between the Romanian Academy and Wallonia – WBI, FRS-FNRS. Research program: “The creation of a model for the evaluation of food quality from the point of view of consumer health and environmental protection”, 2016-2018.
La présente publication a été rendue possible grâce à l’Accord qui lie WBI, le FRS-FNRS et l'Académie Roumaine.
Some of the papers published in this book were presented at the 11th International Conference ELSEDIMA, 26-28 May 2016, Cluj-Napoca, Romania.

How to cite chapters of this book:
Author, A.A. 2017. Title of the chapter. In A. Ozunu, I. A. Nistor, D. C. Petrescu, P. Burny, & R. M. Petrescu-Mag, eds. *Resilient Society*. Environment and Human Action Series. Gembloux, Belgium; Cluj-Napoca, Romania: Les PressesAgronomiques de Gembloux; Bioflux: page-page.

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(in alphabetical order by the family name of the first author)

Foreword

The human imprint on the environment is clearly visible under globalization, whatever is about resources extraction, goods production, or consumption. All these deeply impact on every environmental component, such as forests, agricultural land resources, freshwater, and air quality, because of the need to provide shelter, food, water, or energy to a population of more than seven billion people. How to manage the trade-offs between immediate human needs and to maintain the environment capacity to provide goods and services in the long term seems to be the Earth's epic "neverending story". Therefore, the book "Resilient Society" is intended as an attempt to find several answers to the quest of how to become more resilient to environmental, social, or economic pressure. In this context, resilience is understood as the ability to adapt to or tolerate disturbance without collapsing into a qualitatively different state. The volume articulates within a multidisciplinary approach the study of resilience and vulnerability of socio-ecological systems in an effort to disclose the conditions that lead to changes in environmental and resource regimes.

This first volume entitled "Resilent Society" of the series "Environment and Human Action" gathers contributions presented at the "International Conference Environmental Legislation, Safety Engineering and Disaster Management" (ELSEDIMA), held on May 26-28, 2016, in Cluj-Napoca (Romania), as well as other papers. This editorial activity aims at contributing to the enlargement of multidisciplinary knowledge and collaborations among researchers working in different fields that can contribute to increasing resilience of socio-ecological systems. The book covers diverse but partially overlapping research areas across natural sciences, social sciences, and engineering, thus capturing insights from economic, law, policy, engineering, agricultural, and life sciences areas. Such knowledge enables to gain a holistic view on the environmental and social challenges that shall constitute a common ground for stakeholders and policy-makers.

The editors have confidence that this volume dedicated to resilience will serve as a roadmap for future research and as a catalyst for dialog within scientific community about how to address the environmental interrogations where human actions play a crucial role in shaping the environment. We hope to continue to provoke further discussions about resilience, which might lead to innovations in the future.

The editorial team

Cluj-Napoca and Gembloux
February, 2017

Environmental and Economical Assessment Analysis of the Energy Willow.
A New Biomass Source for the Biorefinery Industry

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Abstract
The societal energy demand is growing steadily and it is known that the bioenergy production can be an alternative solution to reduce the dependence on fossil fuels. Biomass basically stores solar energy, initially collected by plants during the process of photosynthesis. The heat produced by burning 1 kg of dry wood is about 1.25 10^7 J; and as such, the biomass is a large potential source of renewable energy for heat and electricity production. This combustion process is generally built to function on forest biomass as raw material. In this case, important quantities of forest biomass are used in these thermo-electrical conversion units, causing deforestation of the woodland, which has a significant long-term impact on the local environment. The present paper focuses on presenting a new alternative use in bioenergy production, based on growing biomass resources, which can protect the natural biomass wood resources. The study starts by evaluating the biomass potential in the Romanian Central Region. Then, the experimental part of the paper focuses on a case study that presents the value chain of the short rotation plant biomass resources and the role of the energy willow in energy production and in biorefinery industry. Finally, the paper describes the environmental assessment of the large scale energy willow plantations, the biorefinery technologies and the integrated production high added value compounds from this feedstock.

Keywords: biorefinery; biomass; energy willow; energy balance, cost-benefit analysis.

1. Introduction

Substituting fossil fuels in the generation of energy is an important strategy for the EU (European Union) in order to mitigate climate change and enhance security of supply. In fact, the European Directive 2009/28/CE enforces that, by 2020, at least 20 % of the produced energy must be based on renewable resources in each of the EU's national energy mixes. The EU countries have different strategies and legislative tools to operate this, in function of the existing renewable energy potential. In this context, bioenergy has an important role to play, as the use of the biomass in energy production is an effective way to reduce greenhouse gases emissions, in a sustainable way.

Sustainable biomass use for heating, cooling and electricity production can produced a number of positive benefits for society, namely it increases employability and it can respond to demand fluctuations because it can be stored at times of low demand and used to provide energy when needed. Depending on the type of conversion plant, biomass can play a role in balancing the rising share of variable renewable energy sources (like wind and photovoltaic) in the electricity production. Thus, biomass can increase the energy security in Europe and can create a new market and value chain from cultivation and harvesting to conversion into electricity and heat. Statistical data from the NREAP (National Renewable Energy Action Plan) show that in 2012 the total EU 27 biomass supply for electricity, heating, and cooling amounted 103.3 Mtoe and that estimations indicate that biomass supply is projected to increase by nearly 37% (to 132 Mtoe) in 2020 (***, 2010).

Romania is estimated to have a biomass energy potential of 7,594,000 toe/year (or 318 x 10^9 MJ/year) corresponding to some 19% of the total average primary consumption. According to a study developed by BERD (European Bank for Reconstruction and Development) for Romania, in 2007, biomass was composed of the following categories of fuels (Borz et al., 2013 citing BERD, 2007):

- Firewood and wood waste from harvesting operations: 1,175,000 toe (48.8 x 10^9 MJ/year)
- Sawdust and wood waste from wood processing operations: 487,000 toe (20.4 x 10^9MJ/year)
- Agricultural waste: 4,799,000 toe (200.9 x 10^9 MJ/year)
- Biogas: 588,000 toe (24.6 x 10^9 MJ/year)
- Household waste: 545,000 toe (22.8 x 10^9 MJ/year)

The total wood stock in Romania (total standing volume) was estimated to about 1350 mio. m^3 (Scarlat et al., 2011), of which 39% is coniferous, 37% is beech, 13% is oak and 11% represents other species. The average wood stock is of 217 m^3 ha^{-1} but more productive forests having a wood stock of 900-1300 m^3 ha^{-1} are encountered in some regions (hills and mountains). The average forest increment is of 5.6 $m^3 ha^{-1}$ $year^{-1}$ (Scarlat et al., 2011), representing about 35 mio. m^3 $year^{-1}$ at national level. In Romania, the harvested volume was 19.7 mio. m^3 in 2011, an increase, if the year 2010 is considered as reference (with 17.0 mio. m^3). It must be mentioned that the annual allowable cut was of 22.0 mio. m^3 (Sbera, 2012; Borz et al., 2013 citing Ministry of Environment and Forests, 2010).

Furthermore, approximately 4.7 mio. m^3 (representing 24% of the harvested volume) were used as firewood (INS, 2013a) and 0.04 mio. m^3 were used for charcoal production. Statistics regarding the use for other biomass products (i.e., wood chips, pellets, and briquettes) are not available. Besides these energy production routes, a novel feedstock can be used, namely short-rotation cultures/coppice (SRC) (see Figure 1).

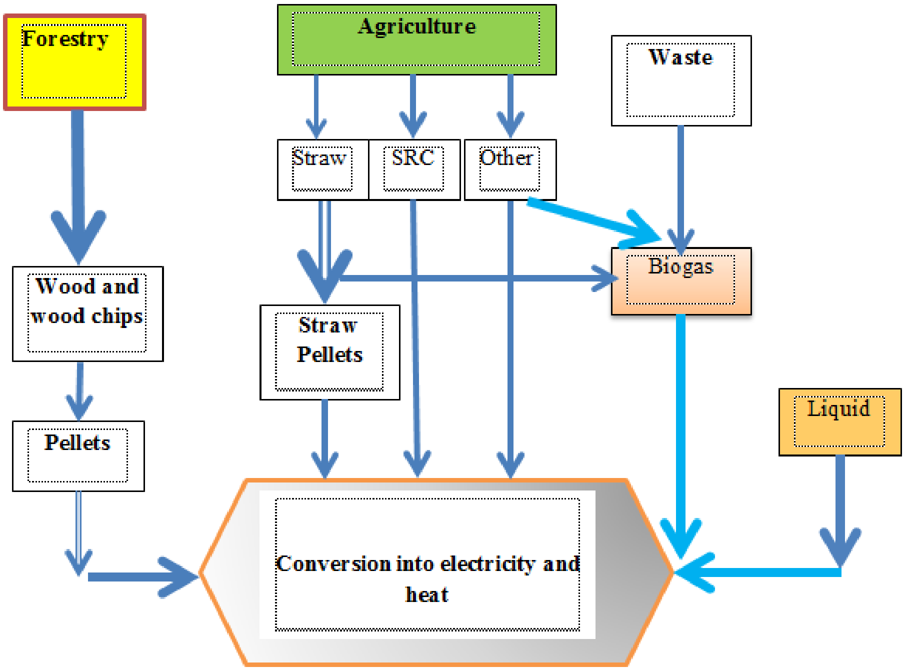

Figure 1. General structure of the biomass feedstock used for energy production
Source: Authors' elaboration

One of the feedstock from the family of the SRC is the energy willow – that is generally cultivated in Central and East European and Scandinavian countries. This plant can be a good solution for framers to produce non-food category products on land marginal to and removed from agricultural production due to overproduction of the basic agricultural commodities.

Field tests were developed to observe the efficiency of short growing period plants. The land was located in Covasna county, Central Romania and it was owned by farmer members of the Green Energy Association (Green Energy Association, 2016). SRC consisted of densely planted willow (high yield or popular varieties), harvested on a 2 to 3 years cycle. One average willow produced 10 to12 ODT/ha/year (oven dry tonne/ha /year) when grown on medium textured soil which was aerated but still held a good supply of moisture, such as clay or sandy loams. The ideal soil for this plant has pH 5.5-7, 5.

Statistical data for Covasna county indicate that around 73,709 ha are used in agricultural production (around 20% of the total county area-INS, 2013a), 2871 ha are unused wetland, and degraded land area caused by different industrial and agricultural activity is around 900 ha (INS, 2013b). That unused and marginal degraded land can be an ideal solution for establishing SRC plantations. According to a Mediafax report, in Romania there are over 1,500,000 hectares of land with high humidity which could be used for energy willow plantation (Mediafax, 2015). Currently, the plantation area of the energy willow reaches around 850 ha. In Covasna county this plant is cultivated only around 100 ha. The authors consider that this plant can be a good solution for sustainable biomass production, based on the previous mentioned statistical data, on the fact that this plant can convert solar energy efficiently, and on the advantage that producing fuel from the willow requires considerably less input energy per produced energy unit than many other energy plants. The willow can be transformed according to consumers' preferences, which generally require wood fuel in form of woodchips. These are dried by natural convention process to moisture content between 25-30 % (decreased from one of 50-55 % that is present in newly harvested willow) (Filbakk et al., 2011; Hofmann et al., 2017; Kofman, 2006; Lindblad et al., 2010; Nurmi & Hillebrand, 2007).

2. Energy willow production technology

2.1. Agronomic technics

Willow biomass crops can be grown on marginal land using a coppice management system, so that multiple harvests are generated from a single planting of genetically improved shrub willow varieties. The willow is left to grow for two years and then harvested during the dormant season. The willows will regenerate after harvest and grow for another two-year cycle. The technology starts with soil preparation. The soil preparation begins with pre-ploughing, herbicide application, and soil fertilization. This procedure is followed by selection of plants and the plantation. Commercially recommended plants are from Sweden and include varieties like Tora, Inger, Tordis, Gudrun, Doris, Jorr, and Olof. The necessary quantity for an area of one hectare is 14000-15000 plants. The plantation is generally done in spring and this process can be made with planting equipment towed by one 150 CP tractor. Current recommendations for planting designs and densities for willow in Romania are based on the double row system developed in Sweden. The first plantation in Covasna district was realized manually but today this activity is made by modern equipment. The current recommended spacing for the double row system is 1.5-1.8 m between each set of double rows, 0.75 m between individual rows, and 0.55-0.59 m between plants along each row. The mentioned agro-technological parameters can be observed in Figure 2.

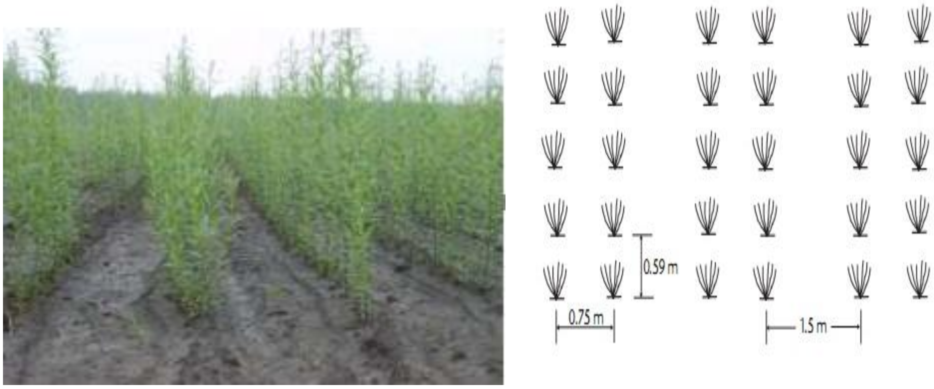

Figure 2. Energy willow plantation *Salix viminalis* var. *Inger*, made according to the described agricultural technology
Source: Photo taken by the authors

After the first year of vegetation period, the plant needs to be cut back, practically to the ground level. This process is necessary to encourage the plant to produce multiple shoots, often eight to ten. Following the cutting, the coppice enters its cropping cycle of between two and three years. The harvesting period for the SRC willow is winter or early spring, normally resulting in a three to three and a half months period (from December to middle March). The process can be realized in the following ways:

- Direct chip harvesting,
- Whole rod harvesting, and
- Billet harvesting.

Each method has its own advantages and disadvantages. The most important advantage of the direct chip harvesting mode is that woodchips can be produced directly and then stored and dried in aerated platforms built near the plantation or they can be transported directly to the thermal plant and used directly when the raw material humidity is lower than 30%. The disadvantage of this method is that the wrongly stored wood chips can degraded and lose their caloric value. The whole stem harvests method is used for 2-4 years old plantations, its main disadvantage are that the handling of 6-8 m long plants is difficult. The billet harvesting method is similar to the method used for sugarcane harvesting and can be used for young plantations where the individual plant diameter is less than 10 mm.

Harvesting is seen as a co-operative or contractors operation because this process requires specialized machines and their acquisition cost is high for small individual farmers. The used harvesting machines have a capacity of 5-6 ha /day. The harvesting logistics and machines can be rent from firms specialized in field of agro-mechanical operation. In the technological scheme described here the direct wood chips harvesting method was used. The plantation needs to be fertilized at least after each harvest but preferably every year following the year of establishment (Toivonen et al., 1998). Based on the short rotation plant production model presented in Best practice guideline (Teagasc, AFBI 2010) and on our experience, the list of technical operation necessary for a good quality willow plantation and high yields is presented in Table 1.

Table 1. Technical operation and its frequency for 22 years cycle

Operation name	Frequency of operation per 22 years cycle (lifetime of the crop)
Pre–ploughing, herbicide	1
Plough	2
Disk	1
Plant	1
Roll	1
Harvest	7
Herbicide	8
Fertilizes	7

Source: Adapted from Teagasc, AFBI 2010

2.2. Biomass yield

In biomass production based on natural photosynthesis, the total biological yields, the solid biomass is 60 %, the leaves represent 10% and the roots are 30%. For energy crop plantations, the yield is generally quoted as tonnes of dry matter (DM) per hectare per year. APIA statistics (APIA, 2016) and experiment results indicate that the maximum yield which can be obtained in optimal agro, meteorological, soil, and technological conditions is around 30 tonnes DM/ha/year. The harvesting is carried out on a two-three years cycle, depending on the biomass yield. The principal factors which influence the solid biomass yield are soil fertility, light exposure, and water availability. Based on authors' experience, in good climatic and soil condition, in Romania, this yield reaches around 20 tonnes DM/ha/year. This biomass feedstock for energy production is delivered to end users as wood chips and the product price depends on the moisture content (M20, M30, or M50) and on the particle size (P16, P31.5, P45, P63, or P100);

generally, wood chips with higher moisture content and larger particle size have lower price. Analysis of the Romanian market shows that the standard price for wood chips with 20-30% moisture content and particle size category P45 is 58.28 Euro/tonne. This value is used in cost benefit analysis.

3. Environmental assessments aspects of the energy willow plantation

The SRC plantation has several advantages for soil and landscape. One is the role of the plant in carbon (C) sequestration. Estimated rates of C accumulation in topsoil (0-40 cm) of arable sites were 40-170 g C/m^2/year during the first decade following SRC establishment (Granel et al., 2002). The increased C concentrations in SRC soils is explained by the lack of tillage in SRC and the high annual amounts of leaf litter deposited on the soil surface. In evaluation of the emissions, the willow SRC is considered carbon neutral. Focusing on carbon emissions and the utilization stage of the life cycle, analysis of the emissions during the bioenergy production in the electricity production units were made. Thus, the units working with willow SRC emitted a net value 0.131-0.132 kg CO_2/ kWh of produced electricity. This level is lower than the emissions resulted from the electricity production in a coal-based system, where this value is between 1.150-0.990 kg CO_2/kWh.

Another environmental advantage results from the fact that this plant has a higher water demand and evapotranspiration rates higher than the classical arable crops and can improve the groundwater quality by minimizing the fertilizer and pesticides needs found in classical crop plantations. These properties and the high nutrient uptake enable to use the sludge from wastewater treatment plant as fertilizer on these cultures and the nutrient rich wastewater for irrigation (Dimitriou et al. 2011). The annual reception capacity of sludge from the waste water treatment plants of the plantation is 20-30 tonnes/ha. This can be scattered on the plantation under rigorous control of the Local Environmentally Agency and OSPA [Office of Soil and Agrochemical Studies, in Romanian: Oficiul de Studii Pedologice si Agrochimice].

Willow plantation has an important impact on phytodiversity of agricultural landscapes. This aspect of the plant is not studied in the region investigated here but we consider that it can be an important research area for biodiversity studies. The literature from this fields showed that a high diversity of birds and a large number of insects and mammals can be found in willow plantations (Sage et al. 2006).

Moreover, willow can be used in phytoremediation processes. It can also be planted near roads and highways to build windbreaks and protect the road and the location from snowfall and noise.

3.1. Energy willow as feedstock for the biorefinery

The biorefinery concept is analogue to petroleum refineries producing a multitude of chemicals and products from biomass. The biorefieneries can be categorized according to platforms, feedstocks, and processes. The classification based on platform includes: biogas, syngas, bio-hydrogen, C6 and C5 sugars, lignin pyrolytic liquid, organic components, bioenergy-electricity, and heat. The classification by feedstock incorporates the followings groups: whole-crop biorefinery which generally uses cereals as feedstock; green biorefinery, which uses naturally wet biomass (i.e., green grass lucerne or immature cereals; and lignocellulose feedstock biorefinery which functions on naturally dry raw materials, such as energy willow. According to the process, the biorefinery can be divided in two major categories: biochemical conversion and thermochemical processes (National Renewable Energy Laboratory, 2009). The former is known also as sugar platform biorefinery and is focused on the fermentation of the sugars extracted from biomass feedstock; the latter is concentrated on bioenergy production from biomass through high temperature-based processes such as gasification or pyrolysis .

For this paper, the authors focused on energy willow, which is a lignocellulose material with macromolecular components formed by cellulose (35- 50%), hemicellulose (25-35%), and lignin (10-25%). The cellulose is the most abundant organic component on the Earth, it is a linear biopolymer of anhydrous glucopyranose linked by β (1-4) glyosidic bonds with chemical formula $(C_6H_{10}O_5)_n$. The cellulose microfibrils are bound to each other and to hemicellulose polymers by hydrogen bonds. The hemicelluloses are heterogeneous polysaccharides and are present in a proportion of 25-35% of the biomass resulted from the energy willow. Lignin is a complex heteropolymer with high molecular mass, and it is a major structural constituent in cell walls; its polyphenolic structure has an important role in protecting the biomass from chemical and biological degradation. The variation of the composition of the biomass from energy willow along a 3 year period is presented in Table 2.

Table 2. Energy willow composition

Item	year 1	year 2	year 3
Water content (%)	52.86	49.62	46.05
Heat value (MJ/kg, dry matter)	18.55	19.25	19.56
Crude ash (%, ODW)	1.89	1.37	1.28
Cellulose (%, ODW)	45.58	48.02	55.94
Lignin (%, ODW)	13.44	12.38	13.79
Hemicellulose (%, ODW)	13.53	13.39	13.96

Source: Szczukowski et al., 2002

Data show that cellulose content of the plant increases significantly with the length of the cutting cycle, while the hemicellulose and lignin content are relatively constant within the studied period. The ash content, together with extractives (by difference) decrease with plant age. It can be concluded that energy willow is a lignocellulose material with high polysaccharide content (in particular cellulose) suitable to be used in bioethanol production through biorefinery technology. A generally biorefinery scheme of biomass in comparison with an oil-refinery is presented in Figure 3.

REFINERY	BIOREFINERY
Oil-Petroleum => - Fuels and energy - Materials for chemical industry	**Biomass =>** - Fuels and energy: bioethanol, biodiesel, biogas, and biohydrogen - Materials for chemical industry: basic and fine chemicals; biopolymers and bioplastic

Figure 3. Oil refinery scheme versus biorefinery
Source: adapted after Kazmi et al, 2012, apud Kamm et al., 2006

The oil based refinery mainly supplies the transport of fuels and energy, and only a relatively small fraction is used for chemistry. At a biorefinery, a relatively larger amount of feedstock is used for chemistry production, together with the production of fuels and energy (Duglas, 2014).

3.2. Economical aspects of the energy willow cultivation and use in bioenergy production

Total costs of the energy willow plantation can be divided in the following categories:

- The costs of the cultivation which include soil preparation cost, planting cost, annual fertilization costs, chemical treatment with herbicides and insecticides costs, and harvesting cost (Velcescu & Staicu, 2011).
- The costs for renting the land and the plantation insurance costs (necessary to cover various risks).

The general expression of tariffs for agricultural works (AWF) is a function of the work complexity and the work fuel consumption.

$$AWF = k \cdot FC \cdot FP \cdot K$$

Where: k is a constant with value between 3.5 and 4.9, FC is the fuel consumption for the work, FP is the fuel price, and K is the operation complexity factor and its value is 0.9 for ploughing, 1.1 for harvesting, and 1 for other works.

Taking into account the fuel consumption of the tractor, the specific constant for each operation, and the actual price for fuel used on Romanian market (which is around 1.0 Euro/l), the cost of each operation/year is evaluated and presented in the Table 3.

Table 3. Operation costs used for economic analysis

Operation name	No of operations / year	FC l/operation /ha	FP (euro)	K	AWF (euro)	
					Calculated with k_{Min}=3.5	Calculated with k_{Max}=3.5
(1)	(2)	(3)	(4)	(5)	(6) = (2) x (3) x (4) x (5) x 3.5	(7) = (2) x (3) x (4) x (5) x 4.5
Ploughing 25 cm deep	1	32	1	0.9	100.8	141.2
Fertilizes	2	2.5	1	1	17.5	24.5
Disking, ploughing	1	5.7	1	0.9	17.96	25.13
Planting	1	15	1	1.1	57.75	80.85
Rolling	2	2.5	1	1	17.5	24.5
Harvesting and chipping	1	15	1	1	52.5	73.5
Treatment with herbicide	1	8	1	1	28	39.2
Total:					292.01	408.81

Source: Authors' calculations

Using this data for operation price, the yield values (which are generally 35-40 t/ ha), and the wood chips price on the Romanian market, (58.5-65 Euro/ t) authors performed the cost benefit analysis for an energy willow plantation of 1 ha. The plantation establishing cost is around 1600-2500 Euro/ ha and the yearly operation cost is 292-409 Euro/ha. For the cost benefit analysis we studied two cases: one is the situation when the farmer works his own land and the second is when land is rented. The analysis results can be seen in the Figure 4.

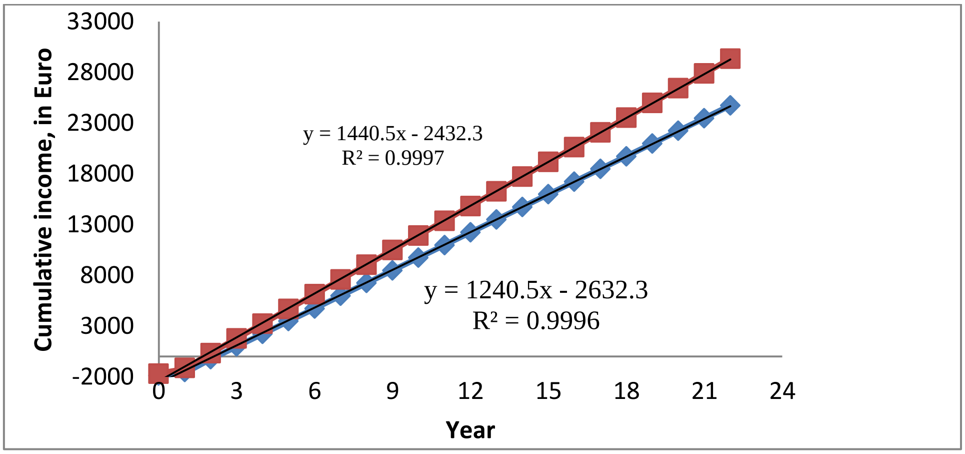

Figure 4. Cost benefit analysis of the energy willow production. Red squares: own land scenario, Blue diamonds: rented land scenario and their statistical analysis parameters
Source: Authors' calculation based on studied data

Taking into account an average yield of 37.5 t/ha/ cycle, a cycle of 2 years, and an average selling price of 61.75 euro/t, an average income of 2315.63 euro/ ha / cycle results from the third year. Average costs are: in the own land scenario: 350.41 euro/ ha/ year (700.82 euro/ cycle). The initial investment can be recovered in the first harvesting year and from the next one a profit can be obtained. This will be around 1614.81/ ha/ cycle for the own land scenario (or 807 euro/ ha/ year for a 2 years cycle).

4. Conclusions

The energy production generated and the environmental impact of the energy willow plantation make it the ideal solution for the use of marginal lands that are not used for agricultural production. The production scheme for energy willow cultivation requires considerable less input energy (consumed in agro technological and mechanical operation)/unit than many other energy plants and therefore energy willow can be cultivated with high yields in Romania for energy production. Moreover, it can have a positive biodiversity impact at local level. The economic analysis shows that the selected plant cultivation technology generates benefits after 3 years of cultivation.

The future challenges are to simultaneously optimize willow biomass crop production, increase the interest of potential producers, and develop long-term markets for willow and other sources of woody biomass. Another objective is to create a co-utilization of the energy willow, taking advantage of the new bioengineering technology where cellulose, hemicelluloses, lignin etc. are fully upgraded in the biorefinery production scheme. The study showed that the presented technology as a sustainable system will depend on continued research on biological, ecological, and socio-economic factors.

Acknowledgement

This research was carried out as part of the H2020 Phoenix Project (Grant Agreement 690925).

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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The Resilience of Social Ecosystems – between Entropy and Neg-Entropy

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Abstract
Agriculture practiced on small land areas (small rural household) in hill and mountain areas from Romania faced an accelerated process of involution that led to the depopulation of villages. The authors proposed a survival project for the small rural household by reconsidering its organization from the status of agricultural product provider to the one of food provider and its adaptation of technologies to the ones typical for the 21st century. The research highlighted the need of involvement of migrant rural youth who left their villages in search of a job and who came back with experience and capital. The present analysis identified the focal points of social ecosystems that should be managed within the limits of ecosystems resilience in terms of entropy and neg-entropy.

Keywords: resilience, social systems, agricultural systems, environmental protection, social ecosystem.

1. Introduction, current state

The history of agriculture and the geography of Romania favoured for a long time the establishment and existence of small rural household located especially in the hill and mountain areas of the country. Their role for the existence of the Romanian nation decreased in importance during the second half of the XX century and the beginning of the XXI century, then the depopulation of villages became a widespread phenomenon and its economic, social, and environmental effects turned out to be disastrous. Awareness of environmental degradation caused a vast literature on the assessment of economic, ecological and social biodiversity (Meinard et al., 2017).

Many agricultural areas affected by the impacts of climate change are causing concern internationally to practice sustainable agriculture (Rusu et al., 2017). Development of sustainable agriculture at worldwide level is a necessity imposed by the demographic explosion that affects food security and the environment (Wang et al., 2017).

At world level, the small rural household (SRH) plays an important economic and social role since it provides 70% of the food products supply of humankind. The European Union (EU28) records 174.1 small farms that have an average area of 14.2 hectares/farm. Romania is inscribed in this space with 6 million SRH with average area of 2 hectares and occupying 2.5% of the total agricultural land.

At EU level, during the last years, significant attention was paid to SRH with the aim to consolidate them and to offer financial support. Thus, in 2013, the European Parliament issued the "Report on the future of small agriculture holdings" which proposes subsidies for encouraging farmers to maintain their function and for developing SRH, improving the infrastructure from the areas of interest and adapting education to the needs of SRH. What seems to be very interesting is that SRH are considered of strategic importance (measure 19 from the Report). Consequently, in the CAP (Common Agricultural Policy) 2014-2020 program SRH will receive direct support payments and the governments of Member States should monitor the consolidation of SRH. In 2010, the conference on "Semi-subsistence farming in EU" (Sibiu, Romania) shed light on the provisions of the CAP 2014-2020 provisions for Romania, suggesting measures for the development of the National Rural Development Plan 2014-2020. In 2013, at the EU conference "Social and Economic Problems of Small Agricultural Holdings in Europe" (Krakow, Poland) it was concluded that the following topics were important for the development of SRH:

- Consolidation/Change of SRH;
- Diversification of activities;
- Place and role of climate changes;
- The risks of civilization for the existence of SRH.

General interest in SRH is highlighted by the Internet posts, too: Yahoo included 15 million posts "agriculture", out of which 3.14 million searches were for SRH (November, 2016), or by actions of civil society, such as the campaign of the organization "Movement for the progress of the Romanian village 2009" with the topic "The small agricultural ownership – its salvation and rehabilitation" (***, 2009). At academic level, the topic of SRH has maintained its importance in time, as proven, for instance, in Romania, by the works of the Institute of Agricultural Economics – Bucharest (Mateoc-Sarb & Otiman, 2011), of the Bucharest University of Economic Studies (Bran et al., 2011), and of independent researchers (Morarescu, 2008), and, in other countries, by the significant number of publication on this topic (Brown, 1995; Davidova, 2014).

2. Conceptual clarifications

Social-ecological system consists of a bio-geo-physical unit and its associated social attractors and institutions. They are complex, adaptive and delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context (Glaser et al., 2008). The following concepts can be used in relation to a social-ecological system to describe its behavior: entropy, neg-entropy, resilience, adaptation, and survival.

Entropy and neg-entropy are terms taken from the second principle of Thermodynamics, being applied for irreversible processes, and they became common in the entropic approach of the living and non-living matter in the quasi-totality of human activities. Some of the entropy definitions are presented in Box 1.

Box 1. Entropy definitions

Measurement of a systems disorder or of its order.

Measure of thermic state of physical systems that increases during their irreversible transformation and remains constant during some irreversible transformations.

Complex continuous and irreparable decay process of the existing resource potential and the creation of disorder.

Measurement of a system's efficiency.

The property of an organism of maintaining in limits that are almost constant the internal environment.

The ability of living beings of creating order.

Sources: Academia Romana, 1996; ***, 2017

In its essence, entropy measures the degradation of a system's energy during a physical, chemical, biological, economic, or other type of process. It increases in time and because of this it could be associated with the passing of time, which makes it an irreversible process.

Neg-entropy, considered as negative value of entropy is defined as an "organizing factor of physical or social systems that opposes to the natural tendency of disorganization" (Schrodinger, 1980). It is also understood as creation of order or the ability of a life form to create order. The creation of negative entropy is a reversal of law of entropy (Rees, 2003; Schrodinger, 1980). It could be said that neg-entropy is the deficit of low entropy needed by a system so that it avoids the status of chaos. In the law of dichotomy the two notions, negative and positive, form a pair that constantly gives content to the existence of life.

Resilience is the capacity of an ecosystem to resist damage and recover quickly in response to perturbing factors. Disturbances of sufficient magnitude or duration can profoundly affect an ecosystem and may force it to reach a threshold beyond which a different regime of processes and structure predominates (Walker et al, 2011).

Adaptation is defined as transformation to respond to certain requirement or as any process through which a system is optimizing its functioning in relation with the surrounding environment (Academia Romana, 1996). Adaption decisions regard the dynamics of the processes, their goals, and the restrains to be supported by the environment that is affected by exterior perturbations (Scarlat & Chiriță, 2012).

Survival is understood as the capacity of coming out from a natural or anthropogenic disaster in a position or state that is better than the average (von Buttlar, 2000). It can also be defined as a paradigm of a sustainable future (Academia Romana, 1996).

3. Methodological specifications

The opportunity of reconsidering the place and role of SRH in the space of the Romanian economy starts with the analysis of the current status, where SRH is considered as component of a wider system, namely a social ecosystem that, together with other social ecosystems, correctly describes a part of the rural environment. The conclusions of the analysis are considered in the selection of the concept (paradigm) preconized to suggest orientations for the evolution of SRH. A range of solutions must be created within the limits of resilience of natural systems (natural resources for agriculture) and of social system in order to make the paradigm viable.

The concepts used are: conservation and sustainability for natural systems and evolution from subsistence (current state) to development and prosperity for social systems. The time horizon for achieving the two desiderates is one human generation time span. The notion of resilience in relation to SRH is understood as SRH capacity of reacting to exterior pressures and to respond to this while returning to the initial performances of the system.

Theoretical and methodological basis of the research was developed by reviewing the national and international scientific literature. The particularity of this research theme is given by the need to address it interdisciplinary. Consequently, we accessed and analyzed relevant and topical information, going through successive stages of documentation on the concepts of entropy and neg-entropy and on the relations between economic and environmental fields, in order to identify impacts at local and global scales. The aims are to understand both the particularities of the economic phenomenon and of the ecological one and highlight their implications in relation to policies and measures implemented at national, European and global levels.

4. The place and role of small rural holding in the national economy and the importance of the study

The SRH is mainly encountered in the hill and mountain areas and less in plain areas because, on the one hand, people were shunned by the (numerous) incursions of foreign armies that took place until the XIX century, and, on the one hand, the variety of natural resources was higher, providing making life easier. SRH were relatively stable in time and its inhabitants gathered information and knowledge along many human generations (especially of neg-entropic type) that allowed them to survive until the second half of the 21st century. In the traditional form, their economic life cycle is enclosed, and this is the reason why SRHs were unable to adapt to progress, to modern agriculture, which became dominant from the second half of the XX century and was organized on large areas of land, mechanized, with chemicals, and economically efficient. A question may rise: "If the existence cycle of the SRH is enclosed, why does SRH still preoccupy researchers and decision makers?" The answer starts with an explanation to the question "What is SRH?" The SRH is defined as the individual agricultural exploitation which has the economic size below 1 ESU (1 ESU – unit of economic dimension equivalent of 1200 euro/year) and which obtains products that are used in self-consumption (Morarescu, 2008). The living standard of the households from these areas is modest, usually being of "subsistence" type, which is one of the reasons why the "city" becomes an attraction factor that depopulates the rural environment.

The place of SRH in the Romanian agriculture. Currently, in Romania, subsistence holdings occupy 45.24% of the total area of 14.6 million hectares of agricultural land, semi-subsistence holdings cover 13.76% of total land, while commercial holdings have a quote of 41% (***, 2008). The term of semi-subsistence is defined as ensuring sufficient resources to maintain life (Academia Romana, 1996). Out of the total number of 4,256,152 agricultural holdings recorded in 2008, 90.96% represented subsistence holdings, 7.55% were semi-subsistence holdings, and 1.5% were commercial holdings (***, 2008). By size classes, the situation of SRH shows a concentration of 72.5% in the 0-2 ha class and of more than 92% in the 0-5 ha (Table 1). The structure of the land fund is presented Table 2.

Table 1. The number of agricultural holdings by size of land owned, their share in total number of holdings, and unused agricultural area (in 2010, in Romania)

Size class	Holdings number	Share (%)	Area of unused land (hectares)
Total	3724332	100	320633
Below 0.1	384944	10.3	34488
0.1-0.3	662122	17.8	43826
0.3-0.5	355182	9.5	26980
0.5-1	617198	16.6	49674
1-2	712288	19.1	65487
2-5	727389	19.5	72909
5-10	182444	4.9	19505
10-20	43609	1.2	4230
20-30	9730	0.3	772
30-50	8213	0.2	633
50-100	7556	0.2	595
Over 100	13657	0.4	1534

Source: INS, 2015 (according to Farm Structure Survey for 2007 and General Agricultural Census for 2010)

At EU28 level, in 2010, out of the 12.2 million farms, 6 million holdings were in the SRH category, with the unitary area below 2 ha, and occupied 2.5% of the total agricultural land.

Table 2. Area of the land fund and its structure (in 2013, in Romania)

Type of land	Size (hectares)		%
Total area of the land fund, out of which	23839.1		-
Agricultural area, out of which	14611.9		100
• Arable		9389.3	64.3
• Pastures		3273.9	122.4
• Hayfields		1541.9	10.6
• Vineyards		210.3	1.4
• Orchards		196.5	1.3
Forests	6742.1		-
Construction	758.3		-
Roads and railways	389.9		-
Waters and ponds	836.0		-
Other areas	500.9		-

Source: INS, 2015 (according to Farm Structure Survey for 2007 and General Agricultural Census for 2010)

In 2010, the total number of agricultural holdings (also including the number of agricultural holdings without utilised agricultural area and without livestock, for example, mushrooms) was 3859043; out of these, 3724332 were agricultural holdings which utilized agricultural area (INS, 2015). Also, out of the total number of agricultural holdings, 99.2% were agricultural holdings without legal status and 0.8% with legal status (INS, 2015). The average of utilized agricultural area per agricultural holding was 3.45 ha and per agricultural holding which utilized agricultural area was 3.57 ha (INS, 2015).

The profile of holdings is influenced by the topography: pastures and hayfields in the mountain area favorable for livestock, vineyards and orchards in the hill area, while the plain is used for mainly for cereals and vegetables. The factors that determined the population decrease (part of the productive potential of the social ecosystem) were economic and social, such as job losses and disruptions to the operation of marketing channels for agricultural products from rural to urban area. Migration was the response of rural ecosystems to the pressure of transition. Simultaneously with population decrease, there were also changes in the number and structure of agricultural holdings. Thereby:

- The number of agricultural holdings decreased from 4.481 million in 2002 to 3.854 million in 2010;
- Sub-subsistence holdings number reduced from 3.948 million to 2.732 million;
- Semi-sub-subsistence holdings tripled their number, reaching 702 thousand;
- Commercial holdings reached 425 thousand compared to 77.8 thousand in the reference year (Borza, 2009).

The structure by age of rural population is unfavorable, which is both a cause and an effect of involution of SRH. Thus, young farmers (less than 40 years) represent less than 10% from the total number farmers and run 10% of the utilized agricultural land (Mateoc-Sirb & Otiman, 2011). In exchange, farmers who exceeded the age of retirement (over 65 years) reach the proportion of 43% of the total number and run 31% of the utilized agricultural area (Mateoc-Sirb & Otiman, 2011). The income of the small farmer was traditionally “small” compared with that of other social categories, with a direct influence on the resilience of SRH resilience in terms of functioning stability and contribution to the existence of the rural settlements.

Data from Table 3 highlight a tragic economic truth, namely the fact that the profit of agricultural activity is almost null, forcing the farmer to search for other earning sources, such as subsidies from European Union, state aids, occasional activities, pensions, etc.

Table 3. Farmers' incomes and expenses (in 2014, in Romania)

Category	Measurement unit	Value
Gross average income - total economy	Lei*/ employee	2,328
Gross average income in agriculture, forestry, and fishing	Lei/employee	1,751
Gross average income in industry	Lei/ employee	2,362
The structure of consumption expenses:		
• food products	%	57.2
• non-food products	%	17.9
• payment of services	%	24.9
Monthly income	Lei/household	2,061.6
Monthly total expenses	Lei/household	1,999.9
Share of food consumed from self-production (from total food consumption)	%	46.1

*Lei= Romanian currency; 1Euro= 4,45 lei (January, 2017)
Source: INS, 2016a

The economic activities in the rural environment have always been mainly based on agriculture, while non-agricultural activities such as forestry and various crafts were less present. However, during the last 10-15 years, tourism, private or state forests exploitation, and production of organic products appeared and developed. In the second half of the 20th century, until the beginning of the 1990s, the Romanian agriculture, including the one organized in SRH, was, in general lines, autonomous from the food provision point of view. Moreover, rural space had positive demographic rates and it was also a provider of labor force for industry and other economic branches, while preserving most of its traditions and social structure.

The resilience limits of the social ecosystem were not exceeded during before 1989 because the pressures, challenges, and perturbing events that occurred in the rural area were "assimilated" in time. The situation changed after the fall of communism, in the 1990s, when the limits of resilience of the rural social ecological system were exceeded due to economic reasons. Even the level of subsistence was threatened, so the reaction of rural population was migration to other countries in order to get a job. The solutions and reactions adopted by the population were: migration of one or both parents in the family and neglect of agricultural activities in favor of other ones. Consequently, at country level, 1.0-1.5 million hectares were not worked (Table 1). Also agriculture contribution to GDP deteriorated: while in 1989 it was of 13.9% in GDP, in 2010 it dropped below 6%, and in 2014 to 4.7% (INS, 2016a). These new situations were part of the cause of the dependence of the country on the import of agricultural products (which is a historical premier and it should not happen to a country with favorable climatic and pedological conditions, as Romania is). In order to preserve the SRHs resilience several indicators should be considered, among which previous accomplishments of Romanian SRHs in terms of their number (Table 4), dimension of active population, production efficiency levels (such as those from 1989, for instance), and the level of these indicators in other EU countries.

Table 4. Number of small agricultural holdings and semi-subsistence farms in EU27 states (in 2010)

	Total	Number		Monthly income	
		Less than 2 ha	Less than 5 ha	Less than 200 euro	Less than 800 euro
EU27	12,015	5,637	8,056	5,132	8,507
Romania	3,859	2,732	3,159	2,717	3,632

Source: Semi-subsistence farming value and directions for development, European Parliament, 13.042013, *apud* Planul National de Dezvoltare Rurala 2014-2020 MADR, 2014

Among the conditions required to achieve or surpass previous performance of SRHs or the performance of other EU countries there are: willingness, vision, and involvement of Romanian political class to reconsider the situation of the agriculture and of the SRH and preservation of natural ecosystems within the limits of their regeneration capacity in order to enhance the agricultural potential. This conservation of the ecosystems until the implementation of a strategy or national recovery plan for the agricultural sector is a critical requirement for survival and subsequent development of the agriculture and SRHs.

5. Preservation of the (productive) economic potential by the management of entropic manifestations

Among the studies dedicated to protection and restoration of natural ecosystems (Bran et al., 2017; Godeanu, 2004; Glaser et al., 2008) an approach that regards the ecosystem modifications in terms of entropy and neg-entropy must be included. The reason is that this can be used for the analysis of both the natural ecosystem quality and for the analysis of social system, offering a comprehensive view of the social ecosystem and making its management easier. The entropic approach of the functioning of a social ecosystem uses terms such as information, knowledge, order, disorder, quality of human resource, limits of knowledge, dynamics of transformations, and resilience (Bran et al., 2013).

The involution of Romanian agriculture with the loss of its autonomy, migration, and depopulation of villages is a reality of the last 25 years. The main causes should be sought for in the weak quality of decision makers, who lacked the information, education, experience, and talent necessary for managing the agricultural holdings, rural settlements, and the agricultural sector of the national economy. The Romanian legal framework often lacked coherence and proper protection of economic, environmental or social interests and, thus, lead to problems such as land fragmentation, rural depopulation, and environmental degradation (Petrescu et al., 2010; Petrescu-Mag et al., 2017). Consequently, social ecosystem lost its resilience and collapsed. Among the phenomenon that led to the involution and fall of the rural economy the following can be clearly outlined: disorganization/ dissolution of cooperative forms of production (Agricultural Production Cooperatives); removal of experts who worked in cooperative farms or in units that belonged to the state; lack of capital for reorganization and functioning; abolition of trade channels for agricultural products; a major fall of knowledge level in the human subsystem of social ecosystems, which led to the crash of agricultural holdings; abandonment of rural area and agricultural activities by active and qualified people; and aging of rural population.

Stopping involution, reorganization of holdings, and survival and development of agricultural activities depend profoundly on the human resource, on its accumulations and its capacity to generate neg-entropy. The latter is a process that takes a long time (equal to stages of professional training through the education system) and that has no superior limit for training and efficiency in the economic activity. Unlike neg-entropy of a social system, a natural system has a superior limit, given by its regeneration capacity, preservation of natural potential, and maintenance of the integrity of system quality obtained through minimal entropy. This goal of bringing social ecosystems within the limits of normal operation involves the control of entropy accumulation of anthropogenic nature, found in the form of environmental degradation: landfills, contaminated land, threatened biodiversity etc. The magnitude of such an approach can be discerned from the data in Table 5, which illustrate environmental damage expressed in areas of degraded land, forest resource degradation, pollution of watercourses.

Table 5. The expressions of entropy in natural ecosystems of Romania (in 1998)

Type of land	Measurement unit	Size
A. Soil		
Natural compaction of soil	thousand ha	3,060
Soil acidification	thousand ha	3,420
High alkalinity	thousand ha	220
Lack of P, K, and microelements	thousand ha	7,789
Soil pollution due to human activities	thousand ha	900
Frequent drought	thousand ha	7,100
Water excess in soil	thousand ha	3,721
Soil erosion by water	thousand ha	6,300
Soil salting	thousand ha	614
Land slides	thousand ha	702
B. Forests		
Defoliation of trees, low-medium	% of total area of 6,237 thousand ha	
Total, out of which:	%	38.30%
Softwood	%	30.80%
Hardwood	%	40.30%
C. Water		
Surface water pollution. Rivers	km	3,131 or 8.6% of total
Draining of Danube puddles	thousand ha	400,000

Sources: Comisia Nationala de Statistica, 1998

Three important types of actions must be implemented from the entropy perspective in the view of improving SRHs performances and o maintaining the production potential of natural ecosystems: interventions on the anthropogenic causes of entropy accumulation (Table 5) (stopping degradation processes); restoration of the environment affected by entropy; and reduction of the effects of natural factors that influence the integrity and quality of natural ecosystems (climate change, droughts, etc.).

In order to protect and save parts of yet not-degraded ecosystems by human activity, protected areas were created (Table 6), having a neg-entropy character and being a benchmark for the assessment of ecosystem resilience. Additional measures should be taken to expand these areas especially to forests, and, according to authors' view, to prohibit hunting wild birds in the Danube Delta.

Table 6. Natural protected areas in Romania (2014)

Type	Number	Total area (thousand ha)
Biosphere reserves	3	664
National parks	13	316.8
Scientific reserves	45	24.6
Natural reserves	671	324.1
Wetlands	19	1,089.4

Source: INS, 2015

Among the factors that deteriorate the quality and stability of ecosystems, outlining their resistance (resilience) limits, there are: consumption of chemical fertilizers (110 kg of active substance/ha for the period 1989-1994); consumption of pesticides (3.5 kg active substance/ha for the period 1988-1997); industrial activities (mining of ores, coal, etc.); disposal of industrial and municipal waste; and constructions, roads, railways, etc. (Comisia Nationala de Statistica, 1998). Consequently, a solution is avoiding the use of fertilizers and pesticides in favor of organic agriculture and of genetically modified organisms (Badea & Otiman, 2006); another is the preservation of a certain part of the natural ecosystems outside economic use (Table 7). It can be stated that, in the current context, that the main component of the resilience of natural ecosystems is the resilience to anthropogenic interventions.

Table 7. Neg-entropy expression in the natural ecosystems of Romania (in 1989 and 2014)

Type of land	UM	Size	Year
Areas arranged for irrigation	Thousand ha	3,168	1989
Areas arranged for irrigation	Thousand ha	300	2014
Draining works	Thousand ha	3,144	1989
Soil erosion mitigation	Thousand ha	2,222	1989
Reforestation	Thousand ha/year	46	1989
Reforestation	Thousand ha/year	15	2014

Source: MADR, 1998; INS, 2016a

6. Social neg-entropy of the rural area

The agriculture, a component of social ecosystems, source of survival for approximately 40% of the population, must be brought and kept within the limits of the resilience of natural systems and economic sustainability. In the last 25 years, due to internal conjuncture, agriculture regressed, the main result - alongside emigration - being the loss of food autonomy, the balance of export-import with food becoming negative. This observation seems paradoxical given that the areas of arable land remain fallow year after year (Table 1).

The involution of the Romanian agriculture was mostly the effect of two factors. One was made of wrong decisions and economically illogical managerial behaviors (Box 2), which additionally worsened the quality and integrity of natural resources that composed the social ecosystem, typical for the Romanian rural area. Another was the indifference of authorities on the worsening situation of rural population and of producers, who were forced to migrate (Table 3).

Box 2. Decisions that led to the involution of the Romanian agriculture and village between 1990-2015

The effects of dissolution of agricultural production cooperatives disorganization of farming.
Bankruptcy of large livestock and poultry farms, owned by state.
Bankruptcy of around 1,200 industrial enterprises and loss of around 3 million jobs, part of them being held by commuters from the rural environment (Table 3); emergence of unemployment in the rural area, migration of individuals.
Liquidation of trade channels for the village-city relation, encouragement of the establishment of hypermarkets within cities, and bankruptcy of small merchants of Romanian agricultural products.
Disadvantageous negotiation of European Union subsidies for SRH during the discussions regarding the adhesion of Romania to the European Union; the subsidies were below the ones provided for other Member States; such subsidies made Romanian products uncompetitive on the domestic and foreign markets.
Indifference of state authorities to the “robbery” of national resources: exploitation of forests beyond any ecological limit (one hectare of forest is cut down every five minutes).
Lack of reaction regarding the selling (externalization) of agricultural land and forests to foreigners.

Source: Authors’ elaboration

Farmers’ lack of reaction to the effects of the situations mentioned in Box 2 is mainly a measure of the low neg-entropy and a consequence of the following factors:

- Involution of education in the rural area, which includes: infrastructure, quality of teaching staff, curriculum, large distances to the school, and chronic sub-financing;
- Lack of experts, because existing ones left once the communist economic entities were liquidated. For instance, in 1989 there were 65,577 experts in the rural area; after only two years, their number felt by 5000 persons;
- Migration of young people;
- Lack of elite, leaders;
- Population aging;

- Difficulties regarding the integration of Roma (gipsy) population in the rural community.

Unfortunately, this massive fall of the SN (national companies) potential is not limited to rural population, but it is encountered at national level (Table 8). It is a fact that makes the level, potential of SN to become an issue, a challenge at national level, because this neg-entropic improvement happens in time, that can mean the time needed for training and valuating the operative potential, and covers the duration of a human generation.

Table 8. Education in Romania (in 1989/1990 and 2014/2015)

Category	Size in the year (thousand persons) 1989/1990	2014/2015	% (2014/2015)/(1989/1990)
Education units	27.3		
School population	5,444.6	3,735.2	69
Teaching staff	0.229	0.264	115
	Primary education		
Enrolled pupils	2,291.5	1,732.3	75
	High school education		
Enrolled pupils	1,346.3	727	54
Out of which:			
Agricultural and forestry profile	0.253	0.164	65
	Vocational education		
Enrolled pupils	304	507	167
	Out of which:		
Agriculture	0.05	0.05	100
Forestry	0.05	0.04	80
	Higher education		
Enrolled students	106	541	510
	Out of which:		
Agriculture	0.43	0.638	148
Forestry	0.16	0.56	350
Veterinary medicine	0.3	0.3	100

Source: INS, 1990; INS, 2016b

Massive drop in the number of school population (by 30%) and in the number of students enrolled in the three forms of education, reduce staff capacity in agriculture to adapt to the new realities of the present, for instance through new forms of organization, as solution for survival, other than migration. Neg-entropic (educational), economic and social recovery, means covering a lost time of 27 years (1989 to 2016). Recovery should not be raised to the level of 1989, but at typical NS level from the beginning of the XXI century. This statement implies not only adapting the education system to the needs of present time, but also taking into account future progress forecasted for agriculture. Illiteracy and dropout from school are specific mainly for poor population and these are serious limits of resilience in rural areas. A special situation framed by social insertion, own neg-entropy, and possible contribution to the recovery of the economy is represented by the local Roma (gipsy) population. The following data outline their place in the rural or national economy (in 2011):

- Number of gypsies: 1-0.5 million;
- Education level of adult population:
  - No primary education: 22% of total
  - Uncompleted primary education: 5.3%
  - Complete primary school: 25.2%
  - Uncompleted gymnasium: 8.5%
  - Complete gymnasium: 33.7%
  - Complete high school: 3.9%
  - Postsecondary education: 0.7%
- Fluency of reading for adult population:
  - Women, good reading: 40%
  - Men, good reading: 50%
- Professions:
  - Modern professions: 16.1%, from the total active population;
  - Traditional professions: 3.9%
  - No professions: 79.4%
- Qualification of native population
  - Qualified: 29.6%
  - Unqualified: 79.4%
- Birth rate, number of children born in992
  - Roma (gipsy): 4-5 children/family
  - Romanian: 2.2 in 1992; less than 2 in 2011 (Taran, 2011; Zamfir & Zamfir, 1993)

The reasons for paying a special attention to Roma people are divers and include: gipsy will become prevalent within the national population in the next 30-50 years in Romania (one human generation time); the number of children per family makes them a majority in collectives with smaller number of children per family (case of European countries); they have to function within a European type country and, therefore, their own NS level, along with the behavioral, moral ones, etc. have to rise to the European level - a difficult task, which cannot be neglected; there are no signs that a significant process of their integration within the Romanian demographic and economic areas is taking place; a high number of them emigrated; the lack of professional qualification and their culture (the nomad character) made them to be placed at the periphery of the society, being perceived more as trouble makers than a supply of labor; there are also successful examples of integration of Roma people, which can serve as examples; their artistic talent and skills in crafting iron, copper, or aluminum create niches in the economic profile of rural households for non-agricultural activities; an urgent solution for the integration of gipsy in the European society is needed.

The incertitude of modernization, of "Europeanization" of Roma ethnics, gives a measure for the resilience of their integration process in dominant communities (rural and urban). If their integration is not accomplished, the Roma ethnics return to traditional behaviors which are not compliant with the current European ones. The focal points (education, professionalism, and moral norms) should be "pushed" as much as possible toward integration. The data in Table 9 are relevant to the solution of the Roma issue: education as a way of ethnic NS formation.

7. Arguments for the survival of the small rural household

The extremely poor situation of Romania compared with the European average regarding economic and social development level create unfavorable premises for approaching the evolution of SRH. The country cannot identify and organize forces for the reformation of the national economy and for adapting to the performances of EU and of the globalized economic area. Consequently, at macroeconomic level, the SRH is situated in a cone of shadow in the preoccupations of decision makers. Unfortunately, a National Strategy of Evolution for the Romanian Economy is lacking. This could allow a vision on the probable evolution of SRH, without leaving its future in an area of uncertainty. Specifically this lack of solution for the salvation of the SRH the authors of the present paper attempt to outline. The following questions arise: "Why is a solution desired?", "Is it theoretically and practically possible?" The answers can be:

- Almost half of Romania's population is living in rural areas, out of which 50-60% is population from settlements where the SRH is prevalent (Table 2). The reaction of rural population from SRH was one of survival: migration in European countries to find a job. The limits of resisting disruptions of various magnitudes, coming from historical times, were exceeded which caused a situation out of control. It had as effects: depopulation of villages, un-cropped farm land, falling birth rate, etc.
- The concept of survival for the Romanian village has several interesting peculiarities namely:

- Initially, and for a long time, the ones who migrated were single individuals (husband or wife); one of them remained in the country to look after children, elderly parents, and the household;
- The next wave of migrants comprised also families or families were formed in host countries;
- The 2-3 (according to others 4) million migrants sent annually amounts of saved money, accounting for 8 million euro. New houses, modernly equipped, were built with this money, and, thus, the number of houses built annually in the rural area exceeded the number of houses made in the urban area. After several years the migrants returned to their villages and families;
- "Returning home" means also an individual with a certain profession, with a mentality typical to inhabitants of the host country;
- Returned home and owning a certain capital, these people intended to initiate a business that would allow survival. The most appropriate would be the one that was practiced abroad and that proved to be economically efficient and modern;
- School was considered compulsory for the future of their children;
- The entrepreneurial spirit was formed and verified in the host countries.

These are some of the reasons (to which others could be added, e.g., of psychological, spiritual, familial, nature, etc. related.) that are encouraging the design of a logical scheme that is using this core – the "village sons" – for stopping the involution of villages, by valuing the neg-entropy of these hundreds of thousands of persons who gradually return in Romania. If we ask "What is critical, what are the limits of resilience for the existence of Romanian village, for the accomplishment of this idea?", one answer can be the following: The limit is the time. The use of neg-entropy, capital, willingness, and determination of returned migrants should be made during their active life time in order to stimulate them to initiate and maintain the economic activities at the level that is expressed in the host countries. Additionally, a natural resource with great potential (Table 11) can be used: natural pastures and hay fields (34% of the country's agricultural area), that are far from being exploited up to their natural nutritive capacity for domestic animals. In 2014, compared with 1989, the number of domestic animals decreased by half (Table 9). It is believed that natural pastures and hayfields are far from being exploited to their potential, despite the fact that there is a long tradition, especially in shepherding, which should be harnessed.

Table 9. Number of domestic animals in Romania (beginning of the year; thousands heads)

Species/ Year	1938	1989	2014	2014/1989 (%)
Cattle	3,653	6,416	2,069	56.6
Pigs	2,761	14,351	5,035	182.4
Sheep	10,027	6,210	9,507	94.8
Goats	364	1,078	1,416	389.0
Horses	1,581	702	523	33.1
Poultry	27,325	127,561	75,435	276.1
Bees, families	460	1,418	1,350	293.5

Source: INS, 1993; INS, 2016a

In the scheme imagined by the authors for the recovery of the Romanian village, the valuation of this resource for sheep and cattle breeding is rational because:

- There is still knowledge in this field;
- The obtained products are needed form human existence;
- A supply chain of valuation for natural pastures and hayfields is recommended for the following: animal breeding, milk and dairy products, meat and meat products.

Processing of products is the strong-point of the salvation and recovery of the Romanian village: agricultural products are locally processed, being traded directly as food products. Processing becomes the attractor of economic activities, of qualified “repatriated” persons, a complex of activities that requires technology, various professions, knowledge, occasion for professional development, profit based on value added by processing of agricultural products.

The recovery SRHs imposes the transformation of individual producers and processors into legal persons that provide a direct supply to retailers or final consumers. This processing segment which is not properly organized today is one of the causes of the involution of the SRH. There is the potential to find professionals among the ones who worked in this segment in host countries. Other supply chains for natural resource valuation could be imagined and applied with additional non-agricultural activities that could absorb all the “repatriated” people and inhabitants able to work from the settlement. The value added by processing and the avoidance of intermediaries become source of incomes for the rural population, means of amortization of investments, reserve for progress, for increasing living standards and exceeding of the subsistence stage.

8. Reconsideration of the rural economy with a special focus on SRH

Reconsideration of the rural economy focusing on SRH is based on the premise that the village has the possibility to survive in an organized form and new economic structure and this process the main neg-entropy contribution relies on returning migrants. The concept proposed for this reconsideration refers to survival by adaptation to the technical and economic realities of the European countries. The SRHs belong to economic and social systems which are in continuous adaptation (Berkes et al., 2003). The core of the modernization proposal has the hereinafter structure.

A) Premises:

- Natural resources, as potential, remain unchanged;
- Population, including migrants, has the motivation, determination, willingness to change for better the faith of the village;
- If the state does not help this process, at least it should not raise barriers (by fees, taxes, bureaucracy) to survival;
- Priority is given to professional quality of village leaders, councilors, and public institutions.

B) Principles and solutions:

- Organization of economic activities in a way that allows the transformation of natural resources into agricultural products, and subsequently into food products; the SRH assumes also the processing of agricultural products;
- Processing is to be deployed on an organized agro-industrial platform that is built and it is functional on the territory of the rural settlement by the name Agro-Industrial Park (AIP). This is the place of investments for the newly established production cooperative, for the investment of various individuals etc. How the platform is organized and run could be similar with the one of industrial parks developed in urban areas. AIP becomes the economic attractor of the cooperative that is served by professionals;
- Production profile is in accordance with value supply chains of natural resources, market demand, and availability of capital for investment;
- Future processing capacities should take in account the minimum economic efficiency. In this case, it could be considered the cooperation of more cooperatives from the area having the same supply chains for production;
- Initiative group for project start: contacting the “sons of the village” who live in Romania (and reunite them in a council, for example), local authorities, representative householders that can serve as models for the community, etc. Actions imply the following:

- Establishment and functioning of the group;
- Establishment of the economic entity and starting actions for the realization of AIP – task of the local public administration; preliminary data for the size, location, and utilities (project data);
- Establishment of Agricultural Cooperatives of Credit using the model from the beginning of the 20th century and attracting the savings of migrants and other legal or physical persons;
- Managing the economic entities (cooperatives) in collaboration with local informal entities following a recovery plan of the settlement's economy by the members of the economic entity.

C) Production profile:

The structure and the sequences of the supply chain of agricultural and non-agricultural products are specific for each economic entity. The common aspects refer to the following requirements:

- A diversified structure;
- Respecting the natural potential in the sense of not exceeding the regeneration capacity (support capacity);
- Maximum value added (the neg-entropy of human resource in action) (Alexandru, 2011).

A new element in the design of production supply chains will be the management of the local economy, professional profile of local staff and especially of those returned from abroad, which must be found in the technological link of AIP. Non-agricultural activities will occupy an important place in the economic space, because many returned migrants are specialized in: construction, trade, family assistance etc. These should find their role in the local economy by initiating supply chains or activities that are appropriated for their training such as construction companies with activities at national level, tourism (guest houses), assisting retired people and convalescents from urban areas, children who are on vacation in the rural area, etc. The following can be added to new non-agricultural activities: sewage treatment for community and the AIP, valuing secondary products generated by processing of agricultural products – skins, wool, fats, bee wax, residual biomass (potentially for biogas), etc. A functioning rural environment also requires schools with a variety of profiles, equipped with dormitories – opportunity for daily delivery of food products. Aging of the population becomes another opportunity for organizing the reception of retired people from urban areas for living the rest of their lives in the village, but having the necessary comfort. This can be viewed also as a financial contribution to the local budget, along with the consumption of products and services.

D) Survival of SRH as ratio between entropy and neg-entropy of population (social neg-entropy):

Entropic accumulations are obvious and most of them are highlighted by the national statistic. The polluting character of industry significantly impacted on the quality of social ecosystems and on environmental factors, many of these entropic activities being translated into irreversible modifications of them: open pit exploitation of minerals and coal, sterile and ash dumps of power plants, soil pollution with oil products, mining ponds with chemical pollutants, deforestations, pollution of surface and groundwater, fertilizer and pesticide residues, etc. Thus, the pollution potential of the Romanian economy with impact on the agricultural land was estimated to be: extractive industry waste: 11,242 tonnes of hazardous waste and 215.05 million tonnes of non-hazardous waste; waste of other industrial activities: 407,237 thousand tonnes of hazardous waste and 56,83 million tonnes of non-hazardous waste; municipal waste: 8,25 million tonnes (INS, 2016a). Global warming was already noticeable in Romania during the last 10-20 years through unusual meteorological manifestations, extending aridity of fields in the southern part of the country, floods, and landslides. Raising entropy is a reality of the present with an increasing trend and consequences on long term.

The economic-social activity of rural settlements could be maintained within the limits of sustainability (the ideal case) if the natural resources that are exploited are not situated below the limit of their regeneration (also, the ideal case). This theoretical balance could be reached by opposing entropic accumulations (of entropic nature) to their correct ecological management, based on knowledge, information, experience, and intelligence or, by a single word, on the social neg-entropy.

Knowledge, social neg-entropy, becomes the “ultimate resource” in the contemporary era and should be formed, maintained, valued, and transmitted to future generations for a logical and unanimous desideratum of the society. In its formation and management the following levels can be outlined:

- Traditional ecological knowledge (known as the classical way of performing various activities);
- Knowledge acquired by education, obtained through accumulation from various members of the society, along generations;
- Knowledge by own life experience.

The period of curricular education (or state education organized by the national system of education and professional training) is of outmost importance in the formation of social neg-entropy. This is because it does not address only the current needs of the society for human capital, but also due to the fact that it secures this in perspective (Table 8). School training can be considered a force that challenges the resilience of the rural society. If until 1989 illiteracy was strictly controlled, after this year, the enrollment in elementary school dropped, reaching 73.9% in 2014, compared with 86.5% in 2009/2010. Illiteracy became a reality having values of two digits as proportion of the total population. Causes should be sought in the poverty of a certain part of the population, large distances between schools and houses, decrease of school number caused by the decline of school population, presence of Roma population (1.0-2.5 million persons) of which more than 50% did not go to school or abandoned it.

This negative focal point of illiteracy for an important segment of persons does not affect only the resilience of social systems of their country of origin, but also the resilience of other EU countries where they migrate. Thus, the lack of neg-entropy associated to a part of these persons (Romanian citizens) makes them to be “entropic” for the society.

School education and population’s income are outlined as main forces (Bajureanu, 2006) that have the role of amplifying by resonance the information, knowledge, practical activities, cognitive and economic potential which are needed for resilience. The time required for the evolution of a human generation may be necessary for person to become a participant in social work. The steps of this process are:

- Childhood – 7 years: acquisition of traditional knowledge needed for behaving within the family;
- Elementary school – 7 years: accumulation of curricular knowledge needed for surviving within the community;
- Gymnasium/professional school – 4 years: gain of knowledge and skills about survival, integration in the average level of training at national level; this is the start for the production of neg-entropy type knowledge (useful for the individual and for the society);
- Higher education – 3 to 8 (or more) years: formation of professional elites, leaders, who assume the reduction of neg-entropy (cognitive) gap between genders, between the village and the city (Bran et al., 2017).

The notion of resilience in the case of reconsidering the neg-entropy of the rural society with the purpose of recovering the economic activity includes the capacity of the society of initiating, supporting, valuing the processes of education, training and experience (which are tools of neg-entropy). These processes are prolonged and expensive and require local individual and social effort, and also an administrative-governmental one.

The survival of the village and its subsequent strengthening and development logically require:

- Return to peak performance of 1989 as the first condition for the survival of the village and as an act of the resilience to NS phenomenon. A second condition is that NS assimilate in education, economy, agriculture and particularly SRH everything that has developed and progressed from 1989 to present. And the third condition is to requiring to the education system, decision makers and the public to shape the future and prepare for it. At national authorities' level, this involves updating school curricula and thinking in perspective the necessary knowledge for society. We can talk about shaping a virtual NS of the next human generation;
- Adaptation to the European performances accumulated between 1989 and 2016; for this case, the village will develop another category of resilience.

In order to accomplishing these objectives several difficult tasks are identified:

- To preserve the potential of natural ecosystems (Table 4)
- To improve the quality of human resource: its neg-entropy in continuous development until a null gap compared with urban areas and European level.
- To resist to the reality according to which the existence of Romanian village is threatened by emigration and depopulation and also by another recently appeared danger: the selling of agricultural land and the outsourcing of large areas of agriculture and forestry land. This is a lethal process for the Romanian economy and society, difficult to control because the price of land in Romania is much lower than in other European countries and because there is a lack of interest for this problem of the Romanian decision makers;
- To cope with the involution of the education on all its chain (Table 8);
- To fight with the apathy of some SRH inhabitants and with population aging.

The capacity of a social ecosystem, of SRH in particular, to implement solutions that support the resilience of the system in order to ensure the survival of the village depends of the following:

- Neg-entropy infusion from abroad (repatriation of migrants);
- Organization, motivation of human resource, finding leaders, creation of legal persons or other types of organization to generate the synergy effect (economic, social etc.);
- Major reformation of the education system;
- Shifting from only producing agricultural products to also processing them;

- Adapting the agricultural technologies to the level of the 21st century;
- Finding solutions for apathy, laziness, poverty, foolishness, and negative external interventions;
- Valuing some manifestations of resilience provided by the inhabitants of rural areas: survival practices, learning capacity, tenacity, and adaptability to technical novelties.

9. Resilience of social ecosystems in thermodynamic interpretation. The case of SRH

The evolution of social ecosystems is continuously marked by the direct linkage between the natural system and the social one, by the extent to which the potential of one part becomes compatible with the other. The process is complex, develops on long term, and continuously seeks the balance between nature and society as a compromise among the principles that govern both of them. The resilience of the social ecosystems comprises the resilience of each component to internal and external disturbances and the resilience of the complex natural-social system. If this resilience is managed appropriately, it forms a dynamic system which supports the existence and evolution of the human society (Scarlat & Chiriță, 2012).

In thermodynamic terms, resilience becomes the stability limit of a system, being under the influence of two contrary groups forces: those that lead to instability, disorder, and reduction of the potential (entropic forces) and those that represent order, the maintenance of the potential (regeneration, newly created potential, and new quality), comprising regeneration capacity, human intelligence, knowledge, and past experience of human systems. Resilience requires a balanced relationship between "hard" components (nature) and "soft" components (society) of the human settlement with has as subdivisions the communes with SRHs.

Reconsidering SRH through the proposed model of processing agricultural products might change for better the evolution of the social ecosystems. Thus, a higher income of inhabitants may allow a living standard closer to the urban one, lowering the attractiveness of the city and of leaving the SRH for it. Hence, the golden rule for eco-social systems management must be "efficiency" which relies on the following requirements:

- In relation to the natural systems: preservation of the natural potential by controlling entropic processes of anthropogenic nature such as pollution and overexploitation. The nature can contribute for a certain extent through its regeneration capacity to metabolization pollutants, and it can act as a balance line – the result of resilience being represented by the production potential of natural systems. Currently, in Romania, the abovementioned requirements are often disregarded. For instance, the forest is sold beyond any logical norm, with disastrous short and long term effects on the environment, people, and economic activities; also, the cropland is sold or rented without any control to foreigners, a process favored by the much lower price of land compared with other European countries. In the latter case the social ecosystem ceases to exist, the limit between order/disorder disappears and the entropic forces, destructive, are imposed.

- In relation to the social systems: focal points aim to enhance the production potential of natural resources (which is limited by their size). This potential can be enhanced only by increased efficiency: high quality and yields, diversification, integration of production chains in cluster type forms or supply chains, supplementary added value, increase of knowledge, talent, experience, innovative and entrepreneurial spirit of rural inhabitants, etc. The resulting focal point is the quality of the human resource, its neg-entropy potential. This is a condition for the development of social ecosystems and of survival for SRH. Fortunately, there are no limits for the human cognitive (neg-entropic) potential. The list of challenges that Romanian villages have to face does not stop here. Thus, for instance, solutions to resist to climate change must also be found, taking into account some realities, such as: climate changes and their effects on environment, the phenomenon of globalization, the strategies of transnational corporations that lack interest for the environment, expressions of "perverse" neg-entropy like violence, arming, social vices, mediocrity of decision makers, etc.

The above described scheme, existing in human practice, requires several decades or more, as it is the case for the restoration of forest land, soil quality, natural ecosystem biodiversity etc. From social and economic point of view, possibilities for shortening the time gap should be sought by decision makers and analysts and by inhabitants of the rural area of SRHs. The solutions can include, for example:

- Introducing neg-entropy in the system by:
  - Bringing real professionals into the system;
  - Removal of mediocrity from decision levels;
  - Using various forms of artificial intelligence, e.g., computers and IT networks;
  - Valuing adults and children who are very intelligent, talented, vocational, and inclusive;

- Adaptation to what is new, representative on national, European or world level.

- Reducing pollution (entropic accumulations) of natural ecosystems. Current practices, research, previous experience make an important source of inspiration for rural inhabitants and polluting entities.

Management of SRHs must take into considerations the future of their inhabitants, the old infrastructure, the knowledge and information accumulated in historical time, the ownership type of the natural ecosystems, etc. The necessity to ensure the resilience of SRHs is required from a larger level, too, such as the need to cope with the effects of climate change at country/ region/ world level or to face various political, economic, and military challenges.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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Resilience to Environmental Pressure: The Role of Agriculture in Wallonia (South of Belgium)

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Abstract
Agriculture is under environmental pressure since its modernization, mainly after the Second World War, which generated the use of large quantities of chemical products as pesticides and fertilizers. However, during the three last decades, the preservation of the quality of the environment progressively became a priority of the Common Agricultural Policy (CAP) and different measures were successively implemented, some of them being compulsory and other ones not, or not yet. This paper focuses on the implementation of agricultural policy measures at the regional level of Wallonia, the Southern part of Belgium, a founder State of the European Union. Three aspects are presented and analyzed: (1) the greening of the CAP, through the so-called "green payment" and its consequences (permanent pasture maintenance, crop diversification, and the establishment of ecological focus areas); (2) the development of organic farming; and (3) the increasing number of specific quality labels. The paper argues that, supported by the CAP and the Walloon regional government through financial, research, education, extension, and advertising measures, the Walloon agriculture is farmed on the direction toward a more sustainable model, a more resilient one to environmental pressure.

Keywords: Wallonia; green payment; organic farming; specific quality products; ecological focus area.

1. Introduction

During the "golden period" 1950-1980, European agriculture registered tremendous progress in term of yields, leading not only to self-sufficiency, but even to structural overproduction. However, the negative side comprised economic and environmental problems which unavoidably appeared and deepened throughout this period. Since the 80's, specific measures were defined in order to take the environment more into account. Therefore, the present paper takes these pro-environmental measures under scrutiny, with respect to Walloon agriculture (South of Belgium) during the year of 2015.

After more than three years of difficult negotiations (Bureau, 2012), the European Parliament, the Commission and the Council of Ministers reached an agreement in June, 2013. New regulations were published in December 2013, defining a new Common Agricultural Policy (CAP). One of its characteristics is to go further in favor of the environment (Matthews, 2013; Petrescu-Mag and Burny, 2015), especially by creating the so-called "green payment" which must represent 30% of the total amount for direct payments for the farmers in each Member State/region. In order to obtain this important support, farmers who are under given conditions (mainly the larger farmers), must respect three conditions in addition to cross-compliance: maintenance of permanent pastures, crop diversification on arable land and presence of ecological focus areas on arable land. Due to late decisions, the implementation of the new CAP began only in 2015, and not in 2014, as it was previously planned. The following lines show the first results of the implementation of the green payment in Wallonia, trying to answer questions such as: "How most of farms are concerned?"; "What are the main ecological focus areas?"; "How most of farms deal with the new rules?"; and "What would happen if the rate of ecological focus areas increased after 2017? "

In addition, the emphasis is put (in the second part of the paper), on organic farming which is now strongly supported by the European Union (EU) and the Walloon government. Organic agriculture is an important piece of the puzzle that delivers solutions for a more sustainable world (Petrescu et al., 2015). Therefore organic agriculture should be considered in a broader context, relating it to rural development, environment, and society (Daugbjerg & Sønderskov, 2012), transforming the environment-agriculture binom into a priority axis of EU and international environmental policies (Brezuleanu et al., 2013; Gázquez-Abad et al., 2011). Next, the recent evolution of the supply-side is pointed out, the public support is examined, and the consumption of organic products is analyzed. Last but not least, the topic of specific quality products is taken under analysis (in the third part of the study). Some of them include characteristics which are favorable to the environment.

2. Implementation of the new common agricultural policy in Wallonia in 2015: a more sustainable model

2.1. The green payment in Wallonia

The political agreement which was finally reached in June, 2013 led to four legal texts including the Regulation (EU) No 1307/2013 of December 17, 2013, dealing more specifically with direct payments to farmers. Consequently, a new architecture for direct payments was defined, leaving important decisions to the Member States or even the regions within them (some measures are optional and the relative importance of each of them can vary) (Hart, 2015). There is however one exception: the green payment, which has to account for 30% of the national/regional envelope for direct payments in each Member State/region. There is no choice about it. Indeed, the green payment is considered as very important in favor of the environment and to fight against climatic change.

In Wallonia, the new structure of the direct payments (Walloon Government, 2015; ***, 2015), after notification to the Commission and its approval, especially about coupled payments (which percentage of the total amount for direct payments is higher than the normally authorized proportion and needs a special approval by the Commission, however respecting the new regulation), is presented in Figure 1.

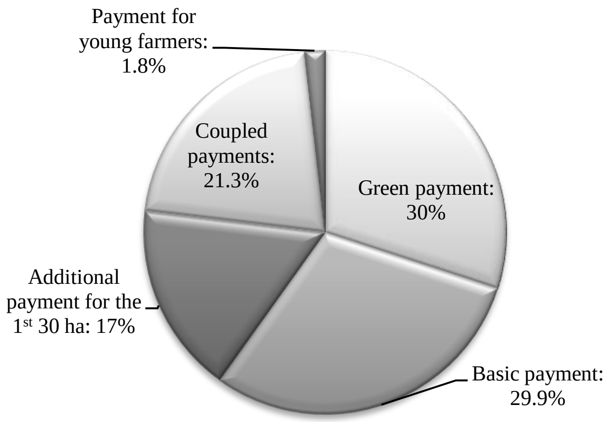

Figure 1. New architecture of direct payments in Wallonia (2015-2020)
Source: Burny & Terrones Gavira, 2015

The way to grant the green payment had to be decided by the Member States/regions: either proportionally to the basic payment, or the same amount for each eligible hectare. The Walloon government chose the first option, in order to avoid too big losses for some farmers compared to the previous period of 2007-2013. In addition, every year, before August 1st, for the implementation during the following year, each Member State/region has to inform the Commission if it chooses to change the implementation ways of the greening.

More specifically, the green payment is linked to three conditions (article 43 of Regulation (EU) No 1307/2013):

(i) Maintenance of permanent pastures;

(ii) Crop diversification;
(iii) Presence of an ecological focus area.

It is important to note that organic farmers automatically get the green payment without any additional constraints and therefore, they do not have to respect the three above-mentioned conditions.

2.2. Maintenance of permanent pastures

Permanent pastures are grassland since at least five years. The year of reference being 2015, each Member State/region establishes the reference ratio as the area of permanent pastures divided by the total agricultural area, at the national/regional or farmer's level. In Wallonia, the regional level was chosen. In the future, the reference ratio cannot decrease by more than 5%.

The Member State/region must also define the permanent pastures which are considered as environmentally fragile. These areas cannot be ploughed or transformed for another purpose (according to article 45 of EU Regulation No 1307/2013). In Wallonia, these permanent pastures are all situated in the NATURA 2000 area.

2.3. Crop diversification

In order to get the green payment, farmers have to practice crop diversification if:

(a) They have between 10 and 30 ha of arable land: in such a case, they must have at least two crops and the most important must not exceed 75% of the arable land area;

(b) They have more than 30 ha of arable land. For this case, they must have at least three crops, the one most important covering no more than 75% of the arable land area, and the two most important no more than 95%.

Land lying fallow, temporary pastures, one gender considered in the botanical classification (e.g., *Triticum, Hordeum*, and *Beta*) or one species for Brassicaceae, Solanaceae, and Cucurbitaceae can be considered as "crops".

In the following cases no diversification is requested:

(a) The farmer has less than 10 ha of arable land;

(b) More than 75% of the arable land are devoted to the production of grass (temporary pastures) or fallow and, at the same time, the remaining arable land area does not exceed 30 ha;

(c) More than 75% of the total agricultural area of the farm is devoted to permanent pastures or the production of grass and, at the same time, the remaining arable land area does not exceed 30 ha.

According to the area declaration of farmers for 2015, in Wallonia, 50% of farmers were not submitted to crop diversification, while 16% were obliged to have at least two crops on their arable land, and 33% had the severe obligation to have at least three crops on their arable land. Around 100 farms (less than 1%) failed to meet the criteria (Table 1).

Table 1. Number of farms concerned with crop diversification in Wallonia in 2015

	Number of farms	%
No obligation	6.323	50
At least two crops	2.040	16
At least three crops	4.221	33
Do not meet the obligations	105	1

Source: Terrones Gavira et al., 2016.

2.4. The ecological focus area

According to the article 46 of Regulation (EU) No 1307/2013, farmers must devote at least 5% of their arable land to ecological focus areas when they have more than 15 ha of arable land.

The Member States/regions can choose which are the ecological focus areas among the following (***, 2014): land lying fallow; terraces; landscape features, including such features adjacent to the arable land of the holding; buffer strips; hectares of agro-forestry; strips of eligible hectares along forest edges; afforested areas; areas with catch crops, or green cover (subject to the application of weighting factors); and areas with nitrogen-fixing crops.

In Wallonia, all the above-mentioned items are considered as ecological focus areas, with the exception of terraces and afforested areas. Some elements are directly converted into ecological focus areas, but others, like isolated trees for example, need a conversion coefficient to be considered as an ecological focus area (Table 2).

Table 2. Conversion coefficients and weighting factors to transform some areas and landscape features into ecological focus areas

Element	Particularity	Description		Conversion coefficient	Weighting factors	Ecological focus area (m^2)
Surface elements (ha)	Plot	Land lying fallow	Per 1 m^2	n/a	1	1
		Areas with short rotation coppice	Per 1 m^2	n/a	0.3	0.3
		Areas with nitrogen-fixing	Per 1 m^2	n/a	0.7	0.7

Element	Particularity	Description		Conversion coefficient	Weighting factors	Ecological focus area (m^2)
		crops				
		Buffer strips	Per 1 m^2	n/a	1.5	1.5
		Strings of eligible hectares along forest edges – without production	Per 1 m^2	n/a	1.5	1.5
	Intercrop plot	Areas with catch crops or green cover	Per 1 m^2	n/a	0.3	0.3
	Topographic elements	Ponds	Per 1 m^2	n/a	1.5	1.5
		Group of trees/Field copses	Per 1 m^2	n/a	1.5	1.5
Linear elements (m)		Field margin	Per 1 m	6	1.5	9
		Ditches	Per 1 m	3	2	6
		Hedges/wooded strips	Per 1 m	5	2	10
Punctual (nb)		Isolated tree	Per tree	20	1.5	30

Source: Terrones Gavira et al., 2016

According to Table 2, it means, for example, that an isolated tree covers an area of 20 m^2 as a mean and has an influence on 20 x 1.5 = 30 m^2 (protection against winds, shadow, etc.).

In Wallonia, in 2015, 54% of the farmers were not obliged to have ecological focus areas (they had less than 15 ha of arable land, or were organic farmers, etc.). Among the remaining 5,828 farmers, 47% devoted between 5 and 6% of their arable land to ecological focus areas, 21% had between 6 and 7% and 29% had more than 7%. A small number of farmers (2.4%) did not reach the minimal level of 5%.

The mean percentage of ecological focus areas reaches 6.9, and the median is 6. So, if the percentage of ecological focus areas would increase to 6, 50% of the farmers who are obliged to respect this constraint in order to get the green payment would be obliged to increase their efforts. If the compulsory percentage of ecological focus area in arable land would be fixed to 7 (a report of the Commission is awaited not later than March 31, 2017 on this topic), 70% of these farmers would be obliged to make additional efforts which could lead to some difficulties.

When farmers have at least 5% of ecological focus areas, it is observed that 79% of them declare only one element, mainly catch crops or green cover (95% of the cases), and 15% have only two elements (Table 3).

Table 3. Number of types of ecological focus areas in Wallonia in 2015

Number of types	Number of farms	% of farms
1	4,487	79
2	850	15
3	230	4
4	76	1
5	30	1
6	13	0
7	2	0
8	0	0
Total	5,688	100

Source: Terrones Gavira et al., 2016

As far as the area is concerned (Table 4), catch crops or green cover represent an overwhelming share: 88.8% of the total ecological focus area in Wallonia. Land lying fallow (4.1%) and nitrogen-fixing crops (3.7%) are far behind. The landscape features are marginal and represent only 2.1%

Table 4. Area of different types of ecological focus areas in Wallonia in 2015

	Area (ha)	%
Land lying fallow	983.7	4.1
Areas with short rotation coppice	9.3	0.0
Areas with nitrogen-fixing crops	898.5	3.7
Buffer strips	206.5	0.9
Strings of eligible hectares along forest edges – without production	99.8	0.4
Areas with catch crops or green cover	21,432.8	88.8
Ponds	1.3	0.0
Group of trees/Field copses	111.1	0.5
Field margin	138.3	0.6
Ditches	42.8	0.2
Hedges/wooded strips	200.8	0.8
Isolated tree	1.6	0.0
Total	24,126.6	100.0

Source: Terrones Gavira et al., 2016.

3. The development of organic farming in Wallonia

3.1. Organic production

In 2015, 4.6% of Belgian farms were producing organic agricultural raw material, and the agricultural area devoted to organic farming reached 5.1% of the Belgian total agricultural area. Within Belgium, there is a big contrast between Flanders, where organic farming is very marginal, and

Wallonia, where it has now a significant share of production and is still increasing.

The evolution of the number of organic farms in Wallonia during the 21st century is illustrated in Figure 2.

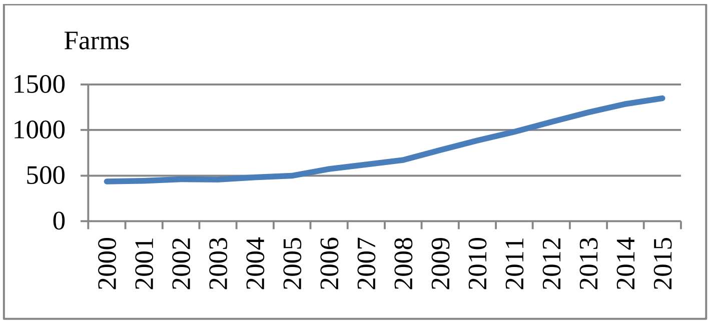

Figure 2. Evolution of the number of organic farms in Wallonia from 2000 to 2015
Source of the basic data: BIOWALLONIE, 2016

Since 2005, the increase rate is remarkable and the number of farms exceeded 1,300 in 2015, which represented 10.5% of the total number of farms in Wallonia. The agricultural area devoted to organic farming followed the same trend (Figure 3) and exceeded 63,000 ha in 2015, which represented 8.7% of the total regional agricultural area. The mean organic farm is a little bit smaller than the mean regional farm (47.1 ha versus 56.9 ha), as organic farming brings some opportunities for small scale farmers (Zeynab Jouzi et al., 2017).

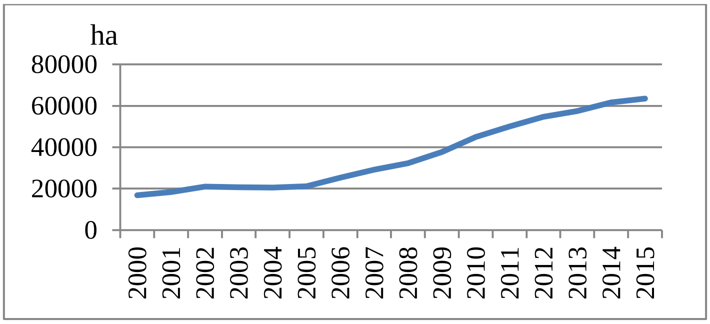

Figure 3. Evolution of the organic farming area in Wallonia from 2000 to 2015
Source of the basic data: BIOWALLONIE, 2016

However, more and more big farms over 100 ha become organic farms, proving the economic opportunities of this way of production. In

Wallonia, 80% of the area concerned with organic farming is covered by pastures (50% of the regional agricultural area), on which cattle for meat and dairy cows are raised. In 2015, the number of organic cattle heads in Wallonia exceeded 77,000 (see Figure 4).

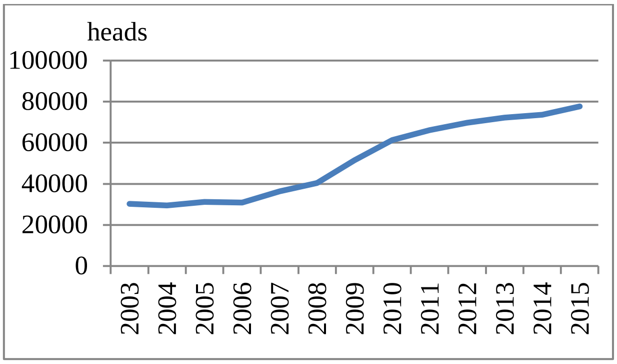

Figure 4. Evolution of the number of organic cattle heads in Wallonia (2003-2015)
Source of the basic data: BIOWALLONIE, 2016

General crops have a share of 18%, the area of organic cereals increases as the demand becomes stronger. Vegetables are produced on 1% of the organic agricultural area. Concerning animal production, the poultry sector is growing rapidly: the number of poultry heads increased by 10% between 2014 and 2015, while the number of laying hen grew by 37%. Between 2007 and 2015, the number of poultry heads doubled, reaching 1.7 million, and the number of laying hen was multiplied by six, reaching nearly 200,000. Organic pigs, sheep, and goats are also raised, but in limited quantities.

3.2. Public support

In Wallonia, organic farming is strongly supported by the public authorities, notably through the rural development program of the CAP (Burny et al., 2016) (Table 5).

Table 5. Financial support (€/ha) for organic farming in Wallonia (2015-2020)

Crop	Area of organic farming		
	0 to 60 ha		Over 60 ha
Meadows and forage crops	200		120
Other annual crops	400		240
	0 to 3 ha	3 to 14 ha	Over 14 ha
Fruit trees, horticulture and seed production	900	750	400

Source of the basic data: Service Public de Wallonie

In order to help farmers to change from conventional agriculture to organic farming, the support during the two compulsory conversion years is even higher (350 €/ha from 0 to 60 ha for meadows, 550 €/ha from 0 to 60 ha for cereals, 1,050 €/ha from 0 to 3 ha for horticulture, for example). This support is co-financed by the Walloon Region and the EU and it is added to the direct payments of the CAP. Organic farmers are automatically eligible to the green payment (Hart, 2015) and so to the other direct payments. In 2013, the Walloon government elaborated a strategic plan for the development of organic farming in Wallonia towards 2020. This plan defines several targets for 2020: to reach 1,750 organic farms, 14% of the regional agricultural area, 500 processing enterprises with a total turnover of 500 million € and a market share of 3% for organic products in the total food market. This plan does not only deal with direct financial support to farmers, processors, cooperatives and retailers, but also with research, teaching, extension services and advertising campaigns. In 2016, the Walloon Minister for Agriculture went even further: for 2020 horizon, the new targets are to reach 2,000 organic farmers and 18% of the regional agricultural area. An additional financial support is also foreseen before the conversion process to organic farming.

In 2016, after a consultation open to all citizens, the Walloon government defined its second "Strategy for sustainable development" which presents targets, measures, and indicators. Of course, organic farming has its role to play in this global strategy.

3.3. Organic consumption

The total food and non-food organic market in Belgium reached 514 million € in 2015, an increase of 18% compared to 2014. More than 9,000 products are available and, as a mean, the Belgian household bought more than 15 times organic products compared to 2013. There are more and more products proposed to consumers, including packaged and prepared food products. Concerning food products, the market share of organic products reached 2.8% in 2015 against 2.3% in 2014, and 1.3% in 2008. More remarkably, the total Belgian expenses for organic food products increased by 18% in 2015 compared to 2014, while the total expenses for food products increased by 1.1% only. The organic products which are concerned with the main expenses per capita are presented in Figure 5.

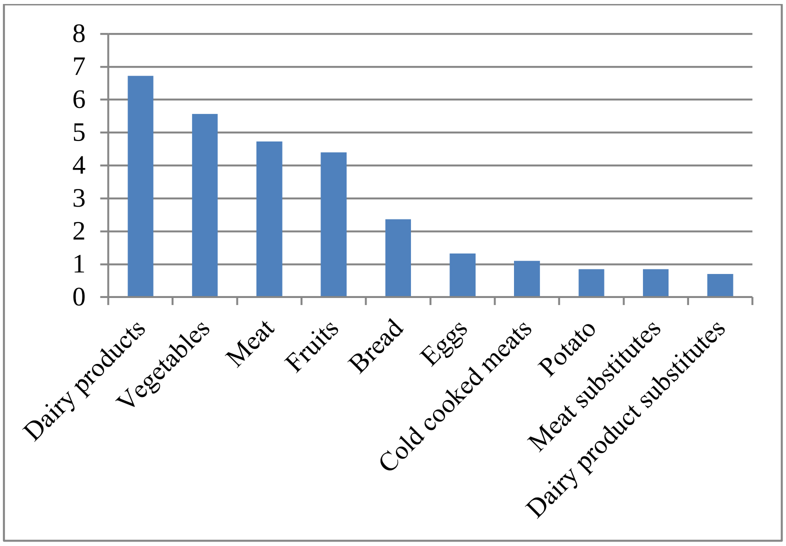

Figure 5. Expenses per capita for organic food products in Belgium in 2015 (€)
Source of the basic data: BIOWALLONIE, 2016

Dairy products are the leaders of the market with 6.72 € per capita, before vegetables (5.57 €) and meat (including poultry, 4.73 €). Fruits are on the fourth position with 4.40 € per capita. So, it clearly appears that fresh products are the most successful organic products. The market share of organic products considerably varies according to the category of food (Figure 6).

It appears that the market share of organic products is by far the highest for meat substitutes (23.5%). However, the market is not large. Behind are eggs (10.5%), vegetables (6.0%), fruits (3.9%), and bread (2.8%) of which the market is much more important. For dairy products, for which the expenses per capita are the most important, the market share of organic products reaches 2.7%.

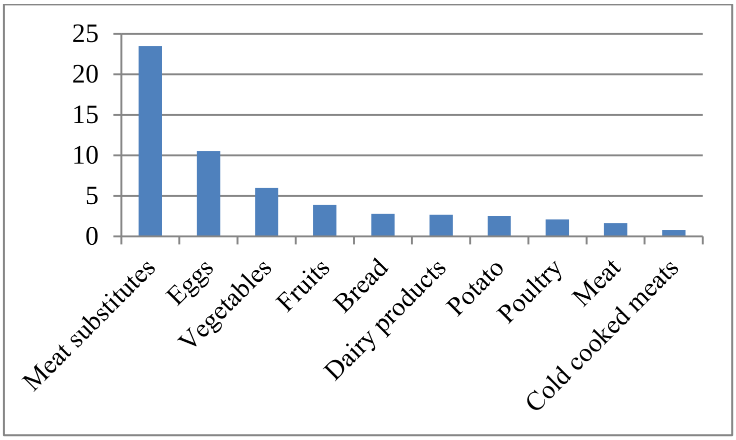

Figure 6. Market share of some organic food products in Belgium in 2015 (%)
Source of the basic data: BIOWALLONIE, 2016

In 2015, 88% of Belgian households bought organic products at least once, and 9% bought at least once per week. The last ones represent 60% of all the expenses. The percentage of buying households (at least once in 2015) varies, of course, according to the products (Figure 7).

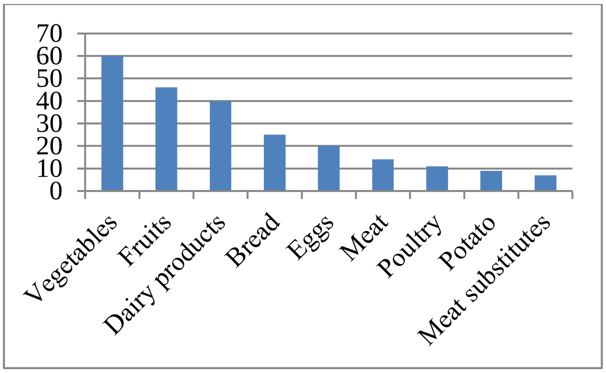

Figure 7. Percentage of Belgian buying households of organic food products at least once per year in 2015
Source of the basic data: BIOWALLONIE, 2016

The highest percentage of Belgian buying households of organic food products is observed for vegetables (60%), fruits (46%) and dairy products (40%). Bread (25%) and eggs (20%) come after. Concerning consumers' profile, high income households with children together with high income retired households represent 50% of the total expenses for organic food products. However, the market share of organic food in the total food expenses is the highest among the groups of single persons aged over 40, and those aged below 40, with 4.1% and 3.9%, respectively (Figure 8).

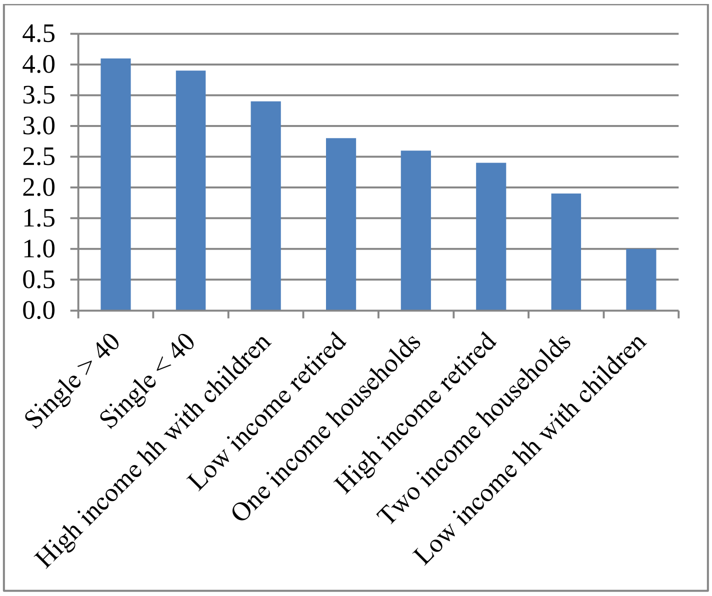

Figure 8. Market share of organic food according to the population group in 2015 (%)
Source of the basic data: BIOWALLONIE, 2016

The high income households with children (3.4%), low income retired persons (2.8%), one income households (2.6%), high income retired persons (2.4%), and two income households (1.9%) follow after that. The share of organic products is the lowest among low income households with children (1.0). Indeed, the prices of organic food products are generally one third higher than the prices of conventional products. The difference is particularly high for eggs. For those who choose to consume organic food, price barrier is often compensated by the trust in the power of organic food to protect human health and the environment (Petrescu and Petrescu-Mag, 2015) or by better sensory attributes (Bryła, 2016; Tobler et al., 2011). In Belgium, organic food products are mainly bought in supermarkets (42%) and shops specialized in organic products (33%). Local shops have a share of 11% (Figure 9). Direct sales are increasing in the food market during the last years. However, the on farm sales of organic products represent only 4%, and open markets 4% of the total organic food market.

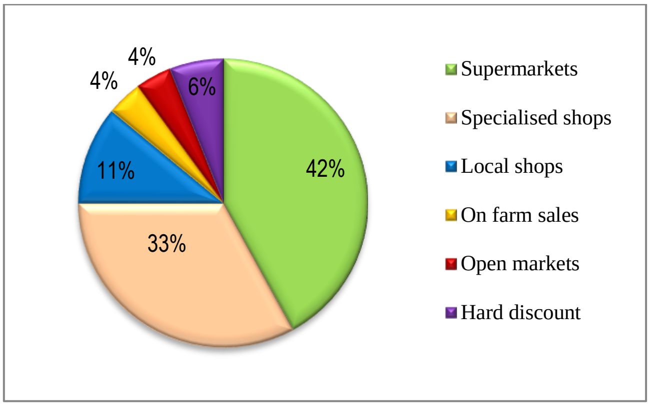

Figure 9. Market share of organic food providers in Belgium in 2015
Source of the basic data: BIOWALLONIE, 2016

4. Specific quality products

Quality labels are intended to protect the environment, human health and/or traditional products and processes by signaling these features to consumers. Their success largely depends on the level of trust consumers have on them (Petrescu-Mag et al., 2016) and on how important the promoted attributes are to consumers. In Belgium, before the regionalization of the country, the first specific quality product to be officially recognized was the "jambon d'Ardenne" (ham prepared in the forest area of Belgium called "Ardenne").

Three years before the EU regulation dealing with origin-labelled products, the Walloon government defined its first regulation dealing with specific quality products (1989). Later on, it registered a regional label, called "EQWALIS" at the EU level (2003), and aimed to cover a large set of specific quality products, like the "Label rouge" in France.

More recently, in a legal code gathering all the regulations dealing with agriculture (Government Walloon, 2015), chapter II precisely specifies the regional system for specific products. On July 14, 2016, a new regulation simplified the rules for the registration of a new product. To be registered as specific quality products, the compulsory criteria are the following:

- The producing farm must be family farm;
- The sharing of the added value among the partners of the channel must be equitable, a significant added value being left to the farmers;
- The preservation of a balanced relation between the development of agriculture and the expectations of the society must be achieved.

An additional difference compared with standard products must be recognized. Among the possibilities there are: “the impact on the environment” and “the use of local inputs at different points of the food chain”.

In Wallonia, in 2016, 11 products were registered under the EU regulation (origin-labelled products and traditional specialties). The objective of the government is now to reach as many as 20 products registered by the EU regulation in 2018, in addition to 10 new specific quality products registered at the regional level.

5. Conclusions

For the period 2015-2020, the new Common Agricultural Policy focuses mainly on more equitable access to agricultural food and on a better environment. The so-called “green payment” was defined to support farmers’ income while depending on additional constraints in favor of the environment. In Wallonia, in 2015, it appears that 50% of the farmers are not obliged to practice crop diversification and 54% do not have to include ecological focus areas in their arable land. This reality resides in the fact that there are many small-size farms and grassland is relatively important. In addition, crop diversification was already practiced before the implementation of the new regulation and the most common way to ensure ecological focus areas is to use catch crops and green cover (which is not a new practice either). Though few farmers do not meet the criteria to get the green payment, the impact of the new CAP does not seem very important on Walloon agricultural practices. However, if the share of ecological focus areas goes up to 7% after 2017, it will have a more significant impact in favor of the environment.

Another important factor favorable to the environment is the recent development of organic farming. In Belgium, the production and the consumption of organic food products significantly increased during the last years. This is due partly to the increase of the demand and partly to the strong support of the public authorities to organic farming and processing. However, there is a problem of inadequation between production and consumption. Organic bovine meat, for example, is often sold as conventional meat, while the production of organic fruits is too small. Thus, it appears that the farmers are more guided by direct financial support than by the higher prices got on the market. Another question is that it was not sure that the financial support granted to farmers did change their previous practices, as some of them already respected organic rules without recognition. However, it is clear that organic farming represents today a significant share of Belgian agriculture and a serious alternative to conventional agriculture, though the threshold of 20% cited by Dufumier (2012) is not reached yet.

The third positive point is the increasing number of specific quality products, which are linked to local production and actors and, in some cases, refer to environmental aspects. The development of these products is also encouraged by the regional authorities.

By adding measures linked to the green payment, organic farming and specific quality products, it appears clearly that Walloon agriculture is farmed on the direction toward a more sustainable development model and, therefore it will be more resilient to environmental pressure.

Acknowledgement

This study was partially developed within the research program "The creation of a model for the evaluation of food quality from the point of view of consumer health and environmental protection", 2016-2018, a bilateral cooperation project between Wallonia – WBI, FRS-FNRS and the Romanian Academy. "La présente publication a été rendue possible grâce à l'Accord qui lie WBI, le FRS-FNRS et l'Académie Roumaine."

Conflict of interest

The author declares he has no conflict of interest in relation to this paper.

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Antibiotics — between Usefulness and Factors of Environmental Pressure Due to Their Residues in Milk

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Abstract
Antibiotics, besides their utmost therapeutic value, can also have undesirable effects on humans and animals even in small quantities and in the long run. The unwanted effects on consumer's health can manifest as allergic and/or toxic reactions. The indirect effects are also important because they can trigger mutations that lead to producing strains of antibiotic resistant microorganisms. Some studies have shown that the polluted milk with antibiotic residues is accompanied by increases of the somatic cell population and of the total germs count. The present study highlights that the presence of antibiotic residues in milk and milk products is of particular interest because, regardless the purpose and justification of their presence, favors risks to consumers. Therefore, the main objective of the paper is to present the dual nature of antibiotics: as a useful ally against bacterial diseases and an environmental pressure factor due to their residues in milk. Presented data support the assertion that more attention should be payed to the milk supply coming from the population households as this is considered to be more susceptible to antibiotic residues contamination.

Keywords: antibiotics; antibiotherapy; milk; residues in milk; risk assessment.

1. Introduction

Antibiotics are substances with proven efficacy in the treatment of bacterial infectious diseases of humans and animals. In small quantities and prolonged intake, antibiotics may determine allergic or even toxic reactions, antibioresistance, and imbalances in the intestinal ecosystem. Some studies showed that antibiotic polluted milk is accompanied by increases of somatic cell population and of total number of germs (Grădinaru et al., 2011). Moreover, the presence of antibiotic residues inhibits lactic bacteria from cultures used in the manufacture of fermented dairy products, may alter taste and aroma, acidification and whey expression with distension of cheese (Grunwald & Petz, 2003).

The aim of this paper is to highlight the benefits of antibiotics usage in the therapy of infectious diseases, and the risk of their residues in foods of animal origin, with direct reference to milk. The importance of the present paper comes from the fact that, besides many dangerous pollutants that contaminate humans and animals, antibiotics and their residues complete the "black list" of toxicants if they are used without a medical prescription, with no respect to target species and rules regarding the required withdrawal time for antibiotic clearing from the animal body.

2. Definition and classification of antibiotics

Antibiotics represent chemical substances, initially of microbial origin, which inhibit the growth of or kill another microorganism (Davies, 2006).

The history of antibiotics began in 1928 when Fleming discovered natural penicillin. Ten years later, Florey and Chain identified the penicillin thermostable forms, known as "crystalline penicillins". In 1945 it was observed that *Cephalosporium acremonium* strain produces an active antibiotic against Gram-positive and Gram-negative bacteria; this antibiotic was later named "cephalosporin" (Moisuc, 1998). Nowadays, many antibiotics (designed by semi-synthesis processes or by total chemical synthesis) are used in veterinary therapy, with various mechanisms and targets of action.

Generally, the action of antibiotics starts by their binding to susceptible cells and initiation of a chain of reactions which finally lead to an arrest of dividing (bacteriostatic effect) or to cell death by autolysis (bactericidal) (Poiată, 2004). The main bacteriostatic antibiotics are tetracyclines, chloramphenicol, and erythromycin. Penicillins, cephalosporins, streptomycin, gentamicin, kanamycin, rifampicin, polymyxins, and bacitracin are considered bactericidal (Ocampo et al., 2014; Stroescu, 1988).

Antibiotics administered by different routes are absorbed and get into the blood system, from where they are distributed to specific tissues, metabolic and excretion organs (especially liver and kidney), and potential tissues of storage. Absorption involves passing through biological membranes and the process is mainly conditioned by drug liposolubility and a low degree of ionization (Angelescu, 1988; Cinca et al., 1999; Dobescu, 1977). At the blood level, antibiotics circulate both free, dissolved in plasma, as well as reversibly bound to serum proteins (Rolinson & Sutherland, 1965). As the coupling of antibiotics with plasma proteins is higher, their blood level is more persistent, while tissues diffusion is slowed down. This connected part acts as a reserve which regulates fluctuations, maintaining optimal concentrations in systemic circulation. The pharmacodynamic effects of antibiotics depend on the balance achieved between their free and bound forms, just the free form being pharmacodynamic active (Dobescu, 1977). As free molecules of antibiotic are consumed, the drug comes off the protein, ensuring therefore a constant level of free molecules (Rolinson & Sutherland, 1965). Some antibiotics, such as tetracyclines, can be deposited in bone tissue; this depot may constitute a reserve of active substance, but may also have local toxic consequences or even sustain a chronic intoxication (Dobescu, 1977).

Drugs' removal from the organism is performed by biotransformation and excretion. Biotransformation involves hepatic microsomal enzymes and non-microsomal, from liver and other tissues (Cederbaum, 2015). Biotransformation processes occur predominantly in the liver, and antibiotics reach this organ through general circulation or when they are absorbed from the intestine through the portal circulation. Water-soluble substances (the unbound part to plasma proteins, those that were water solubilized or that became so after biotransformations) are renally eliminated. Because the renal tubules are provided with cells that usually have non-porous membranes, most of lipophilic substances are reabsorbed at this level. Among the antibiotics that are eliminated through bile erythromycin, rifampin, and tetracycline can be mentioned. Some of the substances that reach the intestine with bile are reabsorbed and pass into the entero-hepatic cycle, remaining in the body for a long time (Angelescu, 1988; Dobescu, 1977).

The elimination of antibiotics in milk is performed by simple diffusion through biological membranes. This passive transport occurs due to the difference in concentration on both sides of the membrane, the chemical structure of the substances (which determines the degree of lipo- or water-solubilization), the difference in pH of the environment on both sides of the membrane (the pH of the cows' blood is 7.4, and the pH of the milk ranges between 6.4 to 6.7), the amount of antibiotics bound to plasma proteins, as well as due to the ionization constant. As a general remark, only unbound molecules to protein plasma or tissue and, of these, only substances with a high degree of liposolubility (and certain solubility in water) will pass into milk (Angelescu, 1988; Dobescu, 1977; Ziv & Sulman, 1975). Chloramphenicol, erythromycin, tetracycline, streptomycin, penicillin G, novobiocine, and neomycin are usually eliminated in milk and their rate of bound to proteins is 12-13% (Râpeanu, 1975).

Several pharmacokinetic studies in lactating cattle were conducted and some of the results on the rate of antibiotics' elimination in milk are presented below:

(i) After intramammary administration at every 24 hours of three infusions of amoxicillin/cloxacillin suspension associated with a single intramuscular injection of procaine penicillin-benzathine penicillin mixture, Popelka et al. (2003) determined high concentrations of penicillin (2693.5 μg/kg) and amoxicillin (2063.0 μg/kg) at 12 hours after the second intramammary administration, and of cloxacillin (22383.25 μg/kg) at 12 hours after the last administration. If the administration of intramammary suspension was not associated with the systemic injection of penicillin, increased levels of amoxicillin (2127.4 μg/kg) and cloxacillin (21697.4 μg/kg) were determined at 12 hours after the last administration.

(ii) After the infusion of procaine penicillin G in two quarters of mammary gland, at 8 hours after treatment and in approximately 67% of cases, this antibiotic was found in milk collected from untreated quarters. The infusion of procaine penicillin G in a single quarter led, in approximately 33% of cases, to its elimination in the milk from the untreated quarters. At 72 hours and 80 hours after the last infusion, the collected milk from 23% and 11%, respectively, treated quarters still contained residues of penicillin. Dihydrostreptomycin was found at 72 hours in 43% of milk samples collected from treated quarters, and at 80 hours after the last intramammary infusion in milk samples collected from 26% of quarters. In the blood serum, penicillin reached maximum values at two hours, and dihydrostreptomycin at 2-4 hours after treatment. Penicillin was present with 28% more amount in kidneys' marrow than in their cortical, and dihydrostreptomycin was determined in increased amounts in the renal cortex. In the case of penicillin, this might be due to its urinary elimination in a rate of 10% by glomerular filtration and 90% by tubular excretion (Rollins et al., 1970).

Antibiotics may be present in milk both after mastitis treatment and after administration by other routes (intrauterine, subconjunctival etc.) (Hajurka et al., 2003; Liljebelke et al., 2000).

The contamination of milk with antibiotics in higher concentrations than their maximum residue limits is illegal, because the consumer safety and the safety of subsequent obtained dairy products are affected. Some studies showed the presence of antibiotic residues in calves fed with contaminated milk, the efficacy of further antimicrobial treatments becoming uncertain due to the phenomenon of antibiotic resistance. Prange et al. (1984) identified antibiotic residues in the urine of 75% of calves fed with contaminated milk (6,600 I.U. penicillin/kg of milk) and of 70% of those fed with milk contaminated in a higher concentration (13,200 I.U. penicillin/kg of milk).

3. Risk assessment of antibiotic residues in milk and milk derivates

Of all foods of animal origin, milk has an increased risk of contamination with antibiotic residues. Since the lactation is initiated and a maximum production achieved, the incidence of mastitis is increasingly higher (Grădinaru et al., 2007). In order to manage the incidence of mastitis in dairy farms, the use of antibiotics in the udder is a key component.

Antibiotic molecules are eliminated in milk with a high prevalence. The analysis of 53 milk samples for beta-lactam antibiotic residues revealed that penicillin was found in 26 samples (24 of them containing residues in higher concentrations than maximum limits), amoxicillin in 3 samples (in higher concentrations than maximum residue limits), and cefapirin in two samples (in lower concentrations than maximum residue limits). The presence of these antibiotics is consistent with their widely use in the therapy of bovine mastitis (Ghidini et al., 2002). Other groups of antibiotics may be also identified as residues in milk, closely related to their therapeutic purpose in dairy cattle (Doan, 1956).

The presence of antibiotic residues in milk and milk products is of particular interest because, regardless the purpose and justification of their presence, favors risks to consumers, as well as technological ones.

3.1. Antibiotic residues in milk and their impact on the consumers' health

(i) Antibioresistance is one of the most important risk of the antibiotics use in antimicrobial therapeutics, various microbial strains resistant at two or even three antibiotics being increasingly more frequently identified. Consumption of milk or milk derivatives contaminated with antibiotic residues may create conditions for antibiotic resistance phenomena, especially in the case of their constant, long-term and at low doses intake. Recently, an increasing number of strains resistant to penicillin *(staphylococci, streptococci, gonococci),* streptomycin and other aminoglycosides *(Bacillus tuberculosis, Gram-negative bacilli intestinal localized),* chloramphenicol, tetracycline *(Gram negative bacilli - Shigela, Salmonella, Escherichia coli, Vibrio, Proteus)* was reported (Lukášová & Šustáčková, 2003; Poiată, 2004). Antibioresistance mechanisms are due to: (a) A spontaneous mutation to resistance of bacteria as a result of random errors in the replication of bacterial chromosome with selection of antibiotic resistant mutants under the influence of antibiotic in the environment; (b) The transfer from one bacteria to another one of some resistance chromosomal genes or of some resistance plasmids determinants (plasmid RTF - “transfer resistance factor”, or the “R” factor of resistance) (Angelescu, 1998; Licker et al., 2002). Even if a number of benefits are assigned to some strains of enterococci (especially to obtain ripened cheeses), it was demonstrated that even they can acquire resistance to antibiotics. Susceptibility testing of 42 enterococci strains isolated from cheese showed that 65.82% of them were resistant to penicillin, 62.02% were resistant to tetracycline, 68.35% to lincomycin, 27.84% to gentamicin, 31.64% to neomycin, 31.64% to erythromycin, and 65.82% to chloramphenicol. These results can be alarming considering the antibiotic resistance as a phenomenon transmitted to other bacteria (Bulajić & Mijačević, 2004; Lukášová & Šustáčková, 2003).

(ii) Imbalances in the intestinal ecosystem. The association of orally administered antibiotics and the consumption of milk or milk products contaminated with antibiotic residues in higher concentrations than the maximum residue limits, increases the risk of imbalances in the intestinal ecosystem by inhibiting normal bacterial populations and reducing the physiological processes of microbial antagonism. Intestinal disbacteriosis recognize in their etiology strains of *Staphylococcus* or *Enterobacteriaceae (Escherichia coli, Proteus etc.)* which are resistant to the action of many antibiotics (Layada et al., 2016; Rafii et al., 2008).

(iii) Immunoreactivity phenomena or antibiotic allergies represent a response at the conflict between the antibiotic (antigen) and the immune system, a response which is similar to other non-pharmacological antigens (Alecu & Alecu, 2002). Penicillins (especially penicillin G and ampicillin), and also cephalosporins, streptomycin, tetracycline, or chloramphenicol frequently produce hypersensitivity reactions. There are data on the immediate type allergy reactions occurrence after kanamycin, gentamicin, polymyxin, erythromycin, nalidixic acid, and rifampicin administrations (Voiculescu & Radu, 1987). As clinical manifestations, the anaphylactic shock is rare, being reported especially after intramuscular or intravenous penicillin administration. This is characterized by hypotension followed by acute cardiovascular collapse. Skin manifestations, such as urticaria, pruritus and erythema, exfoliative dermatitis, or rashes, can also occur due to penicillin intake. Chloramphenicol may cause allergic thrombocytopenia, clinically translated by cutaneous petechiae, fever etc. It can also cause agranulocytosis and allergic type of aplastic anemia (Bilandžic et al., 2011).

(iv) Toxic effects. Most antibiotics are non-toxic when administered in therapeutic doses. Long-term cures associated with the intake of contaminated food with antibiotics can determine disorders of toxic nature. Streptomycin causes pathological acoustic-vestibulare events, by selective toxicity on VIII and VIII bis cranial nerves. Other antibiotics, such as kanamycin, neomycin, tetracylines, polymyxins, and nalidixic can trigger toxic effects on spinal marrow and leukocytes of peripheral blood from their very first uses (Crivineanu et al., 1999). A nephrotoxic effect was observed in streptomycin (in high doses), kanamycin, polymyxin and, to a lesser extent, in tetracycline, chloramphenicol, and gentamicin cures. A subsequent renal failure leads to antibiotic molecules accumulation in blood, generating ototoxic effects, especially observed on aminoglycosides and *polymyxins (Polymyxin B)* administration (Angelescu, 1998). Hepatotoxic effects were observed on rifampin, tetracycline, erythromycin, or nalidixic acid administration. Spinal marrow toxicity induces agranulocytosis, aplastic anemia, conditions most frequently caused by chloramphenicol (Crivineanu & Crivineanu, 2005; Crivineanu et al., 1999).

3.2. Technological implications of antibiotic residues in milk

Besides direct risks on consumers' health, the presence of antibiotic residues in milk has a particular importance due to their industrial consequences. The presence of antibiotic residues inhibit lactic bacteria from cultures used in the manufacture of fermented dairy products, may alter the taste and aroma, acidification and whey expression, with cheese distension alteration (Grunwald & Petz, 2003). The levels of antibiotics that determined the inhibition of starter cultures used in cheese manufacture were reported below the limits of detection of the screening methods used in the dairy industry (Packham et al., 2001).

Neomycin effect on starter cultures used in the production of cheese, yogurt, fermented milk, and fermented cream was established on the basis of coagulation times. The concentration of up to 2 mg neomycin/l in milk had no effect on bacterial growth in any of the tested starter cultures. No studies have been reported on the effect of neomycin on pH during fermentation (WHO, 2003). Lincomycin does not affect the bacterial starter cultures in concentrations up to 0.16 mg per liter of milk (WHO, 2001).

Antibiotic residues in milk are not completely destroyed as a result of heating treatments. Their inactivation is dependent on the intensity of applied temperature, the time of action and their molecular structure. A special role in increasing resistance to heating treatments is granted to the protein fraction of milk, molecules which act as protective colloids. Some studies showed the following rate of antibiotics' inactivation, depending on the heating treatment applied:

(i) A temperature of 72-74^{0}C applied for 15-20 seconds inactivates 8% of penicillin residues in milk; a temperature of 90^{0}C for 30 min inactivates 20% of penicillin residues, 50% of them being inactivated by boiling and milk sterilization.

(ii) A temperature of 83^{0}C applied for 10 minutes inactivates 27% of cephalexin residues and 35% of cefuroxime residues in milk; at 120^{0}C for 20 minutes over 65% of penicillins and 90% of cephalosporins were inactivated.

(iii) 60-75% of terramycin *(oxytetracycline)* residues were inactivated at a temperature of 85^0C applied for 30 minutes. Milk sterilization totally inactivates terramycin residues.
(iv) 60% of neomycin residues were inactivated at temperatures of 100^0C applied for 30 minutes.
(v) A temperature of 140^0C applied for 10 seconds inactivated 17% residues of kanamycin and 40% of neomycin; at 120^0C for 20 minutes, more than 95% of aminoglycosides tested concentrations were inactivated (gentamicin: 50, 100, and 200 µg/l; kanamycin: 300, 600, and 1200 µg/l; neomycin: 200, 400, and 800 µg/l; and streptomycin: 200, 400, and 800 µg/l).
(vi) 90% of the tetracycline residues were inactivated at 100^0C for 30 minutes.
(vii) Chloramphenicol is a thermo-resistant antibiotic, without changes after heating treatments applied (Șindilar, 1998; Zorraquino et al., 2008; Zorraquino et al., 2009).

4. Conclusions

The present work allows us to depict an image about antibiotics and antibiotherapy, and the risks of antibiotic residues in milk and dairy products.

Milk is one of the most commonly food contaminated with residues of antibiotics usually due to their incorrect use in veterinary therapy and to the deficiency in the withdrawal time respecting before milking for human or animal consumption. Rigorous controls of the incoming raw milk in processing units discourages the delivering milk from farms with antibiotic residues. More attention should be paid for the milk delivered by the population households, which is considered to be more susceptible to antibiotic residues contamination.

Conflict of interest

The author declares he has no conflict of interest in relation to this paper.

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The Environmental Impact of Concrete Production and the Necessity of Its Greening

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Abstract
Cement is an extremely important component of building materials which is used for housing and infrastructure. Cement processing requires a high level of energy consumption. Despite all the developments made by this industry, environmental and health problems arising from cement production are present all over the world. Emissions from the cement manufacturing processes degrade air quality and result in environmental pollution. The aim of this study is to synthesize some aspects regarding methods of greening concrete, such as alternative fuels, incorporation of agricultural waste, etc., characteristics of this type of concrete, and short and long term benefits to the environment, in line with the most important recommendations of the present legislation. The importance of this review comes from the fact that it shows several aspects about greening cement production, given that the environmental pollution level is directly influenced by the increased demand for this material in its current form.

Keywords: cement production; environmental pollution; green concrete.

1. Introduction

Climate changes became a global concern, attracting increasingly more attention from scientists and policy makers. The climate will continue to change over the time, so interventions are needed to diminish worldwide pollution and to contribute to the preservation of the global environment. In developed countries, energy consumption in constructions sector amounts to about 40%, and heating and cooling requires approximately 60% of total energy consumed in buildings. Regarding the European context, buildings are responsible for almost a third of the total carbon dioxide emissions (Ingrao et al., 2015).

Cement is an extremely important component of building materials that are used for housing and infrastructure. Its production is a unit of measure of economic growth of any country, considering that the demand for cement is directly linked to the rate of development. The cement industry has an important contribution to the EU economy through the 20 million jobs and the share of almost 10% of GDP that it generates (Teixeira et al., 2016). Cement production consists of three main stages which comprise preparation of raw materials, clinker production, and cement production. Limestone, clay, and other raw materials are extracted and transferred to the factory where they are crushed and powdered. They are mixed in the right proportions to achieve the desired composition. After it passes through a pre-heater, the prepared composition is then introduced into a kiln, where it is exposed to temperatures of about 1450^0C. This process generates physical and chemical changes that transform the raw mix into clinker. This stage of production is the biggest consumer of energy. The clinker is mixed with additives and other mineral components, such as gypsum, slag, and fly ash in order to obtain the required properties of the final product (Salas et al., 2016).

For the production of about 1 tonne of Portland cement about 1,500 kg of raw materials are required: approximately 1.2 tonnes of limestone and marl, about 0.4 tonnes of clay, and around 0.05 tonnes of natural or synthetic gypsum. The raw materials used in the manufacture of cement, in particular limestone, release about 65% of the total CO_2 assigned to this industry. The remaining 35% of emissions are caused by burning fossil fuels for the decomposition of limestone during cement production (Ali et al., 2015).

Cement processing requires a high level of energy consumption. This industry still creates environmental and health problems all over the world, despite all developments made in its technological processes. Emissions from the cement manufacturing processes degrade air quality and result in environmental pollution.

The cement industry contributes to global warming and climate change, being one of the most important industries responsible for major emissions of greenhouse gases, contributing (in 2015) by almost 8.0% of the total global emissions (Olivier et al., 2016), and being the third largest source of industrial pollution. Cement manufacturing processes are highly energy-intensive, with high fuel consumption which results in emissions. It emits more than 500,000 tonnes per year of sulfur dioxide, nitrogen oxide, and carbon monoxide (Ali et al., 2015). Wang et al. (2013) cited by Salas et al. (2016) identify four factors that induce changes in emissions of greenhouse gases from the production of cement: energy emission, energy structure, energy intensity, and clinker production. The activity of clinker production represents the dominant factor to the increase of greenhouse emissions. Therefore, to address global warming and the imperative environmental changes, it was suggested that CO_2 emissions had to be reduced by 50% until 2050 (Ali et al., 2015).

Although the CO_2 production is considered a natural process caused by biological activities, it brings along serious environmental problems generated by an anthropogenic source – human development which leads to the reduction of real possibilities of absorption (deforestation and afforestation reduction). This reality is worsened by the inexistence of clean technologies that are not expensive both in financial and energy terms. CO_2 emissions due to the use of the fossil fuel and to cement production are steadily increasing. Thus, data reported in 2013 showed values by 61% higher than those recorded in 1990, by 2.3% higher than in 2012, and by 2.5% lower than those estimated for 2014 and it was indicated that CO_2 emissions could be equal and even exceed 1 tonne for 1 tonne of cement produced (Błaszczyński & Król, 2015).

Cement plants are a significant source of sulfur dioxide, nitrogen oxide, and carbon monoxide, which are associated with the following health problems and environmental damages (Ali et al., 2015):

(a) CO_2 emissions are the main contributor to global warming effect related to cement, ranging between 98.8% and 100% of the total. According to Gao et al. (2015) cited by Mo et al. (2016), cement industry was estimated to be responsible for about 1.8 Gt annual emissions of carbon dioxide and about 5-7% of all generated anthropogenic CO_2 emissions. Life cycle analysis shows that approximately 0.8 t of CO_2 are emitted in the production of 1 ton of cement (Flower & Sanjayan, 2007 cited by Mo et al., 2016).

(b) In high concentrations, sulfur dioxide (SO_2) can affect breathing and may aggravate the existing respiratory and cardiovascular diseases. SO_2 is also a main factor which contributes to acid deposition, acid rain, or smog.

(c) Nitric oxide (NO) may cause or contribute to smog and acid rain generation, global warming, deterioration of water quality, and visual impairment. Not eventually, NO emissions are also the main cause of eutrophication (Josa et al., 2007 cited by Salas et al., 2016). Affected populations include mostly children and people with lung diseases such as asthma. The exposure to these conditions can cause damage to lung tissue for people who work or live near factories.

(d) Carbon monoxide (CO) can cause adverse effects on health by reducing oxygen supply to organs and tissues of the body and on the nervous and cardiovascular systems. CO also contributes to smog that can cause respiratory problems.

(e) Heavy metals. Human activities, such as mining and industrial processing are the main sources of heavy metal contamination in the environment (Al-Dadi et al., 2014 cited by Salas et al., 2016). Formation of photochemical ozone, heavy metals and carcinogenic diseases caused by cement production depend heavily on fossil fuels and the used raw materials and come up mostly from the processes of energy production (electricity and refining fuel) (Josa et al., 2007 cited by Salas et al., 2016).

(f) The main impact of cement output on land quality comes from quarries, waste disposal, storage of materials, and atmospheric deposition (Al-Dadi et al., 2014 cited by Salas et al., 2016).

The aim of this study is to synthesize some aspects regarding methods of greening concrete, characteristics of this type of concrete, and short and long term benefits to the environment, in line with the most important recommendations of the Construction Products Regulation no. 305/2011 (which replaced Directive 89/106/EEC) which defines essential requirements for building materials. These refer to strength and stability, fire safety, hygiene, health and the environment, safety and accessibility in use, protection against noise, energy saving and thermal insulation, and sustainable use of natural resources.

The importance of this review is strengthened by the fact that the global demand for cement is expected to have an increase of about 4.5% per year up to 5.2 billion tonnes by 2019. The concrete with cement will continue to be the most popular type of concrete worldwide and will represent 75% of total demand in 2019 (Table 1).

Table 1. Global demand for cement

Zone	**Cement demand (mill. tonnes)**			**Annual growth (%)**	
	2009	2014	2019	2009-2014	2014-2019
North America	115	136	168	3.4	4.3
West Europe	163	126	142	-5.0	2.4
Asia/ Pacific	2149	3158	3940	8.0	4.5
Central and South America	119	153	190	5.2	4.4
East Europe	105	120	139	2.7	3.0
Africa/ Middle East	358	467	611	5.5	5.5
Total	3009	4160	5190	6.7	4.5

Source: ***, 2016, http://www.theconcreteproducer.com

Ecodesign and energy efficiency are concepts that express the need to look for new materials and technologies that are environmentally friendly in order to replace the conventional materials for the building constructions, allowing thereby the decrease of the environmental impact in terms of energy consumption and emissions with greenhouse effect. Sustainable materials are those that are usually made from natural or recycled materials whose production has a low environmental impact, requiring small amounts of energy and non-renewable resources. Production of recycled materials is a growing phenomenon and it is linked to the prevention of environmental pollution from industrial and agricultural wastes (Ingrao et al., 2015).

2. The "concrete" – concept and methods of greening

The concrete is, generally, a mixture of large aggregates, fine aggregates, and a cement binder. These ingredients are mixed with appropriate amounts of water, then a chemical reaction of hydration takes place, leading to concrete elements or structures which are very strong and rigid. Fine aggregates may come from natural sources or may be obtained by crushing large aggregates, so that the particle size ranges from 150 microns to 4 mm; better resistance is obtained when coarse sand is used (for beams, plates, pillars, or foundations) (Badur & Chaudhary, 2008). Of all the components of concrete, aggregates are very important in producing it and the bond between paste and aggregate tends to devise the upper limit of concrete strength (Neville, 1997).

Related to the environmental impact of concrete production, several aspects can be highlighted such as damage of habitats through extraction of materials, usage of large amounts of energy for extraction, production and transportation of cement. Although concrete contains only 9-13% cement, energy used for its production represents 92% of the energy consumed for the production of concrete. Cement dust contains free silica crystals, lime and traces of chromium, and all of these may have a negative impact on workers' health and on the environment (Kubba, 2012). Mixing concrete requires large amounts of water and generates alkaline wastewater, thus the infiltrations could contaminate vegetation and waterways. Excessive use of aggregates causes depletion of these natural resources, and unsustainable extraction and mining for these materials can lead to environmental problems, such as damage of landscape and disturbance of eco-systems, water, soil, and air contamination (Blankendaal et al., 2014 cited by Mo et al., 2016).

Due to the increasing use of concrete in construction industry worldwide, there is a growing demand for more environmentally friendly production of concrete. One of the main reasons for this trend is attributed to the negative environmental impact brought by the use of materials for the manufacture of concrete, such as aggregates and cement.

2.1. Improvement measures

The International Energy Agency (IEA) focuses on four categories of improvement measures for reducing CO_2 emissions in the cement industry (International Energy Agency, 2009 cited by Salas et al., 2016):

energy efficiency, alternative fuels, substitution of clinker, and carbon capture and storage.

(a) Energy efficiency

Improving energy efficiency involves the implementation of the best available technologies whenever it is possible. The most significant improvements are related to energy efficiency measures in the system of the kiln, i.e., by reducing the quantity of fuel required to produce the same amount of clinker (Valderrama et al., 2012 cited by Salas et al., 2016). The main improvements are related to efficiency increase in dosing and grinding of raw materials, emissions reduction in the cyclone tower, less noise into the cooling grill, large capacity of the kiln filter, and greater efficiency and fewer emissions in the kiln system. These improvements determine a reduction of electricity and of used heat, therefore, a reduction of environmental impact which means a more sustainable production and economic benefits (Valderrama et al., 2012 cited by Salas et al., 2016).

(b) Alternative fuels

Alternative fuels include usually residues of agricultural and non-agricultural biomass, petroleum based wastes, various wastes, and hazardous chemical wastes. Cement production allows the use of wastes to substitute traditional raw materials and fuels. Using fuels from wastes leads to a reduction of environmental impact and fuel costs. For example, in this way, a reduction of the emissions from cement plants and landfills can be simultaneously obtained (Salas et al., 2016). Likewise, burning alternative fuels is an ideal method for heat energy recovery from wastes.

(c) Replacement of the raw materials

Calcination process (clinker production) represents about 58% of the total impact of cement production on climate (García-Gusano et al., 2014 cited by Salas et al., 2016). In an effort to conserve the environment by developing eco concrete, researchers have explored the possibility of using industrial by-products and waste materials in concrete (Mo et al., 2016).

Wastes and additional cementitious materials such as fly ash, blast furnace slag, silica fumes, rice husk ash, and metakaolin can be used as a partial replacement of Portland cement. Fly ash and slag were used consistently throughout the world to improve the properties of concrete (Siddique, 2004 and Zhang & Poon, 2015 cited by Mo et al., 2016; Zhao et al., 2015 cited by Salas et al., 2016) and to reduce the risks of environmental pollution (Bărbuţă et al., 2014; Sidique, 2004; Tangchirapat, 2009). Fly ash particles are generally spherical and have a size between 0.5-100 microns and are formed mainly of silicon dioxide. Physical and chemical properties of fly ash vary according to each power plant in part, mainly due to differences in the coal source (Sun et al., 2003). The substitution of 15-35%

of the cement with fly ash in the concrete mix leads to an increase of its strength, improves the reaction to sulphates action, decreases the permeability, reduces the needed quantity of water, and enhance the workability (Badur & Chaudhary, 2008). Slag usually increases workability and decreases the necessary water quantity due to increased volume of paste (increase in volume of the paste is determined by relatively low density of the slag) (Li et al., 2016). To protect steel reinforcement, concrete with granulated slag requires a smaller thickness of the coating than conventional concrete due to lower permeability (Altwair & Kabir, 2010a; Altwair & Kabir, 2010b). The same benefits have been reported when using silica fume or ash from fuel as supplementary material for concrete (Awal & Hussin, 1997; Chindaprasirt et al., 2008; Rukzona & Chindaprasirt, 2009a; Rukzona & Chindaprasirt, 2009b; Tangchirapat, 2009). Silica fume is a dust with the particle diameter 100 times smaller than that of the dry cement. The best effect of SiO_2 as an additive in concrete is obtained from the replacement of 15% of the weight of the cement, but because it is an expensive material, it is used only in a volume of up to 5% (Walczak et al., 2015).

The use of steel fibers of 1-50 mm length and a weight of 1% up to 3% of the concrete provides a significant improvement in resistance to fracturing. Such combinations are used for structural elements in the areas with seismic risk, structures of clamshell type that form buildings like the one located in the Oceanographic Park Committee of Valencia, subway stations, tunnels, reservoirs, ponds, reinforcing elements for the hills, slopes and walls, bridges for pedestrian and auto traffic like those of Sherbrooke (Canada), Seoul (Korea), Sakata-Mirai (Japan), or the bridge over Shepherds Creek, 150 km north of Sydney (Australia) (Błaszczyński & Przybylska-Fałek, 2015; Wille et al., 2014).

Moreover, the use of construction waste as a source of aggregates for the production of a new concrete has become increasingly common in recent years. Concrete recycling is a relatively simple process that involves breaking the existing concrete and shredding of up to desired dimensions (Bhutta et al., 2013). Moreover, due to excess of granite from India, granite blocks are crushed periodically (250-400 tonnes of granite are annually generated), replacing the sand with granite finely grounded, which is adequate to obtain a compression resistance of concrete higher by 22% (Singh et al., 2016). These materials have improved properties of the mixture and are less energy consuming than cement (Patel & Pitroda, 2013).

Reduction of CO_2 emissions by substituting the cement is likely to be greater than the reduction by improving thermal efficiency and use of alternative fuels. Because the carbonation rate is higher for the cement replaced by blast furnace slag or fly ash in a high proportion (50% slag and 35% fly ash), this type of cement suffered a reduction of about 10% of his life service. This durability loss of cement in case of high rates of replacement leads to higher annual emissions of CO_2 than the smaller replacement rates (Garcia-Segura et al., 2013 cited by Salas et al., 2016). The use of fly ash for Portland cement replacement causes an emission factor of material smaller than the use of blast furnace slag.

Proske et al. (2013) cited by Salas et al. (2016) found that the compressive strength loss due to lower cement clinker could be offset by reducing the volume of water and using fly ash and blast furnace slag. Cement low in clinker is considered to be cement with a low impact on the environment due to smaller energy implied and embedded emissions of CO_2. The effect of substituting high-impact cement with low impact cement is very significant. For this reason, substantial improvement can be achieved by changing consumption patterns, especially in those places where most part of the cement consumption is represented by Portland cement.

Incorporation of local aggregates and/or recycled ones (e.g., crushed concrete acquired from demolitions) is an excellent way to reduce the impact of solid waste, transit emissions and habitat disturbance (Kubba, 2012). While the use of industrial by-products in concrete has been well established, incorporating waste in concrete production is still in primary research, especially regarding waste from agricultural industry. This type of waste is usually burned or sent to landfill (Karadi, 2010 cited by Mo et al., 2016), causing environmental problems such as water and air pollution and soil contamination. The use of agricultural waste in the production of concrete contributes to environmental preservation, drawing the attention of researchers around the world (Mo et al., 2016). For example, among the most known agricultural waste investigated for concrete production there are those from palm oil industry, such as waste of palm oil bark (Shafigh et al., 2014 cited by Mo et al., 2016) and ash of oil palm fuel (Safiuddin et al., 2011 cited by Mo et al., 2016), those from coconut industry such as waste of coconut shell (Mo et al., 2014 cited by Mo et al., 2016) and coir (Pacheco-Torgal & Jalali, 2011 cited by Mo et al., 2016), as well as those from rice industry such as rice husks (Apri et al., 2015 cited by Mo et al., 2016). These agricultural wastes have been used in the manufacture of concrete in the form of aggregates, reinforcing fibers and as additional cementitious materials. Lately, research has also focused on the use of agricultural waste like those from agricultural crops (e.g., bamboo, corn, wheat, sisal, and grass fat) and those from fish farming (oysters, clams etc.) for partial replacement of the cement in concrete composition with plants that contain various minerals and silicates (which are present in plants because, in the growth process, plants extract them from earth). Inorganic elements, particularly silicates, are found in greater amounts in annual plants than in the trees with long life, so that plant waste is a potential source of replacement material of the cement with pozzolan reactivity. Another common use of agricultural waste is as reinforcement fibers for increasing the strength of the concrete. The use of natural fibers is due to their low cost, to the need for a low degree of processing, to their eco-friendly character, and most important, to their high resistance – some natural fibers are as strong as the synthetic ones. Moreover, in attempting to protect the environment, some of these agricultural wastes were used as replacement for concrete aggregates in order to reduce dependence on conventional aggregates such as granite, gravel, and natural sand (Mo et al., 2016). Using natural materials is one of the ways to achieve energy efficiency and sustainability in construction (Štirmer et al., 2014). The use of fibers can also be made for reasons of recycling; polypropylene, for example, is very used in concrete recipe because there are very large amounts of polypropylene wastes since it represents one of the most common plastics with numerous applications that include devices for packaging, textiles, laboratory equipment, or auto parts. In Australia, for example, between the years 2012-2013, the total consumption was 220,000 tonnes of polypropylene and only 21% of this quantity was recycled. Therefore, the need for higher rates of recycling of this material is increasingly evident, if we want to avoid damage of the environment through pollution to be irreparable (Yin et al., 2016).

In nonstructural applications, the use of concrete can be reduced by trapping air in the finished product, or by the use of low density aggregates. The trapped air displaces concrete, decreasing its thermal conductivity, reducing weight and material costs without compromising durability and fire resistance. Similar features are achieved by using low-density aggregates such as vermiculite, perlite, pumice, shale, polystyrene granules, and mineral fibers (Kubba, 2012).

Concrete that uses polymers is a new and complex concept in the form of concrete modified with polymers, which is presented as a composite material consisting of two solid phases: *aggregates*, dispersed discontinuously through the material, and *binder* (the binder being represented in its turn in a cementitious phase and polymeric phase, used in appropriate quantities). Depending on the volume of polymer phase in the binder phase, the material changes from cementitious concrete with polymer in polymeric concrete. Polymeric concrete is a composite similar to conventional concrete, where a resin based binder substitutes the cement (Bărbuță & Harja, 2008). The composition of the polymeric concrete is determined by its applications and it is used very efficiently in prefabricated elements (Reis, 2006). In the case of cementitious concrete with polymer, the binder is a matrix cement-polymer, added as dispersion in fresh mixture or as a polymeric powder.

Regardless of its type, polymeric concrete has the advantages of excellent mechanical and chemical resistance, a short maturation, and good thermal and acoustic insulation properties, reduces the initiation and propagation of cracks, and increases the material flexibility. However, all of these can be achieved with high production costs compared to an ordinary concrete (Agavriloaie et al., 2012; Chen et al., 2016). Because of rapid setting and high strength properties, polymeric concrete is used in a variety of construction applications, rehabilitation, and repairs such as repair material for sidewalks, floors, dams, reservoirs, basements, lining material in the food and chemical industry (Bărbuţă et al., 2014; Reis, 2006). Using polymers for such purpose is becoming more common lately, both because of proven efficacy as a binder in the production of high-quality concrete, and also due to lower production cost [normally producing high-quality concrete requires 1000 kg of binder /m3 (Yu et al., 2014)]. The aggregates used in dry condition in the manufacture of polymeric concrete can include silicates, quartz, crushed stone, gravel, limestone, limestone, granite or clay and fillers as well as fly ash, silica fume, phosphogypsum, blast furnace slag, many of them are known for improving the properties of polymeric concrete (Bărbuță & Harja, 2008).

(d) Carbon Capture and Storage (CCS)

CCS does not reduce the production of CO_2; separation, capture and storage of carbon dioxide prevent CO_2 from being released. Carbon capture may be one of the few ways to achieve significant reduction in CO_2 emissions in the cement industry. However, it faces a number of barriers, both technical and economic, to its implementation (Benhelal et al., 2013 cited by Salas et al., 2016). Besides its enormous cost and slow implementation, CCS is challenged by the competition with more feasible solutions, such as clinker substitution or fossil fuels replacement (Garcia-Gusano et al., 2013 cited by Salas et al., 2016).

Other measures that contribute to the development of ecological character of concrete were highlighted by Kubba (2012):

(1) Recycling on site of the demolished concrete which can be used as aggregates or fillers to new projects, or recycling in local waste deposits.

(2) Rehabilitation, whenever possible, of parts of existing structures such as plates or walls which are in satisfactory condition.

(3) Using prefabricated systems to minimize material waste and reduce the impact of waste water on soil.

(4) Incorporation of higher quantities of fly ash, blast furnace slag, silica fume, and/or rice husk ash, ensuring at the same time the necessary characteristics of the final product, in order to reduce cement consumption by 15% up to 100%.

(5) The use of alternative materials as substitutes for concrete, such as insulating concrete variants to reduce waste, to improve thermal performance and to shorten construction time. It is also recommended to use aerated concrete or other lightweight concrete to add insulation value, while reducing weight and obtaining the required quantity of concrete. Also, using rapidly renewable materials such as corn cobs or straw bale helps to reduce the need for insulation and finishing materials, both for residential and commercial projects.

(6) Minimization of losses through careful planning of quantities of concrete.

(7) Use of porous concrete to allow water to infiltrate into the soil to filter the pollutants and to recharge groundwater. Urban and suburban areas contain large impervious surfaces that cause a number of problems. It is estimated that up to 75% of the urban surface is covered by impermeable pavement that is a solid surface that prevents water ingress, leading to inhibition of groundwater restoring and forcing it to drain, contributing to erosion, floods, direction of pollutants into local water, as well as the increasing complexity and cost of pluvial water treatment. Also, because the asphalt and other paving materials with impermeable surfaces have the quality of heat absorbing, they increase in a high proportion the temperature of the ambient air, thus creating an effect of heat island and increasing demand for energy for cooling. An important feature of permeable paving (known as porous pavement) is the large amount of holes in its composition allowing the water to drain into the ground. Porous pavement (which can be used in making parks and paths of access) can incorporate recycled aggregates or fly ash, which helps to reduce integrated energy and wastes.

Improvement measures focused on the first three solutions are considered mature technologies because they have been fully studied and applied. These mature technologies are relatively inexpensive and technically feasible to implement. Nevertheless, CCS has a great potential for improvement, but presents several obstacles to its implementation, both technical and economic.

3. Conclusions

Buildings contribute significantly to environmental pollution both by natural resources consumption and CO, CO_2, SO_2, and NO emissions. The concrete is produced from limestone, clay and sand, requiring energy consumption in all production stages. Additionally, some raw materials are considered resources with limited availability in time (e.g., limestone, stone shale, clay, natural sand, or natural rocks), raising the problem of keeping them as natural reserves for a longer period. In this context, environmentally friendly concrete production can be cheap, resource protective and can provide a reduction in greenhouse gas emissions due to the waste used as substitute of cement. Moreover, by using different wastes many land areas designed as storage spaces can be ecologically rehabilitated.

Conflict of interest

The author declares she has no conflict of interest in relation to this paper.

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The Current Importance of Pest and Entomological Risk Situations for Wheat Crops in Central Transylvania (Romania)

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Abstract

The paper presents the importance of wheat pest in the Transylvanian Plain (over the last 10 years) specifying the entomocenotic risk situations in relation to climate change and cultural technologies, in agroforestry system and the open field area with traditional plowed system or with soil conservative no tillage system, from Agricultural Research and Development Station (ARDS) Turda (NW of Romania, Cluj county). During 2006-2015, under open field area conditions, the entomocenotical particularities have revealed the eudominance of thrips – 57%, the dominance of dangerous populations of Chrysomelidae – 10%, of wheat flies –12%, of aphids – 14%, the important presence of leafhoppers – 4%, and of sunbugs – 2% in the pests structure. The abundance of pests represents a risk situation for the wheat crops. In Turda, the explosion of pest populations is reported in relation to the fluctuations of climate manifestations and also to the reduced abundance of entomophagous, which account for only 14% in the arthropods structure. As compared to the traditional plowing system, in the conservative no tillage system, the importance of the main pests such as thrips, flies, aphids, leafhoppers and soil pests (*Agriotes, Zabrus,* etc.) are highlighted. Thus, the research revealed the presence of a useful natural fund of entomophagous fauna characterized by the species richness and the efficiency of their capacity to limit the activity of phytophagous insects, information which can be used for increasing the resilience to pests' attacks.

Keywords: wheat pests, wheat thrips, flies, aphids, leafhoppers, sunbugs

1. Introduction

Every year, phytophagous pests cause significant wheat crop losses with consequences on the chances to attain the objectives of food security, productivity goals, and sustainable development of agriculture and environment (Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014;

Malschi et al., 2005). Taking into consideration the numerous pests of wheat crops, we need to point out the significance of the attacks which lead to the failure of productive potential of cultivated varieties and even to harvest compromise in extreme risk situations due to the abundance of phytophagous insects.

The applicative entomological research was conducted in central Transylvania, at the Agricultural Research and Development Station (ARDS) Turda, for the last four decades. The results show that wheat pest control is an important sequence of the system of the cultural integrated technology. During 1974-2015 period, more than 50 species of insect pests have been highlighted in the structure of enthomocenoses of the wheat crops at the ARDS Turda. A specific complex of pests has been observed through the damage caused by Diptera species (wheat flies)*: Opomyza florum F., Delia coarctata* (Fallén), *Phorbia securis* Tiensuu, *P. penicillifera* Jermy, *Oscinella frit* L. *etc.;* of aphids: *Schizaphis graminum* Rond., *Macrosiphum avenae* Fabr., *Rhopalosiphum padi* L., *Metopolophium dirhodum* Walk., and of leafhoppers: *Psammotettix alienus* Dahlb., *Macrosteles laevis* Rib., *Javesella pellucida* Fabr., etc.; wheat thrips: *Haplothrips tritici* Kurdj.*;* cereal leaf beetles: *Oulema melanopus L;* cereal fleas: *Chaetocnema aridula* Gyll., *Phyllotreta vitulla* Redt.; cereal sunbugs: (*Eurygaster maura, Aelia acuminata* etc.); wire worms and other pests from soil: *Agriotes, Opatrum, Zabrus, Agrotis etc.* (Table 1) (Malschi, 2001; Malschi, 2003; Malschi, 2004; Malschi et al., 1980; Malschi et al., 2015; Malschi et al., 2016, Malschi & Mustea, 1992; Malschi & Mustea, 1997).

The damages caused by the pests can reach significant values. They range from 300 to 1500 kg/ha yield losses, where the spring attack of Diptera larvae reaches 50-90% of plants and destroy 10-25% of stalks. Yield losses can be from 14 to 25% of non-attacked yield in wheat and spring barley following the attack of *Oulema* larvae; from 15 to 20% of yield in case of the spike pests, at the average density of 22 of thrips larvae/ear and 32 of aphids/ear. In the case of early sowing in September, the cereals flies, aphids, and leafhoppers can compromise crops (Malschi, 2000; Malschi, 2001; Malschi, 2004; Malschi & Mustea, 1998a; Popov et al., 1996).

The research has revealed the presence of a useful natural fund of entomophagous fauna characterized by the species richness and the efficiency of their capacity to limit the activity of phytophagous insects, information which can be used for increasing the resilience to pest's attacks. All known groups of auxiliary entomophagous, parasites, and especially predators were signaled (e.g., *Aranea; Dermaptera; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae* etc.); *Coleoptera (Sylphidae, Coccinellidae, Carabidae, Cicindelidae, Staphylinidae*, *Cantharidae*, *Malachiidae*); *Diptera (Syrphidae, Scatophagidae, Empididae etc.); Hymenoptera (Formicidae* etc.); *Neuroptera (Chrysopidae*). The presence of entomophagous in the spring to autumn crops with a weigh of 25-50% in the structure of the arthropod fauna naturally limits pests (Table 2). The research conducted in the laboratory following the model of predator–prey interactions (observed in cereal biocoenosis) has revealed the role and importance of auxiliary entomophages (Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi & Mustea, 1995; Malschi & Mustea, 1997; Malschi & Mustea, 1998b; Malschi et al., 2003) (Table 3). Therefore, the elaboration of Sustainable Development strategies that include the conservation and use of regional biodiversity involved in the achievement of productivity and stability of agro-ecosystems is mandatory (Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014).

Table 1. List of registered pest species in ARSD Turda (1980-2015)

1. Ord. Collembola	Fam. Sminthuridae: *Sminthurus viridis* L.
2. Ord. Orthoptera	Fam. Tettigoniidae: *Tettigonia viridissima* L. Fam. Cantatopidae: *Decticus verrucivorus* L. Fam. Acrididae: *Dociostaurus marocanus* Th., *Calliptamus italicus* L. Fam. Gryllidae: *Gryllus campestris* L.
3. Ord. Heteroptera	Fam. Scutelleridae: *Eurygaster maura* L., etc. Fam. Pentatomidae: *Aelia acuminata* L., etc. Fam. Miridae: *Trigonotylus ruficornis* Geofr., *Lygus pratensis* L., *L. rugulipennis* P.
4. Ord. Homoptera:	
Sord. Cicadina	Fam. Cicadellidae: *Psammotettix alienus* Dahl., *Macrosteles laevis* Rib., *M. sexnotatus* Fall. Fam. Delphacidae: *Javesella pellucida* Fabr.
Sord. Aphidina	Fam. Aphididae: *Schizapis graminum* Road., *Sitobion avenae* Fabr., *Rhopalosiphum padi* L.,*Metopolophium dirhodum* Walk.
5. Ord. Thysanoptera	Fam. Tripidae: *Stenothrips graminum* Uz., *Limothrips denticornis* Hal. Fam. Phlaeothripidae: *Haplothrips tritici* Kurdj., *H. aculeatus* Fabr.
6 Ord. Coleoptera	Fam. Carabidae: *Zabrus tenebrioides* Goeze. Fam. Elateridae: *Agriotes lineatus* L., *A. ustulatus* L., *A. sputator* L., *A. obscurus* L. Fam. Tenebrionidae: *Opatrum sabulosum* L. Fam. Scarabeidae: *Anisoplia segetum* Hb. Fam. Chrysomelidae: *Oulema melanopus* L., *Chaetocnema aridula* Gyll., *Phyllotreta vittula* Redt., *Crepidodera aurata* Marsham.
7. Ord. Hymenoptera	Fam. Cephidae: *Cephus pygmaeus* L., *Trachelus tabidus* F. Fam Tenthredinidae: *Dolerus haematodis* Klg.
8. Ord. Diptera:	Fam. Tipulidae: *Tipula oleracea* L.

Sord. Nematocera	Fam. Bibionidae: *Bibio hortulanus* L. Fam. Cecidomyiidae: *Contarinia tritici* Kirby., *Mayetiola destructor* Say., *Haplodiplosis equestris* Wagn., *Sitodiplosis mosellana* Gehin.
Sord. Brachicera	Fam. Opomyzidae: *Opomyza florum* F., *O. germinationis* L., *Geomyza tripunctata* Fall. Fam. Anthomyiidae: *Delia coarctata* Fall., *D. platura* Meig., *D. liturata* Zett. *Phorbia penicillifera* Jermy., *Phorbia securis* Tiensuu. Fam. Chloropidae: *Oscinella frit* L., *O. pusilla* Meig., *Tropidoscinis albipalpis* Meig., *Elachiptera cornuta* Fall., *Chlorops pumilionis* Bjerk., *Meromyza nigriventris* Mac., *Lasiosina cinctipes* Meig., *Cetema elongata* Meig, *Comarota curvinervis* Latr. Fam. Scatophagidae: *Amaurosoma flavipes* Fll. Fam. Agromyzidae: *Phytomyza nigra* Fll. Fam. Ephydridae: *Hydrellia griseolla* Fll.
9. Ord. Lepidoptera	Fam. Tineidae: *Ochsenheimeria taurella* Schiff. Fam. Noctuidae: *Hadena basilinea* F., *Agrotis segetum* Schiff.

Source: Adapted from Malschi, 2007; Malschi, 2008; Malschi, 2009.

Table 2. List of registered entomophagous arthropods in ARSD Turda (1980-2015)

Cl. Arahnida	
1. Ord. Aranea	Fam. Lycosidae: *Trochosa* sp. Fam. Araneidae: *Araneus diadematus* Clerck
2. Ord. Acari	Fam. Phytoseiidae: *Phytoseiulus persimilis* Ath-Hen. Fam. Trombidiidae: *Trombidium holosericeum* L.
Clasa Insecta	
1. Ord. Dermaptera	Fam. Forficulidae: *Forficula auricularia* L.
2. Ord. Heteroptera	Fam. Nabidae: *Nabis ferus* L. Fam. Anthocoridae: *Anthocoris nemorum* L. Fam Miridae: *Daraeocoris ruber* L.
3. Ord. Thysanoptera	Fam. Aeolothripidae: *Aeolothrips intermedius* Bagn.
4. Ord Coleoptera	Fam. Carabidae: *Poecilus cupreus* L., *Amara aenea* De Geer., *Pterostichus melanarius* Ill., *P. macer* Marsh., *Harpalus distinguendus* Duft., *H. rufipes* De Geer., *H. aeneus* L. *H.affinis* Sch., *Brachinus explodens* Duft., *Loricera pilicornis* F., *Platynus dorsalis* Pont; *Dolichus halensis* Schall., *Agonum muelleri* Herbst, *Carabus coriaceus* L., *Carabus nemoralis* Mull. Fam. Cicindelidae: *Cicindela campestris* L. Fam. Staphylinidae: *Tachyporus hypnorum* L., *Staphylinus* sp. Fam. Sylphidae: *Sylpha obscura* L., *Necrophorus vespillo* L. Fam. Cantharidae: *Cantharis fusca* L., Fam. Malachiidae: *Malachius bipustulatus* L. Fam. Coccinellidae: *Coccinella septempunctata* L., *Propylaea quatuordecimpunctata* L., *Adalia bipunctata* L., *Anattis occellata* L., *Hippodamia tridecimpunctata* L., *Adonia variegata* Goeze., *Chilocorus bipustulatus* L.

5. Ord. Hymenoptera	Fam. Formicidae
6. Ord. Planipennia	Fam. Chrysopidae: *Chrysopa carnea* Stephn. (larva)
7. Ord. Diptera	Fam. Empididae: *Platypalpus* sp., Fam. Dolichopodidae: *Medetera* sp., Fam. Scatophagidae: *Scatophaga stercoraria* L. , Fam. Tachinidae: *Lydella* sp., Fam. Syrphidae: *Episyrphus balteatus* De Geer, *Syrphus ribesii* L., *Metasyrphus corollae* Fabr.

Source: Adapted from Malschi, 2007; Malschi, 2008; Malschi, 2009.

Table 3. List of active entomophagous predators in cereal agrobiocenosis of Transylvania and the entomophages activity (number of consumed individuals of phytophagus species/day/ individual)

Groups and Families	Genera and Species	Refferences on the entomophagous activity (ratio/day/individual)
Aranea		Cândea, 1986; Mühle-Wetzel, 1990
Forficulidae	*Forficula auricularia* L.	Hassan, 1992
Chrysopidae	*Chrysopa carnea* Stephn. (larva)	Cândea, 1986 (32 aphids/day); Malschi, 2007; Malschi, 2009 (10 eggs-5 larvae of *Oulema*/day, 10 adults-40 larvae of *Haplothrips tritici/*day, 30-50 aphids/day, 10 eggs of *Eurygaster/*day, *3 larvae of Opomyza/day,* 2 larvae of *Phorbia securis/*day*).*
Nabidae	*Nabis ferus* L.	Wetzel, 1991 (15 aphids/day); Malschi, 2007; Malschi, 2009 (8 eggs - 5 larvae *Oulema*/day, 42 larvae of *Haplothrips tritici*, 60 *Sitobion avenae/*day, 25 *Rhopalosiphum padi/* day, 10 eggs of *Eurygaster/* day, 3-4 larvae-pupa of *Opomyza florum* or *Phorbia/*day/ 1 *Nabis* adult; 30 larvae of *Haplothrips tritici*, 25 *Sitobion avenae/*day, 17 *Rhopalosiphum padi/* day/ 1 *Nabis* larva).
Anthocorydae	*Orius*	Voicu, 1993; Perju, 1988
Coccinellidae	*Coccinella 7-punctata* L. *Prophylea 14-punctata* L.	Mühle-Wetzel, 1990 (115 aphids/day); Basedow, 1990 (38 aphids /day); Malschi, 2007; Malschi, 2009 (10 eggs-3 larvae of *Oulema*/day, 35 larvae of *Haplothrips tritici/*day, 50 *Sitobion avenae/*day, 25 *Rhopalosiphum padi/*day, 2 larvae of *Opomyza florum/*day/ 1 *Coccinella 7-punctata* adult; and 7 eggs-3 larvae of *Oulema*/ day, 20 larvae of *Haplothrips tritici/*day, 40 *Sitobion avenae/*day, 25 *Rhopalosiphum padi/*day, 2 larve *Opomyza florum/*day/ 1 *Prophylea 14-punctata* adult*).*
Cantharidae	*Cantharis fusca* L.	Wetzel, 1991 (8 aphids/day); Malschi, 2007, Malschi, 2009 (6 eggs of *Oulema*/ day, 15 adults of *Haplothrips tritici/day*, 40 *Sitobion avenae/*day, 2 larvae of *Opomyza /* day, 4 larvae of *Phorbia securis/*day.
Malachiidae	*Malachius bipustulatus* L.	Steiner, 1976; Cândea, 1986; Malschi, 2007; Malschi, 2009 (10 larvae of *Oulema*/day, 15

		adults and 30 larvae of *Haplothrips tritici/*day, 40 *Sitobion avenae/*day, 3 larvae of *Phorbia securis/*day*)*.
Staphylinidae	*Tachyporus hypnorum* L. *Staphylinus*	Basedow, 1990 (19 aphids/day); Malschi, 2007; Malschi, 2009 (8 eggs of *Oulema*/day, 25 aphids/day, 1 larva of *Opomyza or Phorbia/*day*)* Chambon, 1984; Sunderland, 1985; Malschi, 2007, 2009 (10 eggs of *Oulema*/day, 30 *Sitobion avenae/*day, *15 Rhopalosiphum padi/*day, 1 larva of *Opomyza/* day, 4 larvae or pupa of *Phorbia/*day*)*.
Carabidae	*Poecilus cupreus* L.	Welling M., 1990; Ciochia, 1986; Malschi, 2007; Malschi, 2009 (9 eggs-6 larvae of *Oulema*/day, 60 *Sitobion avenae/*day, 50 *Rhopalosiphum padi/*day, *10* eggs *of Eurygaster/day*, 5-10 larvae-pupa of *Opomyza florum/day*, 5-7 larvae-pupa of *Phorbia/*day).
	Amara aenea De Geer	Basedow, 1990 (11 aphids/day); Malschi, 2009 (9 eggs-5 larvae of *Oulema*/day, 50 *Rhopalosiphum padi/*day, 10 eggs of *Eurygaster/*day, 8 larvae *Phorbia/*day).
	Harpalus rufipes De Geer	Basedow, 1990 (27-130 aphids/day); Malschi, 2007; Malschi, 2009 (8 eggs-9 larvae of *Oulema*/day, 60 *Sitobion avenae/*day, 50 *Rhopalosiphum padi/*day, 10 eggs of *Eurygaster/*day, 1 larva of *Opomyza florum/*day, 2-1 larvae-pupa of *Phorbi* /day).
	Harpalus distinguendus Duft.	Malschi, 2007; Malschi, 2009 (8 eggs-3 larvae of *Oulema*/day, 50 *Rhopalosiphum padi/*day, 2 larvae or 2 pupa of *Phorbia securis/*day).
	Harpalus aeneus L.	Malschi, 2007; Malschi, 2009 (5 eggs-4 larvae of *Oulema*/day, 50 *Rhopalosiphum padi/*day, 2 pupa of *Opomyza florum/*day, 4 larvae-2 pupa of *Phorbia securis/*day*)*.
	Brachinus explodens Duft.	Cândea, 1986; Malschi, 2009 (5 larve *Oulema* / day, 25 *Sitobion avenae/* day, 30 *Rhopalosiphum padi/* day.
Sylphidae	*Sylpha obscura* L.	Sunderland, 1985 (aphidds); Malschi, 2007; Malschi, 2009 (14 eggs-3 larve *Oulema*/day, *10* eggs *Eurygaster/*day, 1-4 larvae-pupa of *Opomyza florum/*day, 2-4 larvae-pupa of *Phorbia/*day.
Cicindellidae	*Cicindela germanica* L.	Panin, 1951; Ciochia, 1986
Emipididae	*Platypalpus*	Chambon, 1984; Stark, 1987
Chloropidae	*Thaumatomyia glabra* Mg	Skufin, 1978
Syrphidae	*Episyrphus baltaeatus* Dg. (larva)	Mühle-Wetzel, 1990 (20-80 aphids/day); Malschi, 2007; Malschi, 2009 (15 adults of *Haplothrips tritici/*day, 25 *Sitobion avenae/*day).

Scatophagidae	*Scatophaga stercoraria* L. (larva)	Chambon, 1984
Aeolothripidae	*Aeolothrips intermedius* Bagnall	Chambon, 1984
Formicidae		Cândea, 1986; Sunderland, 1985

Source: Adapted from Malschi, 2007; Malschi, 2008; Malschi, 2009

Knowing the pests and their integrated control is an important direction in the phytosanitary practice of wheat crop, in Transylvania (Baicu, 1989; Baicu, 1996; Baicu & Săvescu, 1978; Bărbulescu, 1984; Bărbulescu et al., 1973, Bărbulescu et al., 2002; Bucurean, 1996; Malschi, 1980; Malschi, 1982; Malschi, 1993; Malschi, 1995; Malschi, 1998; Malschi, 2000; Malschi, 2001b; Malschi, 2003; Malschi, 2004; Malschi, 2005; Malschi et al., 1980; Malschi et al., 2005; Malschi et al., 2006; Malschi et al., 2010; Malschi, 2013; Malschi et al., 2015; Malschi & Mustea, 1995; Malschi & Mustea, 1997; Malschi & Mustea, 1998a; Malschi et al., 2003; Mărgărit et al., 1984; Munteanu, 1973; Munteanu & Bredt, 1973; Munteanu et al., 1983; Mustea, 1973; Perju, 1983; Perju, 1999; Perju et al., 1989; Perju & Peterfy, 1968; Popov et al., 1983; Popov, 1984; Popov et al., 2007a; Rogojanu & Perju, 1979; Roman et al., 1982; Roşca et al., 2011). Thus, measures targeting the increase of the resilience of social-ecological systems can be implemented.

In recent decades, numerous publications presented the importance of wheat pests and their control based on the research conducted within the agricultural research network in the country. Comprehensive studies of great importance to practice were performed on cereal sunbugs (Popov 1983, 1984, 1999, 2003), on wheat thrips (Baniţă, 1976; Malschi, 2001b); on cereal leaf beetles (Bucurean, 1996; Malschi, 2000; Popov et al., 2005); on wheat stem borer (Baniţă & Popov, 1976; Baniţă et al., 1992); on saddle gall midges (Baniţă et al., 1973; Petcu & Popov, 1978; Popov et al., 1989), on aphids (Bărbulescu, 1965; Bărbulescu, 1972; Bărbulescu, 1975 Bărbulescu, 1982; Malschi, 2008; Malschi, 2009; Malschi et al., 2003; Malschi et al., 2006); on leafhoppers (Munteanu, 1973); on wheat flies (Bărbulescu et al., 1973; Bărbulescu, 1984; Malschi, 1980; Malschi, 1982; Malschi, 1993; Malschi, 1998; Malschi, 2001; Malschi, 2007) or on the pests from soil and on the seed preventive treatments for Zabrus corn ground beetles, wireworms, aphids etc. (Popov et al., 1997; Popov et al., 2001; Popov et al., 2007b; Popov et al., 2010). More research on biodiversity of entomophagous useful fauna were also developed (Baniţă, 1999; Fabritius et al., 1985; Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi & Mustea, 1995; Popov, 1975; Popov, 1980; Popov, 1984; Popov, 1985; Popov, 1999; Popov et al., 2009; Roşca et al., 2008).

The integrated wheat pest management in Transylvania includes as an important link the measures for conservation, use and reconstruction of biodiversity, of flora diversity, of arthropods fauna diversity, especially entomophagous, through biological methods in agricultural ecosystems (Malschi, 2003; Malschi, 2004; Malschi, 2005; Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014; Malschi et al., 1980; Malschi et al., 2005; Malschi et al., 2010; Malschi et al., 2012; Malschi et al., 2013a; Malschi et al., 2013b; Malschi et al., 2013c; Malschi et al., 2014; Malschi et al., 2015). These biotechnologies relate to different aspects of sustainable use of bioresources:

(i) Protection and increase of the use of entomophagous natural activity;

(ii) Enrichment of the edges of cultivated field with plants species with attractiveness to entomophagous;

(iii) Preservation of the diversity of marginal flora and meadows and pastures flora, consisting of various flowering plants important for the development of entomophagous *(e.g., Pastinaca sativa, Daucus carota, Achillea millefolium, Hypericum perforatum, Tanacetum vulgare, Cichorium inthybus, Sinapis arvensis, Papaver rhoeas, Sonchus arvensis, Veronica persica, Matricaria chamomilla, Myosotis arvensis, Viola arvensis, Lolium perene, Plantago major.);*

(iv) Planting of trees and shrubs strips and of the grassed protective embankments which are favorable to the development of eco-tone areas for the entomophages migration in the cultures;

(v) Planting of agroforestry belts consisting of trees and shrubs species: *Cerasus avium, Malus sylvestris, Pyrus pyraster, Prunus spinosa, Crataegus monogyna, Rosa canina, Corylus avellana, Ligustrum vulgare, Staphylea pinnata, Ribes spp., Sambucus nigra etc.*, on exterior rows, and *Quercus robur, Ulmus spp, Robinia pseudacacia, Acer platanoides, Acer pseudoplatanus, Fraxinus excelsior, Tillia cordata, Salix caprea* etc., on interior rows (Lupe & Spîrchez, 1955; Malschi, 2003; Malschi, 2005; Malschi & Mustea, 1995; Popescu, 1993).

The existence of diversified flora within the protective agroforestry curtain represents the main factor ensuring the survival, growth and richness of species, and the season migration from one field to another of the arthropod useful Entomophagous predators (Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014).

2. Material and methods

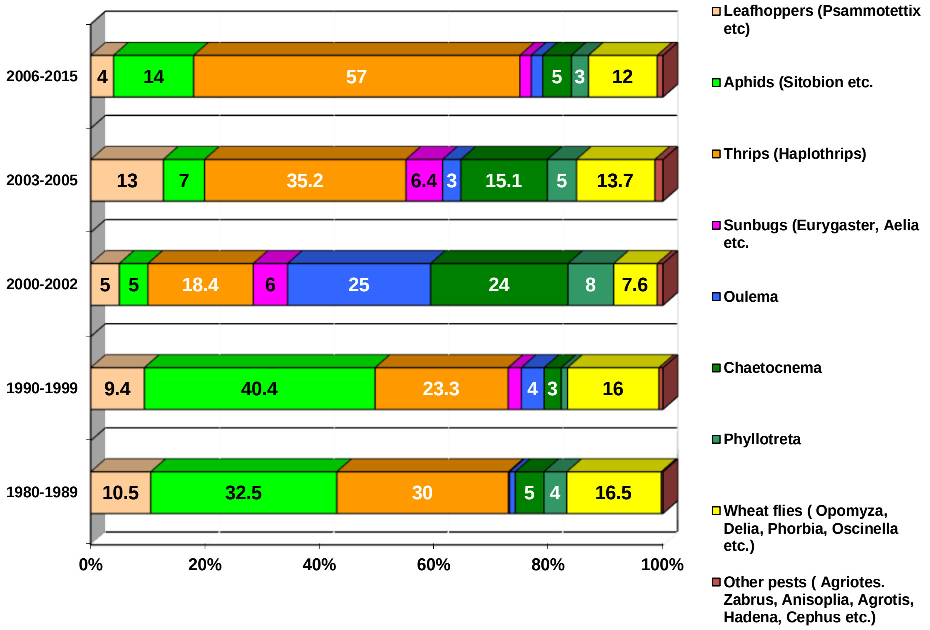
During 2006-2015 period, the importance of wheat pest in central Transylvania has been highlighted by noting the dynamics, the numerical abundance, and the structural percentage share of the main groups of arthropod fauna. The investigations were conducted in wheat crops in large experimental lots in different cultural systems (the agro-forestry system with curtains, the open field system with traditional plowing, and the conservative – no tillage – system). In the no-intervention research lots all zonal recommendations of technology and phytosanitary complex were applied, including optimal sowing time, seed treatments and phytosanitary complex treatments on vegetation. The studied variants regarding the effect of authorized insecticidal treatment included an untreated plot and an integrated pests control plot with insecticides application for two different treatment moments: 1 – at the end of tillering in the 25-33 DC stage, at herbicides time, applying neonicotinoids, and 2 – at flag leaf stage and ear appearance in the 45-59 DC stage, applying pyrethroids.

Pest monitoring was performed based on the samples collected with entomological net, by decadal 100 sweep-net catches / sample, during the vegetation period of each year. The species inventory, the abundance, and the dynamics of populations according to the density factors (technological and climatic factors, and entomophagous biological limiters) were registered. In order to obtain data on biology and ecology of phytophages and entomophages useful species, the observations were conducted using the Barber ground pitfalls and the white boards with glue. In the investigations carried out since 1980, at the ARDS Turda, the same methods of sample collection of wheat insect pests and of entomophagous auxiliary arthropods were used.

The presentation of the results took into account technological systems of culture and climate change, showing the evolution and a comparison of pests. Correlations and quadratic regressions were calculated in order to study e.g., the relationship of wheat pests evolution with climatic conditions and abundance of entomophages.

3. Results and discussions

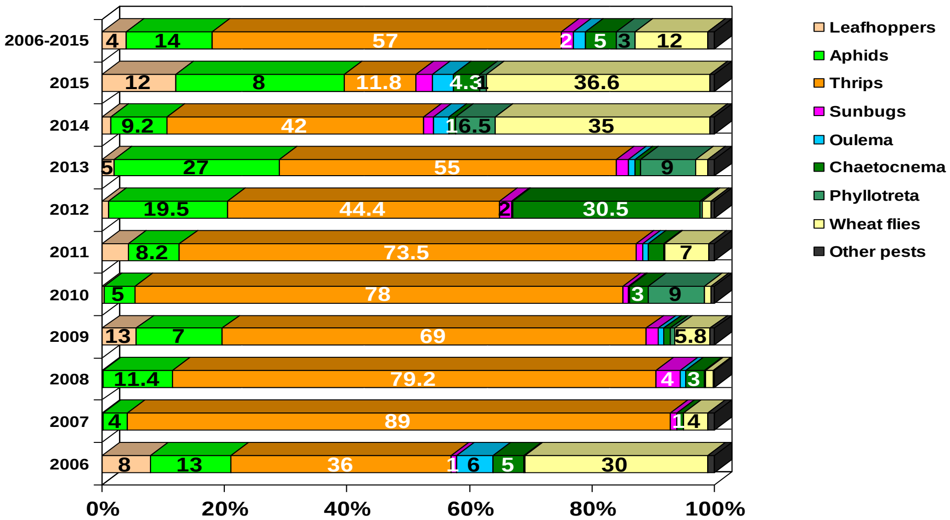
During 2006-2015, the permanent attention granted to the study of the correlation between the dynamics of wheat pests attack and the evolution of agri-environmental complex zonal factors led to the observation of the relationship between climate change and wheat crop enthomocenoses (Figures 1, 2).



Classes of dominance: Eudominant: 32-100%; Dominant: 10-31.9%; Underdominant: 3.2-9.9%; Signalized: 1-3.1%; Feeble signalized: 0.32-0.99%; Sporadic: <0.32% (Wetzel, 1995).

Figure 1. Dynamics of wheat pest structure (%) (between 1980-2015, at ARDS Turda)

Source: Malschi et al., 2014; Malschi et al., 2015; Malschi et al., 2016



Classes of dominance: Eudominant: 32-100%; Dominant: 10-31.9%; Underdominant: 3.2-9.9%; Signalized: 1-3.1%; Feeble signalized: 0.32-0.99%; Sporadic: < 0.32% (Wetzel, 1995).

Figure 2. Dynamics of wheat pest structure (%) (between 2006-2015, at ARDS Turda)
Source: Authors' elaboration

The global warming effects such as the installation of extremely hot periods and droughts in spring-summer, represented particularly important ecological factors that determined different changes in species composition, favoring development of a narrow-spectrum of species populations which became dominant and dangerous due to their numerical increase, local invasions and powerful attacks (Figure 3).

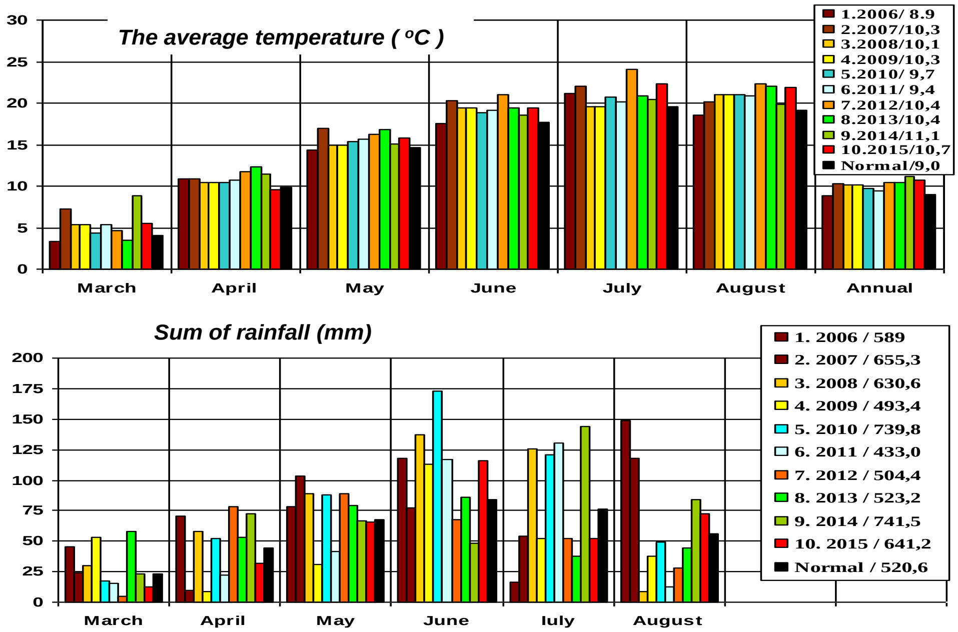


Figure 3. Average temperatures and sum of rainfall at Turda conditions by month, from March to August and by year, between 2007-2014

Source: Authors' elaboration based on data from Turda meteorological station (longitude: 23°47'; latitude 46°35'; altitude 427m)

3.1. The evolution of wheat pests in Transylvania in relation to the climate change

In contrast to the previous periods of the study when the weight of different groups of pests was evenly distributed, during the last 10 years, there are obvious changes in the structure of harmful entomofauna (Figures 4, 5, 6):

- The increase of abundance and eudominance of wheat thrips in the annual structure of harmful entomofauna and large variations of seasonal abundance and of attack potential;

- Dominance of certain monovoltine species: thrips, wheat flies (*Opomyza florum*, *Delia coarctata*, *Phorbia penicillifera*), *Oulema*, *Eurygaster* and *Aelia*, soil pests (*Zabrus*, *Agriotes*), and some polivoltine species linked to the cultivation of cereals: *Oscinella* and other Chloropidae, leafhoppers, aphids **(**Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014; Malschi et al., 2010; Malschi et al., 2013; Malschi et al., 2015; Malschi et al., 2016; Perju et al., 2001; Popov et al., 2003).

During the 1980-1999 period, the pest structure reflects the eudominance of aphids and leafhoppers, the dominance of Diptera, Chrysomelidae, wheat thrips, and the presence of cereal bugs. The warmest years of 2000-2002 favored the explosive development of Chrysomelidae (*Oulema, Chaetocnema,* and *Phyllotreta*). The years 2003-2005 were also extremely hot and dry, which led to the installation of eudominance of thrips, leafhoppers, wheat flies, and of fleas *Chaetocnema*, and to the largest abundance of sunbugs (6.4%).

During the 1980-2005 period, separate schemes and moments for control key pest groups were tested, depending on the biological cycles of the species of Diptera, leafhoppers, *Oulema*, thrips, aphids and on the importance of entomophagous. In this case, special treatment at warning at different times of insecticides application is recommended based on preventive measures (especially practicing optimal sowing time after the first decade of October, application of seed treatments with insecticides and fungicides, and other phytosanitary and agro-technical measures). In the years 1980-2005, the following times of treatment applications at warning were recommended:

- For Diptera, in early spring (for *Opomyza florum*, *Delia coarctata*, *Phorbia penicillifera*) and at the end of tillering in May, (for *Phorbia securis, Oscinella* and other chloropidae), as well as for leafhoppers, using a systemic and contact insecticide;
- For *Oulema* (pest with a long cycle to June), two treatments were recommended (for adults and larvae), especially pyrethroids to protect the natural entomophagus which are very active in killing eggs and larvae;
- For wheat thrips (a pest with long cycle until July to August), two treatments were recommended (for adults and larvae), aiming to protect natural entomophagus which are very efficient in destroying adults, eggs and larvae of thrips (Malschi, 1980; Malschi, 1982; Malschi, 1993; Malschi, 1995; Malschi, 1998; Malschi, 2000; Malschi, 2001; Malschi, 2003; Malschi, 2004; Malschi, 2005; Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014; Malschi et al., 1980; Malschi et al., 2003; Malschi et al., 2005; Malschi et al., 2006; Malschi et al., 2010; Malschi et al., 2013; Malschi et al., 2015; Malschi et al., 2016; Malschi & Mustea, 1992; Malschi & Mustea, 1995; Malschi & Mustea, 1997; Malschi & Mustea, 1998).

In 2006, pest structure of earlier periods was maintained. The annual average temperature with normal values (8,9^{o}C) and the annual precipitation (589 mm) which was higher than normal (520.6 mm) were favorable to an equilibrated evolution of zonal pests which registered the structural percentages of 36% to thrips, 30% to Diptera, 13% to aphids, 8% to leafhoppers, 6% to *Oulema*, 5% to *Chaetocnema*, 1% to *Eurygaster* and *Aelia*, and 1% to other species.

The 2007-2011 period was characterized by climatic warming and heat and favored thrips population explosions, reaching the highest values into the annual structure of damaging entomofauna, accounting for 69-89%. (Figures 4, 5, and 6).

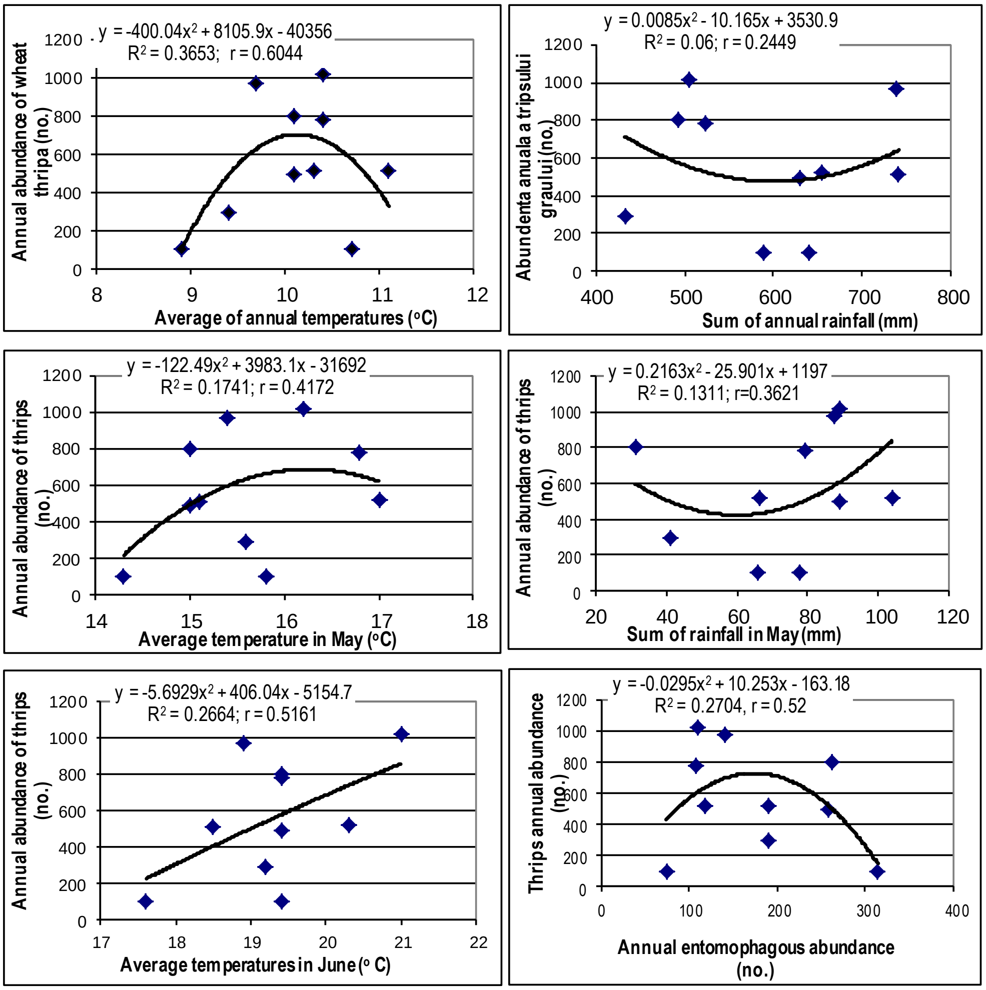


Figure 4. Dynamics of wheat thrips depending on climate and entomophagous during 2006-2015 at the ARDS Turda
Source: Malschi et al., 2016

The 2012-2015 period was characterized by increasing warming, recorded an annual average of temperatures of 10.4-11.1°C with 1-2°C more than normal. The 2012 year and 2013 year, hot and dry and having the annual rainfall below the normal values (from 433 to 504.2 mm, respectively) were still favorable for thrips, aphids, wheat fleas, and sunbugs. Between 2014 and 2015, heat and rain (with annual rainfall more than normal, by 741.5 and 641.2 mm) were favorable to eudominant Diptera populations and to the further development of thrips, aphids, leafhoppers, cereal leaf beetles, and sunbugs (Figures 4, 5, and 6).

Different types of farms, fragmentation of cultivated areas, mosaic of agroecological conditions, incomplete and incorrect application of cultural techniques, such as the practice of monoculture, the sowing outside the regional optimal time recommended for the second decade of October in order to prevent autumn pests attack, failure to apply the agrotechnical and phytosanitary measures contributed to these changes.

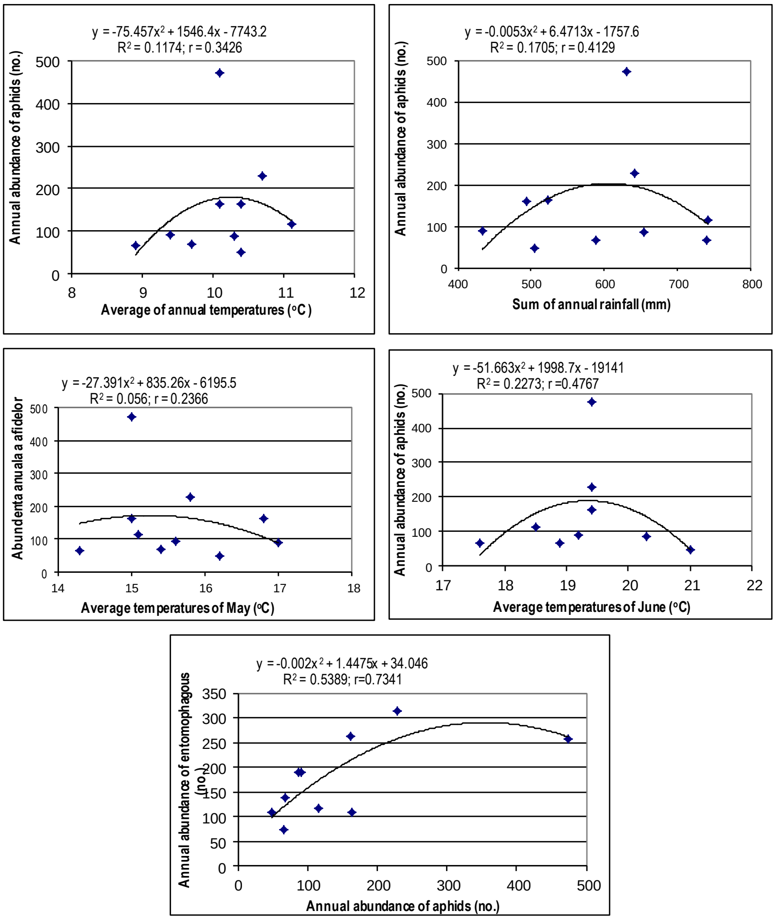


Figure 5. Dynamics of wheat aphids depending on climate and entomophagous during 2006-2015 at ARDS Turda

Source: Malschi et al., 2016

In the farming system with soil minimal tillage and no tillage, used to minimize the effects of droughts and global warming, the increase of pest abundance (frequently surprising of the groups of thrips, wheat flies, leafhoppers, aphids etc.) was noted, too, requiring adequate integrated control measures for these entomocenotic risk situations (Figure 7). In the open field area, with conservative soil system with minimal tillage or no tillage, a higher abundance of Diptera Chloropidae and Anthomyiidae, of leafhoppers and aphids was evident (Malschi, 2009; Malschi, 2014; Malschi et al., 2010; Malschi et al. 2013; Malschi et al. 2015; Perju & Malschi, 2001). It is important to note that in the agro-forestry system an entomocenotic balance was maintained during 1980-1989 (with the same structure of damaging entomofauna and the greater abundance of auxiliary entomophages than in the open field crops system) (Malschi, 2003; Malschi, 2005; Malschi, 2007; Malschi, 2008; Malschi, 2009; Malschi, 2014; Malschi et al., 2010; Malschi et al., 2013; Malschi et al., 2015; Malschi & Mustea, 1995) (Figure 8).

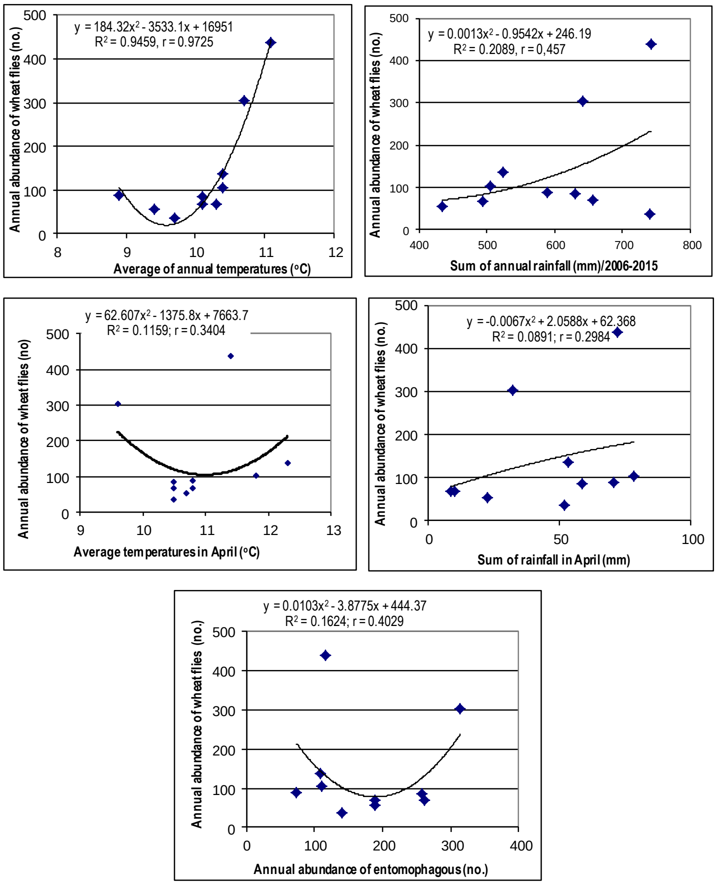


Figure 6. Dynamics of wheat flies depending on climate and entomophagous during 2006-2015 at ARDS Turda
Source: Malschi et al., 2016

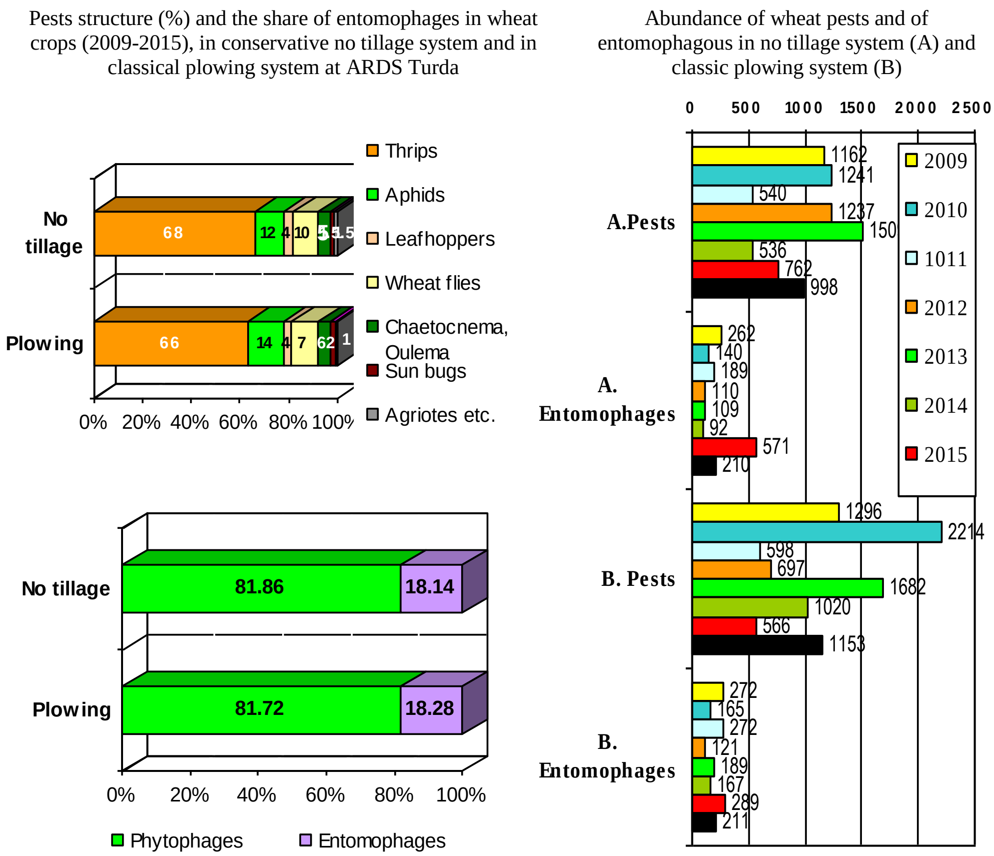


Figure 7. Entomocoenotic relation, dynamics of structure and abundance of wheat pests in no tillage and classical plowing systems (between 2009-2015, at ARDS Turda)
Source: Adapted from Malschi et al., 2015; Malschi et al., 2016

Under entomological risk conditions caused by warming and drought the danger of pest abundance increased. Since the early April, the wheat flies species of Chloropidae: *Oscinella*, *Elachiptera*, *Meromyza*, etc., Anthomyidae: *Phorbia*, *Delia*, Opomyzidae: *Opomyza*; the concentration of *Chaetocnema aridula* and *Oulema melanopus* were reported concomitantly with the flight of leafhoppers (*Javesella*, *Psammotettix*, and *Macrosteles*). Wheat thrips (*Haplothrips tritici*) was the most abundant pest, dangerous for the ear formation in bellows and for grain development. Of particular importance were the wheat flies, the leafhoppers and aphids (*Sitobion*, *Schizaphis*, *Rhopalosiphum*, etc.) which were extremely dangerous for autumn early crops (Figure 9).

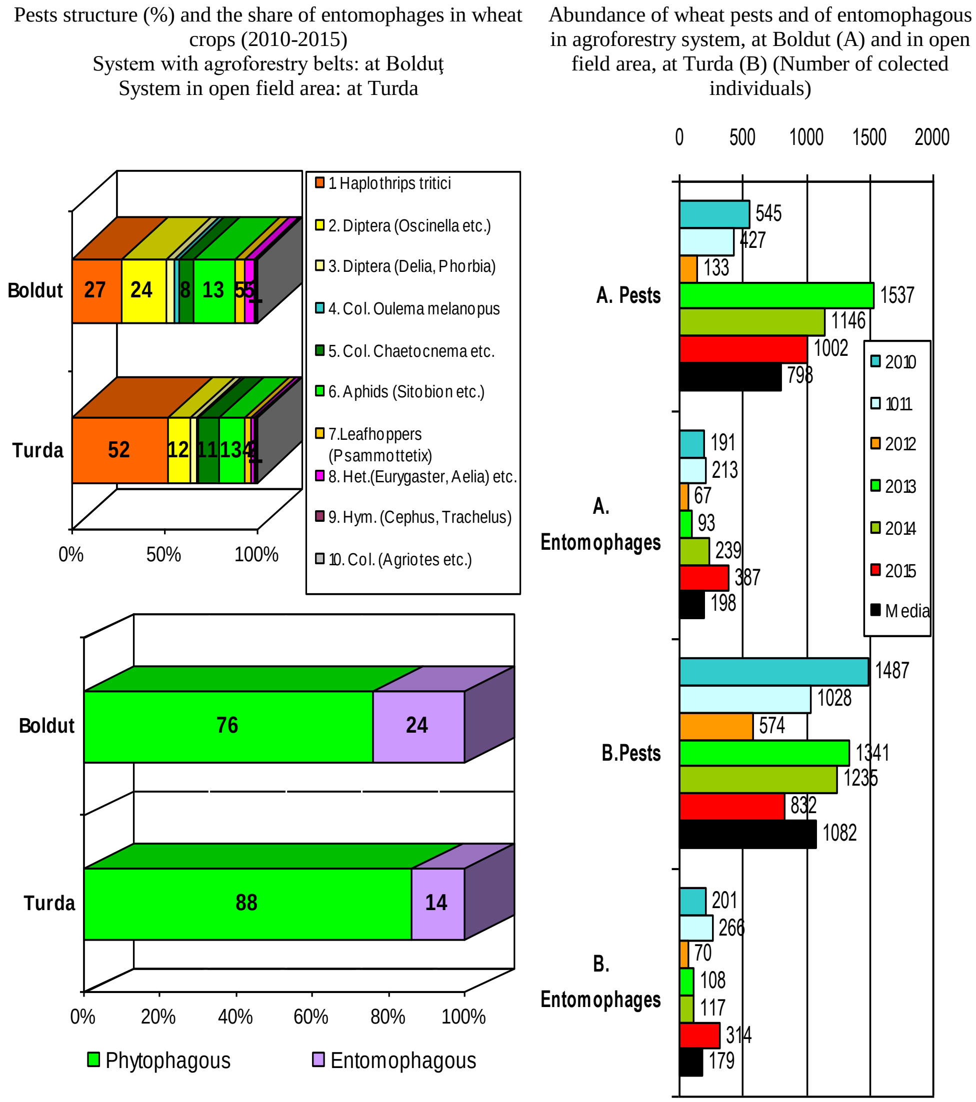
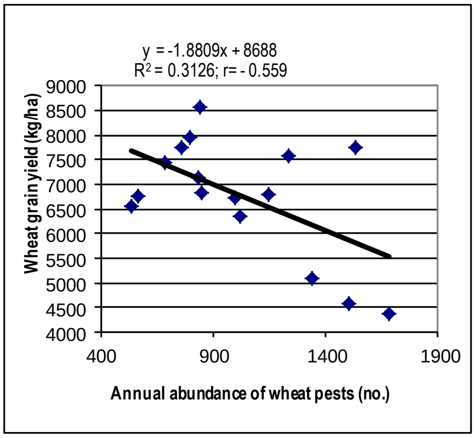


Figure 8. Entomocoenotic relation, structure (%) and abundance of wheat pests in open field area at Turda and in agro-forestry system Cean–Bolduț, 2010-2015, ARDS Turda
Source: Malschi et al., 2015; Malschi et al., 2016

In Transylvania, the integrated system of wheat pest control must include agrotechnical preventive measures (especially respecting the sowing time in the second decade of October) and application of insecticide treatments, such as seed treatments and spraying treatments on vegetation (treatment 1 in the spring, no later than the end of tillering – in the case of herbicides application; treatment 2 at the phenophase of bellows and ear emergence; and other treatments at warning).



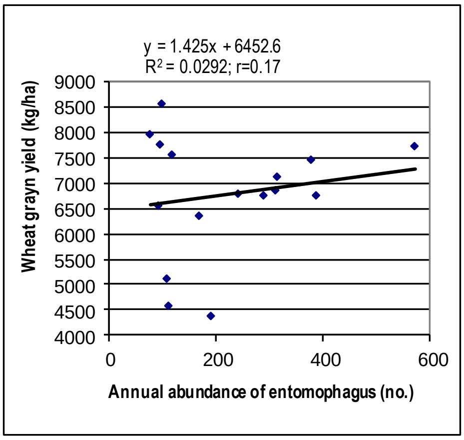


Figure 9. Entomocenotic risk situations on wheat yield, during 2006-2015, in relation to climate change and cultural technologies, at ARSD Turda
Source: Malschi et al., 2016

4. Conclusions

The paper presented the evolution of the importance of wheat pests in central Transylvania, during the past 10 years (2006-2015), specifying the entomocenotic risk situations in relation to climate change and eco-technologies of culture (agroforestry system with curtains, open field system in classical-plowed and in conservative system – with minimal tillage and soil untilled), from ARDS Turda. In the pest structure of wheat under the open field area of the ARDS Turda, the entomocoenotic particularities revealed the most important groups of zonal pests characterized by: the eudominant thrips of wheat – 57%, the dangerous populations of aphids – 14%, the Diptera – 12%, and Chrysomelidae – 10%, the importance of populations of leafhoppers – 4% and sunbugs – 2%. During the last 10 years, the abundance of these pests represented a risk for wheat crops located in the open field area. The reported explosions of pest populations were related to climate fluctuations and decrease of abundance of entomophages, which had a share of only 14% in the arthropods structure.

Under no conservative tillage system, the wheat thrips, Diptera, aphids, leafhoppers, the pests from soil (Agriotes, Zabrus etc.) were highlighted as major wheat pests. Compared with traditional plowing system, a large share of Diptera Chloropidae, of aphids and leafhoppers, was noted in the conservative system requiring special attention for the adequate application of integrated pest control.

In the case of the farming system with agro-forestry curtains, multiannual maintenance of entomocenotic balance was observed. The share of the pest key groups was balanced, with constant annual levels and without evidence of dangerous population explosions. The entomophagous had a share of 24% in the structure of collected arthropod fauna, carrying an important and effective natural biological limitation of pest, and, therefore the insecticide treatments were unnecessary in most years.

Acknowledgement

Special thanks go to the Agricultural Research and Development Station Turda for supporting this research. This paper is dedicated to the memory of the Director of the ARDS Turda, Prof. eng. Ioan Haş, PhD. This study was partially developed within the research program "The creation of a model for the evaluation of food quality from the point of view of consumer health and environmental protection", 2016-2018, a bilateral cooperation project between the Romanian Academy and Wallonia – WBI, FRS-FNRS. "La présente publication a été rendue possible grâce à l'Accord qui lie WBI, le FRS-FNRS et l'Académie Roumaine."

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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The Rating of Large Romanian Dams into Seismic Risk Classes

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Abstract
One step of the process towards increasing resilience of a community to natural or man-made disasters is the seismic risk assessment of various constructions, such as dams. The need to adopt modern operating rules and hydrotechnical constructions monitoring activities in all phases of dam existence (construction, operation, modernization/rehabilitation, and post-use) was reflected into new regulatory acts from Romania. They respond to changes caused by long periods of exploitation (20-50 years) and by socio-economic development of the areas downstream of large dams, which increased the potential damage associated with possible incidents or accidents at dams.
The present study evaluates 227 dams situated on Romanian rivers. This research rates them in seismic risk classes using the information from the National Inventory of Dams and a methodology developed as part of a general earthquake risk and loss estimation program for the State of South Carolina which can be applied to any country in the world. Based on the theory described by Bureau & Ballentine (2002) and Bureau (2003), the analysis focuses on dams' structural vulnerability depending on age, dams' height and lake water volume, and also on the downstream risk, characterized by possible fatalities and economic losses in the case of a flood caused by a dam rupture. Dams' seismic vulnerability is also an important factor for risk classification and it is calculated as the response of dams to the seismic action, characterized by the maximum expected peak ground motion (PGA). In this paper, the expected PGA is assessed using probabilistic hazard assessment approaches and is estimated for 1000 years return period. The risk class gives the signal when an emergency action plan should be implemented in the region and when inspections are imperative, thus increasing the resilience of a community to disasters.

Keywords: earthquake, Romanian dams, seismic hazard assessment, seismic risk classes

1. Introduction

The safety of dams has a significant impact on the resilience of a community to natural or man-made disasters and, therefore, their seismic risk assessment is a mandatory step to safeguard infrastructure and population. The average age of 250 Romanian large dams, tabulated in the Romanian Register of Large Dams (RRMB) from a total of 2617 permanent and temporary dams, is 40 years old. There are 3 dams of more than 100 years old in Romania. The oldest one (112 years old, in 2017), Sadu II, Sibiu, which was put into operation in 1905, is a small 18 m high gravity dam (Figure 1). More than 100 dams are in the immediate vicinity of populated areas, like the Morii Dam on Dambovita River, situated in the Western part of Bucharest (the capital of Romania) (Figure 2).

Figure 1. Sadu II Dam, Sibiu, Romania, the oldest dam in Romania
Source: Google Earth

Figure 2. Lacul Morii Dam, Bucharest seen from River View House
Source: Google Earths and Panoramio by "arsenikos"

From the 250 dams included in RRMB, the present work focuses only on 227 large dams, built on Romanian rivers, because the remaining 23 dams were too small or not finished yet.

The highest dam from Romania is Vidraru Dam, situated in Fagaras mountains, on Arges river, and it is 166 m height. It was put into operation in 1965. Izvorul Muntelui Dam (Bistrita river, very close to the city of Bicaz) is the second one, and the largest from the Eastern part of Romania (Moldova region) with a height h=127 m and a volume Vlake=1230hm^3.

Although dams are built following specific design and engineering rules regarding structural strength, serious dam accidents took place all over the world; it also happened in Romania, in 1991, on Belci dam (Figure 3; Diacon et al., 1992; Moldovan et. al, 2016a) situated on Tazlau river (that flows into Trotus river, a tributary of Siret river), and in 1997 after the Cornăţel dam break, from the Vedea water catchment area.

Figure 3. The left bank of the Belci dam
Source: Authors' elaboration

The dams and the accumulation lakes constitute the main potential sources of risk to downstream settlements in the case of hydrotechnical accidents. The impact of a dam failure is critical for two reasons: (1) their catastrophic failure can cause many fatalities and destroy dwellings and other structures downstream the facility, and (2) the storage capacity is lost and their functionality is destroyed and not recovered until the dam is rebuilt (large dams were built for hydroelectric power and smaller dams in oder to to provide water for industrial needs or irrigation).

The present study is the result of different national projects, conducted during the last 10 years (e.g., NUCLEU PN 30 01/2009, UEFISCDI PCCA 2013 Program, and DARING 69/2014), being a step toward building downstream safety in Romania. The paper deals with probabilistic seismic hazard assessment in dam sites, structure vulnerability, and downstream risk evaluation, having as final goal the seismic risk rating of 227 Romanian dams.

2. Methodology

The methodology used in this paper to perform seismic risk ranking of Romanian Dams was developed as part of a general earthquake risk and loss estimation program for the State of South Carolina (URS Corporation et al., 2002), and presented by Bureau & Ballentine (2002) and Bureau (2003). The methodology is quantifying the Total Risk Factor (TRF) [see equation (1)] of any dam by using various risk factors and weighting points.

$$TRF = [(CRF + HRF + ARF) + DHF] \times PDF = SF \text{ x } PDF \qquad (1)$$

where:

- CRF is the lake capacity risk factor;
- HRF is the dams' height risk factor;
- ARF is the dams' age risk factor;
- DHF, the overall downstream hazard factor is based on population and property exposed at risk;
- The sum of first three above mentioned factors represents the structure influence, and together with the downstream factor are named Structure and Site Factors (SF);
- PDF is the predicted damage factor and it is a function of the site-dependent seismic hazard and observed performances of similar dams under the seismic action (Bureau, 2003).

2.1. Structure and Site Factors (SF)

In Table 1, are presented the values taken by CRF and HRF, as a function of lake capacity and dams' height. From Table 1, one can see that large reservoirs associated with high dams, that might cause significant flooding, have associated large risk factors (Bureau, 2003).

Table 1. Definition of capacity and height risk factors

Risk factor	Contribution to the total risk			
	Extreme	High	Moderate	Reduced
Capacity (m^3)	>61,673,500	61,673,500-1,233,470	1,233,470-123,347	<123,347
CRF	6	4	2	0
Height (m)	>24.38	24.38-12.192	12.192-6.1	<6.1
HRF	6	4	2	0

Source: Bureau, 2003

The values of ARF (age risk factor), from equation (1), indicate that old dams are more vulnerable than the modern ones, as a consequence of time deterioration (Bureau & Ballentine, 2002) – Table 2.

Table 2. Definition of ARF (dams' age risk factor)

Dam's age	<1900	1900-1925	1925-1950	1950-1975	1975-2000	>2000
ARF	6	5	4	3	2	1

Source: Bureau, 2003

The overall downstream hazard factor (DHF) is composed by the downstream evacuation requirements factor (ERF) which depends on the exposed at risk human population and the downstream damage risk index (DRI). DRI is obtained from the value of private, commercial, industrial, or government property in the potential flooded area (Table 3). ERF and DRI factors should preferably be obtained from a combination of detailed downstream information, inundation scenarios, and economic studies. The DHF should be periodically updated. DHF is defined as:

$$DHF = ERF + DRI \qquad (2)$$

Table 3. Definition of downstream risk factor (DHF)

Risk factor	Contribution to TRF (share)			
	extreme	high	moderate	reduced
Persons	>1000	1000-100	100-1	0
ERF	12	8	4	1
Property value	high	moderate	reduced	None
DRI	12	8	4	1

Source: Bureau, 2003

2.2. The Predicted Damage Factor (PDF)

The Predicted Damage Factor (PDF) is computed for each dam, and its value is given in equation (3):

$$PDF=2.5*PDI \qquad (3)$$

where:

PDI= Predicted Damage Index

The Predicted Damage Index (PDI) computed for different earthquakes scenarios depends on the Earthquake Severity Index (ESI) at each dam site, and is graphically obtained from dams' vulnerability curves developed by Bureau and Ballentine (2002), from observed seismic performance of real dams during real earthquakes (Figure 4). The ESI is given in equation (4) and represents *a robust estimate of the severity of shaking for dam evaluation purposes* (Bureau, 2003).

$$ESI=PGA*(M-4.5)^3 \quad (4)$$

where:
PGA is the peak ground acceleration, measured in *g*, M is the maximum Richter or moment magnitude (Mw) of the seismic scenario.

The predicted ground motion can be estimated also by means of probabilistic approaches during a return period of Tr years.

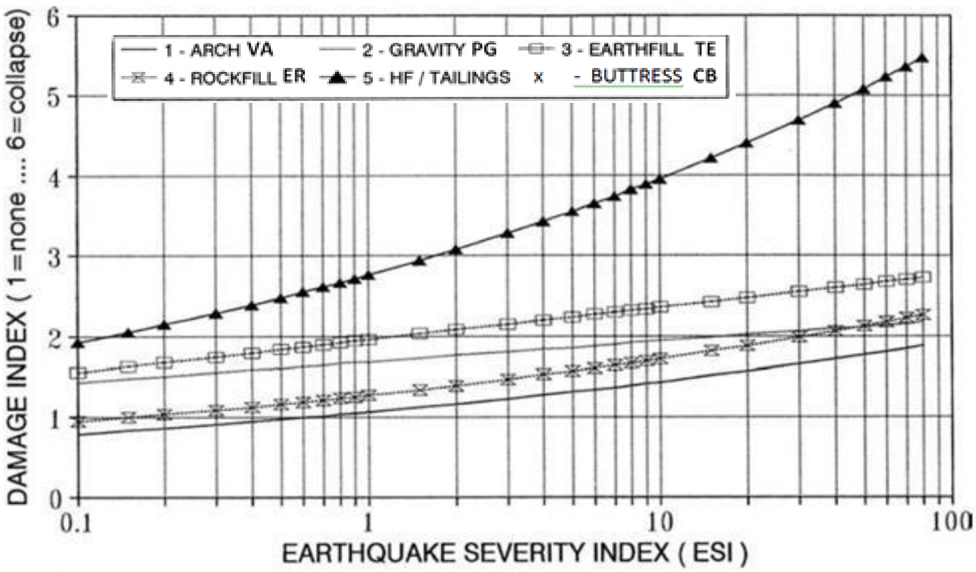

Figure 4. Dam vulnerability curves: *PDI = f(ESI)*
Source: Bureau and Ballentine, 2002

The PDI rates only the relative vulnerability of each dam type, and includes a significant uncertainty, especially when extrapolated to large ESI values, which can be quantified from the standard deviations associated with the mean estimates (Bureau, 2003).

Each curve is associated with a dam type: 1 “Arc” type dam, 2 “gravitational” or weight type, 3 to “earth filling” type, 4 embankment dams, and 5 to hydraulic filled dams. The most vulnerable are the hydraulic fill type, while “Arc” type dams had the best performance. There is no information about buttress dams (CB) and we used curve 3 for this type of dams.

The dams risk classes are related to the TRF value as shown in Table 4.

The Risk Class meaning is: I - low risk, II – moderate risk, III – high risk and IV- extreme risk.

Table 4. Dams' Risk Classes values and meanings

TRF	Risk class of dam	Risk explanation
2-25	I	Reduced
25-125	II	Moderate
125-250	III	High
>250	IV	Extreme

Source: Bureau & Ballentine, 2002

The above presented methodology was used for vulnerability and risk ranking of 227 Romanian dams.

3. Seismic risk classes for large Romanian dams

The main source of information about studied dams, the Romanian Register of Large Dams (RRMB) that contains information in Excell format regarding commissioning year, dimensions, characteristics, etc. was completed with the existing information from RoWater site (RoWater). Table 5 and Figure 5 present the geographical distribution of 227 Romanian dams studied in the present paper.

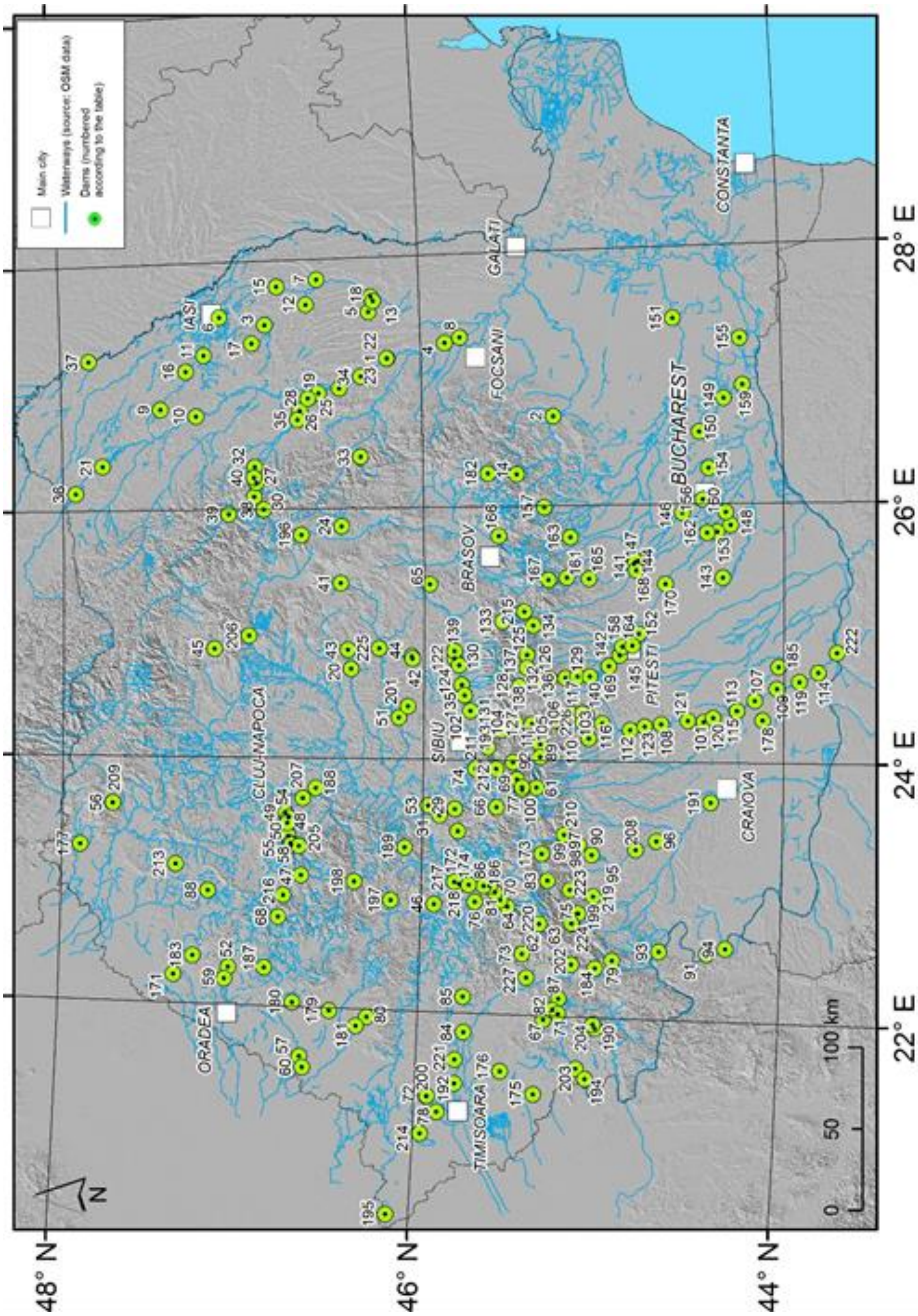

Figure 5. Geographical distribution of studied dams, with ID’s as labels
Source: Authors’ elaboration

Table 5. Geographical distribution of studied dams

Dam ID	Dam name	Long	Lat	River	Dam ID	Dam name	Long	Lat	River
1	BERESTI	27.19	46.19	Siret	**43**	BEZID	24.87	46.42	Cusmed
2	CANDESTI	26.70	45.27	Buzau	**44**	BRADENI	24.80	46.06	Hartibaciu
3	CAZANESTI	27.49	46.86	Durduc	**45**	COLIBITA	24.88	47.16	Bistrita
4	COSMESTI	27.30	45.87	Siret	**46**	DEVA MINTIA	22.85	45.93	Mures
5	CUIBUL VULTUR	27.56	46.28	Tutova	**47**	DRAGAN	23.06	46.67	Dragan
6	EZARENI	27.56	47.11	Ezareni	**48**	FANTANELE	23.56	46.76	Somesul Cald
7	MANJESTI	27.84	46.57	Crasna	**49**	FLORESTI II	23.52	46.74	Somesul Mic
8	MOVILENI	27.34	45.78	Siret	**50**	GILAU	23.37	46.74	Somesu Mic
9	PARCOVACI	26.82	47.45	Bahlui	**51**	IGHIS	24.33	46.14	Ighis
10	PASCANI	26.76	47.25	Siret	**52**	LUGASU	22.30	47.06	Crisul Repede
11	PODU ILOAIEI	27.25	47.20	Bahluet	**53**	OASA	23.63	45.97	Sebes
12	PUSCASI	27.64	46.63	Racova	**54**	SOMESUL C	23.48	46.75	Somesul Cald
13	RAPA ALBASTRA	27.69	46.27	Simila	**55**	SOMESUL R	23.31	46.73	Somesul Rece
14	SIRIU	26.25	45.48	Buzau	**56**	STRAMTORI	23.62	47.72	Firiza
15	SOLESTI	27.79	46.79	Vasluet	**57**	TAMASDA	21.60	46.65	Crisul Negru
16	TANSA BELCES	27.13	47.31	Bahlui	**58**	TARNITA	23.30	46.73	Somesul Cald
17	TUNGUJEI	27.34	46.94	Sacovat	**59**	TILEAGD	22.21	47.08	Crisul Repede
18	VALEA SEACA	27.65	46.26	Valea Sea	**60**	ZERIND	21.52	46.63	Crisul Negru
19	BACAU	26.93	46.57	Bistrita	**61**	BALINDRU	23.79	45.37	Lotru
20	BALAUSERI	24.72	46.41	Tarnava	**62**	CERNA	22.72	45.34	Cerna
21	BUCECEA	26.37	47.78	Siret	**63**	CERNA	22.73	45.16	Cerna
22	CALIMANESTI	27.19	46.19	Siret	**64**	CINCIS	22.85	45.52	Cerna
23	CLOCOTIS	27.19	46.19	Bistrita	**65**	DOPCA	25.39	45.97	Valea Mare
24	FRUMOASA	25.86	46.46	Frumoasa	**66**	GALBENU	23.63	45.59	Latorita
25	GALBENI	26.96	46.46	Siret	**67**	GOZNA	21.97	45.30	Barzava
26	GARLENI	26.79	46.68	Bistrita	**68**	GURA APELOR	22.72	46.79	Raul Mare
27	IZVORUL MUNTE	26.10	46.94	Bistrita	**69**	GURA RAULUI	23.85	45.48	Cibin
28	LILIECI	26.89	46.63	Bistrita	**70**	HATEG	22.90	45.56	Raul Mare
29	OBREJII CAPAL	23.61	45.82	Sebes	**71**	HERCULANE	22.14	45.22	Cerna
30	PANGARATI	26.22	46.93	Bistrita	**72**	IANOVA	21.33	45.93	Gherteamus
31	PETRESTI	23.56	45.91	Sebes	**73**	LESU	22.48	45.43	Iad
32	PIATRA NEAMT	26.34	46.93	Bistrita	**74**	NEGOVANU	23.93	45.71	Sadu
33	POIANA UZULUI	26.41	46.35	Uz	**75**	OSTROVUL	22.81	45.13	Raul Mare
34	RACACIUNI	27.05	46.34	Siret	**76**	PACLISA	22.88	45.70	Raul Mare
35	RACOVA	26.72	46.69	Bistrita	**77**	PETRIMANU	23.77	45.45	Latorita
36	ROGOJESTI	26.14	47.93	Siret	**78**	PISCHIA	21.21	45.87	Bega Veche
37	STANCA	27.23	47.84	Prut	**79**	POIANA MAR	22.45	44.93	Bistra Mar
38	TASCA BICAZ	26.00	46.89	Bicaz	**80**	SECUL	21.94	46.28	Barzava
39	TOPOLICENI	25.96	47.08	Bistrita	**81**	SUBCETATE	22.96	45.59	Strei
40	VADURI	26.26	46.94	Bistrita	**82**	SURDUC	22.05	45.25	Gladna
41	ZETEA	25.40	46.46	Tarnava	**83**	TAU	23.06	45.30	Sebes
42	BENESTI	24.82	46.07	Hartibaciu	**84**	TAUT	21.85	45.74	Valea Cigher

Dam ID	Dam name	Long	Lat	River	Dam ID	Dam name	Long	Lat	River
85	TREI APE	22.13	45.75	Timis	**129**	CURTEA AG.	24.66	45.15	Arges
86	VALEA PESTI	23.01	45.62	V Pesti	**130**	FAGARAS	24.86	45.83	Olt
87	VALIUG	22.02	45.22	Barzava	**131**	LOTRIOARA	24.24	45.57	Olt
88	VARSOLT	22.92	47.18	Crasna	**132**	OESTI	24.64	45.30	Arges
89	BRADISOR	24.13	45.35	Lotru	**133**	PECINEAGU	25.09	45.57	Dambovita
90	CURTISOARA	23.27	45.06	Jiu	**134**	RAUSOR	25.06	45.39	RTargului
93	PFI	22.53	44.67	Dunare	**135**	SCOREIU	24.51	45.78	Olt
94	PFII	22.56	44.30	Dunare	**136**	TURNU	24.32	45.27	Olt
95	TARGU JIU	23.27	45.06	Jiu	**137**	VALSAN	24.73	45.43	Valsan
96	TURCENI	23.39	44.70	Jiu	**138**	VIDRARU	24.63	45.37	Arges
97	TURCINESTI	23.27	45.06	Jiu	**139**	VISTEA	24.75	45.81	Olt
98	VADENI	23.35	45.13	Jiu	**140**	ZIGONENI	24.66	45.08	Arges
99	VALEA SADULUI	23.38	45.18	Jiu	**141**	ADUNATI	25.54	44.83	Ilfov
100	VIDRA	23.79	45.45	Lotru	**142**	BASCOV	24.83	44.91	Arges
101	ARCESTI	24.31	44.45	Olt	**143**	BOLBOCI	25.43	44.34	Ialomita
102	AVRIG	24.39	45.74	Olt	**144**	BRATESTI	25.56	44.81	Ilfov
103	BABENI	24.30	45.01	Olt	**145**	BUDEASA	24.83	44.91	Arges
104	CAINENI	24.30	45.50	Olt	**146**	BUFTEA	25.93	44.56	Colentina
105	CALIMANESTI	24.30	45.23	Olt	**147**	BUNGETU II	25.56	44.82	Ilfov
106	DAESTI	24.37	45.18	Olt	**148**	FACAU	25.84	44.30	Ilfovat
107	DRAGANESTI	24.48	44.16	Olt	**149**	FRASINET	26.82	44.32	Mostistea
108	DRAGASANI	24.29	44.68	Olt	**150**	FUNDULEA	26.56	44.46	Mostistea
109	FRUNZARU	24.57	44.04	Olt	**151**	GH DOJA	27.45	44.60	Fundata
110	GOVORA	24.18	45.08	Olt	**152**	GOLESTI	25.00	44.81	Arges
111	GURA LOTRULUI	24.29	45.36	Olt	**153**	GRADINARI	25.78	44.37	Ilfovat
112	IONESTI	24.25	44.85	Olt	**154**	GURBANESTI	26.28	44.41	Mostistea
113	IPOTESTI	24.40	44.26	Olt	**155**	IEZER	27.28	44.23	Mostistea
114	IZBICENI	24.70	43.81	Olt	**156**	LACU MORII	26.04	44.45	Dambovita
115	RACOVITA	24.40	44.26	Olt	**157**	MANECIU	25.99	45.33	Teleajen
116	RM VALCEA	24.37	45.10	Olt	**158**	MARACINENI	24.89	44.90	Doamnei
117	RAURENI	24.38	45.12	Olt	**159**	MARIUTA	26.92	44.22	Mostistea
118	ROBESTI	24.30	45.49	Olt	**160**	MIHAILESTI	25.94	44.32	Arges
119	RUSANESTI	24.63	43.92	Olt	**161**	MOROIENI	25.44	45.21	Ialomita
120	SLATINA	24.35	44.39	Olt	**162**	OGREZENI	25.78	44.43	Arges
121	STREJESTI	24.32	44.53	Olt	**163**	PALTINU	25.75	45.19	Doftana
122	VOILA	24.80	45.83	Olt	**164**	PITESTI	24.90	44.84	Arges
123	ZAVIDENI	24.28	44.77	Olt	**165**	PUCIOASA	25.43	45.08	Ialomita
124	ARPASU	24.59	45.79	Olt	**166**	SACELE	25.77	45.58	Tarlung
125	BACIU	24.83	45.43	Doamnei	**167**	SCROPOASA	25.42	45.31	Ialomita
126	CERBURENI	24.65	45.22	Arges	**168**	VACARESTI	25.49	44.82	Dambovita
127	CORNETU	24.29	45.40	Cornet	**169**	VALCELE	24.74	44.98	Arges
128	CUMPANITA	24.58	45.47	Cumpana	**170**	ZAVOIU ORBULUI	25.38	44.66	Arges

Dam ID	Dam name	Long	Lat	River	Dam ID	Dam name	Long	Lat	River
171	ABRAMUT-CREST	22.23	47.36	V Fancica	**201**	NEMSA	24.42	46.09	Mojna
172	BACIA	23.02	45.79	Strei	**202**	POIANA RUSCA	22.41	45.16	Paraul Rece
173	BALEIA	23.27	45.34	Baleia	**203**	POLDER VARADIA	21.52	45.06	Caras
174	BRETEA	23.01	45.65	Strei	**204**	PONEASCA	21.95	45.02	Poneasca
175	BUTIN	21.38	45.34	Moravita	**205**	RASCA MICA	23.29	46.68	Somes
176	CADAR DUBOZ	21.55	45.53	Poganis	**206**	RASTOLITA	24.98	46.97	Rastolita
177	CALINESTI	23.28	47.90	Tur	**207**	REDIU	23.68	46.67	Martinesti
178	CARACAL	24.33	44.12	Gologan	**208**	ROVINARI	23.32	44.81	Jiu
181	CHIER	21.87	46.34	Dulita	**209**	RUNCU	23.62	47.72	Mara
182	CIRESU	26.26	45.64	Basca Mare	**210**	SADU GORJ	23.42	45.21	Sadu
183	CIUTELEC	22.39	47.26	Valea Bistra	**211**	SADU II	24.10	45.64	Sadu
184	CORNEREVA	22.39	45.02	Belareca	**212**	SADU V	23.93	45.60	Sadu
185	CRANGENI	24.74	44.03	Calmatuiu Sec	**213**	SALATIG	23.13	47.37	Mineu
186	CUGIR	23.44	45.80	Cugirul Mare	**214**	SATCHINEZ	21.03	45.96	V Sicso
187	DOBRESTI ORADEA	22.31	46.86	Vida	**215**	SATIC SPERIATA	25.17	45.44	Dambovita
188	FANEATA VACILOR	23.76	46.60	Faneata Vacilor	**216**	SECUIEU	22.90	46.77	Secuieu
189	FENES	23.30	46.10	Ampoi	**217**	SIMERIA	23.04	45.82	Strei
190	G GOLUMB	21.92	45.01	V Minisului	**218**	STREI	23.02	45.74	Strei
191	ISALNITA	23.69	44.40	Jiu	**219**	TISMANA	22.95	45.04	Tismana
192	IZVORIN	21.44	45.78	Slatina	**220**	TOMEASA	22.72	45.34	Raul Ses
193	JIDOAIA	23.99	45.50	Jidoaia	**221**	TOPOLOVAT	21.63	45.78	V Mociur
194	LISOVA	21.60	45.11	Lisava	**222**	TR.MAGURELE	24.85	43.71	Dunarea
195	MANASTIUR	20.38	46.12	Apa Mare	**223**	VAJA	22.99	45.17	Bistrita
196	MESTEACANUL	25.79	46.68	Olt	**224**	V IOVAN	22.73	45.16	Cerna
197	MIHAILENI	22.88	46.17	Crisul Alb	**225**	VANATORI	24.88	46.25	Tarnava
198	MIHOESTI	23.02	46.37	Aries	**226**	VLADESTI	24.31	45.12	Olanesti
199	MOTRU	22.81	45.12	Motru	**227**	ZERVESTI	22.30	45.40	Sebes
200	MURANI	21.33	45.93	Magherus					

Source: Authors' elaboration

3.1. Risk related to structure

For the 227 dams, besides the exact determination of the geographical coordinates, information about construction features required in calculating seismic risk was also determined: year of commissioning (PIF in Table 6 from section 3.3), type of dam, dam height (in meters), and volume of the lake in hm^3 (millions of m^3) (Table 6). Using this information, the risk factors due to age (ARF), height (HRF), and lake capacity (CRF) are also presented in Table 6. The risk factors ARF and HRF and CRF for all 227 dams from Table 6 are mapped in Figure 6 and Figure 7.

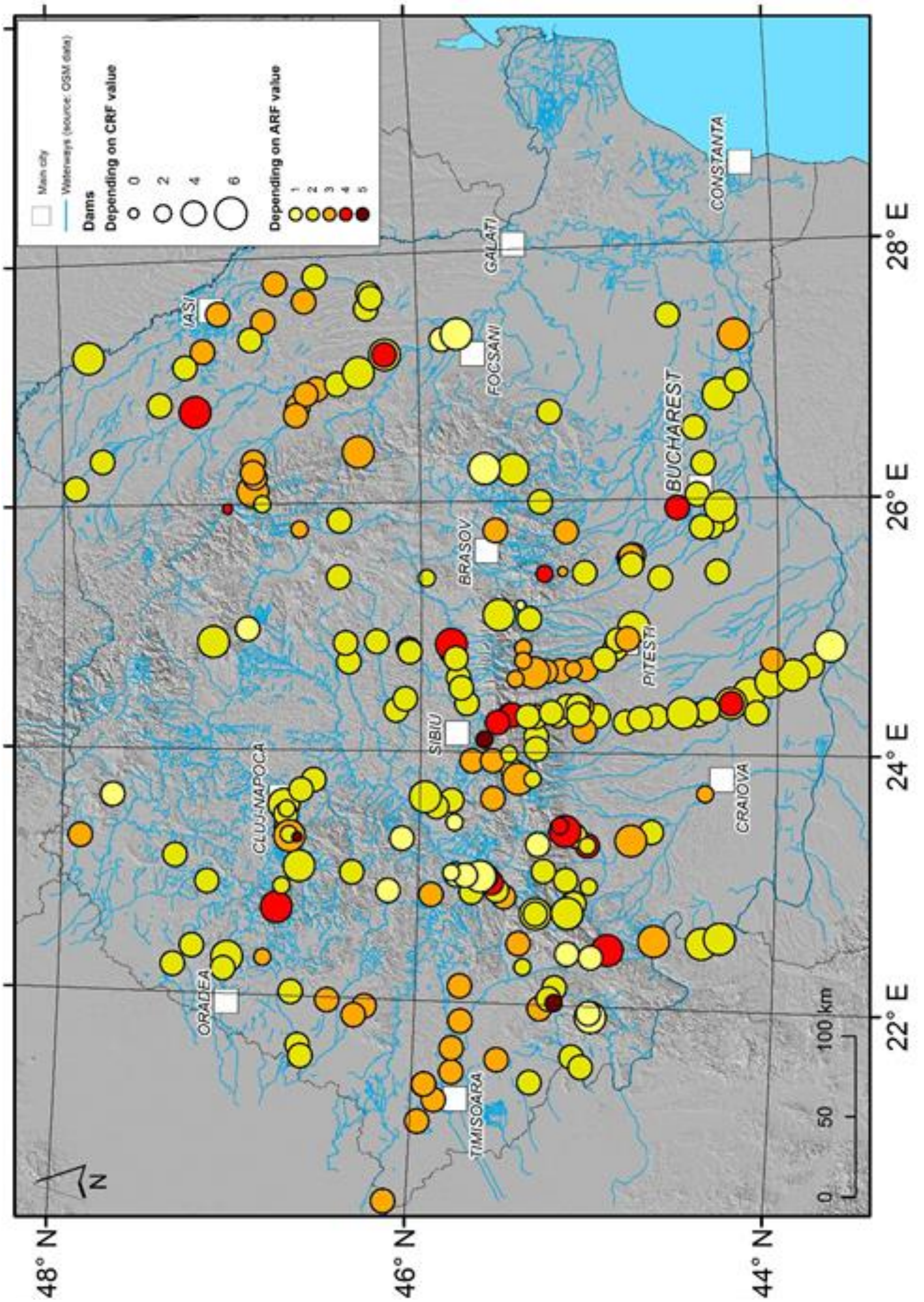

Figure 6. Dam characterization according to age risk factor (ARF) and capacity risk factor (CRF)
Source: Authors' elaboration

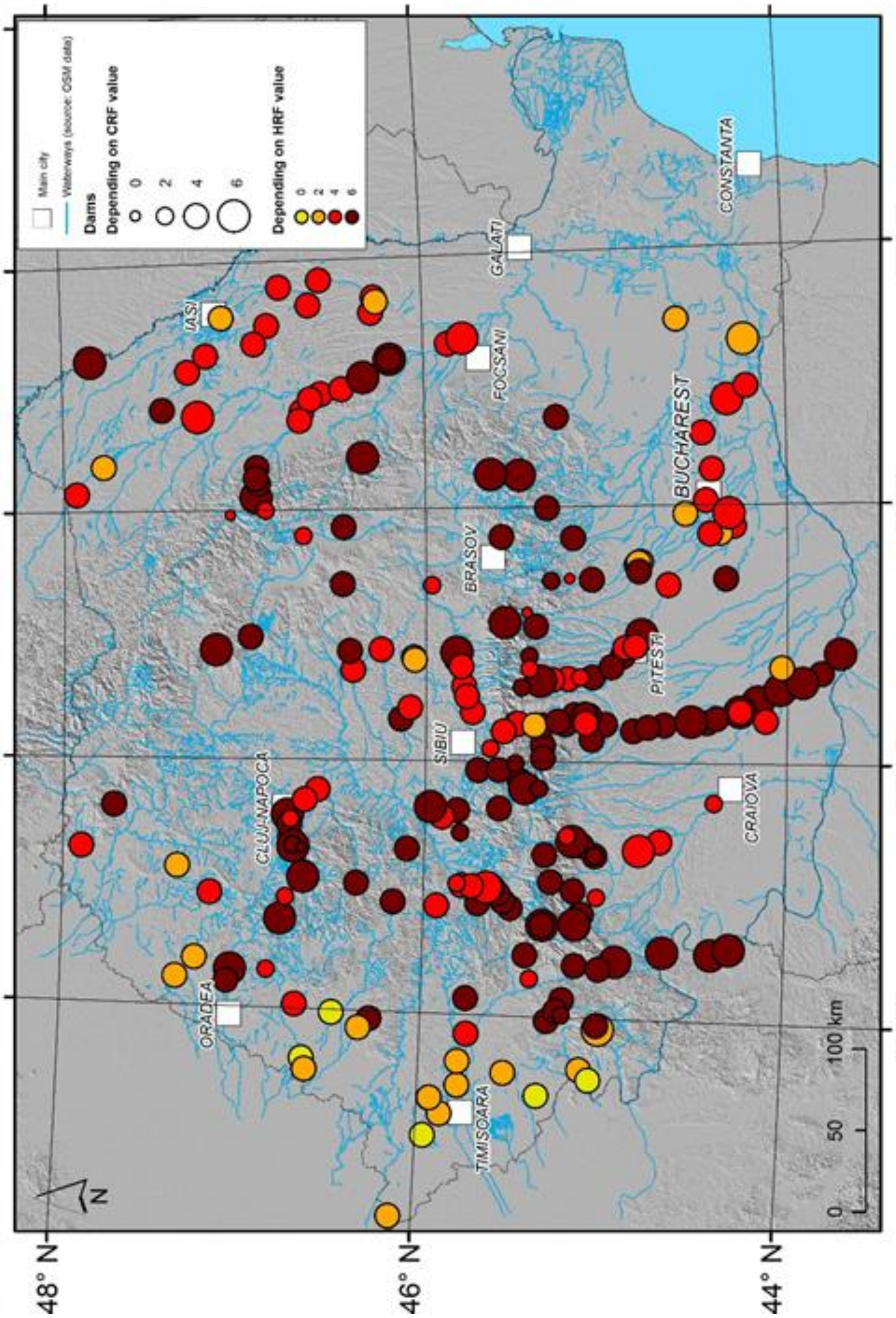

Figure 7. Dam characterization according to height risk factor (HRF) and capacity risk factor (CRF)
Source: Authors' elaboration

From Figure 7 and Table 1, one can observe that all dams with height larger than 24 m are included in an extreme HRF, and they represent 55% of dams from the total number of 227.

3.2. The downstream risk (DHF)

The risk factor of the downstream water accumulations, takes into account the dam location, the villages located downstream, the distance and the height difference between them, the number of inhabitants which should be evacuated, and the existing infrastructure (hydro-energetic plants, roads, highways, gas stations, railroad stations, and widely populated and visited tourist attractions).

In order to calculate the downstream risk factor, different scenarios were realized regarding flooding areas downstream from dams. For some of these scenarios (for Poiana Uzului and Izvorul Muntelui Dams), 1D flood modelling was performed, using the well-known Hec-Ras and GeoHecRas solutions (US Army Corps of Engineers, 2014); the digital elevation model (DEM) was obtained from Aster GDEM Data at 1 arc-second resolution, allowing a rough estimation of the flood area extent. Various scenarios regarding dam failure (through pipping) were considered (using the Froehlich, 2008 method) and the worst case plausible scenarios lead to the determination of risk areas – where houses and people could be affected.

For other dams, the downstream risk was calculated more empirically, by overlaying and spatially analyzing in GIS various datasets. The localities in the downstream vicinity of the studied dams and the number of inhabitants were identified, and information regarding the value of downstream properties was obtained. The transposition of this information into risk factors was done in Table 6 as well. The information related to downstream towns was retrieved from city halls internet sites and from Wikipedia.

3.3. Seismic Vulnerability Rating – the predicted damage factor (PDF)

Dam vulnerability curves, [curves developed by the Bureau & Ballentine (2002) using dams seismic performance observed during earthquakes] can be used to calculate the predicted damage index (PDI). PDI depends on the type of dams, seismic hazard, and tectonic environment.

Expected maximum amplitude of soil movement in dam sites is expressed through earthquake severity index (ESI), which gives us (in order to evaluate the dam) a robust estimation of the severity of possible movement in site (Bureau, 2003).

Table 6. Dam structure and downstream risk factors (where Year is the year of commissioning, height is the dam height in meters, capacity is the lake volume in hmc; ARF, HRF, CRF, and DHF are risk factors)

Dam ID	**Year**	**ARF**	**H m**	**HRF**	**V hmc**	**CRF**	**DHF**	**SF**	**Dam ID**	**Year**	**ARF**	**H m**	**HRF**	**V hmc**	**CRF**	**DHF**	**SF**
1	1985	2	29	6	120.0	6	24	38	**39**	2010	4	20	4	0.1	0	20	28
2	1989	2	26	6	4.5	4	16	28	**40**	1965	3	27	6	5.6	4	20	33
3	1975	3	15	4	21.1	4	24	35	**41**	1993	2	48	6	44.0	4	20	32
4	2016	1	20	4	17.0	4	16	25	**42**	1994	2	9	2	7.7	4	20	28
5	1979	2	17	4	54.0	4	16	26	**43**	1992	2	29	6	31.0	4	16	28
6	1964	3	9	2	4.3	4	16	25	**44**	1988	2	8	2	7.2	4	20	28
7	1978	2	14	4	40.9	4	16	26	**45**	1991	2	92	6	90.0	6	20	34
8	2011	1	22	4	63.6	6	16	27	**46**	1969	3	18	4	2.5	4	24	35
9	1985	2	25	6	9.4	4	16	28	**47**	1987	2	120	6	112	6	20	34
10	2010	4	17	4	68.7	6	24	38	**48**	1978	2	92	6	225	6	20	34
11	1964	3	14	4	33.0	4	16	27	**49**	1986	2	16	4	1.0	2	20	28
12	1973	3	16	4	14.9	4	16	27	**50**	1971	3	23	4	4.2	4	20	31
13	1985	2	18	4	24.8	4	24	34	**51**	1978	2	36	6	13.4	4	16	28
14	1994	2	122	6	155.0	6	16	30	**52**	1989	2	29	6	65.4	6	16	30
15	1974	3	14	4	47.0	4	24	35	**53**	1979	2	91	6	136	6	20	34
16	1977	2	14	4	30.3	4	16	26	**54**	1983	2	34	6	7.0	4	20	32
17	1987	2	20	4	25.0	4	16	26	**55**	1977	2	43	6	0.8	2	20	30
18	1977	2	11	2	6.0	4	16	24	**56**	1964	3	52	6	16.6	4	20	33
19	1966	3	18	4	4.0	4	24	35	**57**	1990	2	5	0	22.1	4	16	22
20	1983	2	19	4	24.0	4	20	30	**58**	1974	3	97	6	74.0	6	20	35
21	1977	2	12	2	25.0	4	20	28	**59**	1988	2	37	6	52.9	4	16	28
22	1992	2	23	4	44.3	4	20	30	**60**	1990	2	6	2	23.4	4	16	24
23	2010	4	56	6	3.3	4	20	34	**61**	1978	2	42	6	0.7	2	20	30
24	1986	2	38	6	10.6	4	20	32	**62**	1980	2	110	6	124	6	20	34
25	1983	2	24	4	39.6	4	20	30	**63**	1979	2	110	6	124	6	20	34
26	1965	3	19	4	5.1	4	20	31	**64**	1964	3	48	6	43.0	4	20	33
27	1961	3	127	6	1230	6	24	39	**65**	1988	2	18	4	1.1	2	20	28
28	1965	3	19	4	7.4	4	20	31	**66**	1974	3	59	6	2.4	4	20	33
29	1986	2	42	6	3.5	4	20	32	**67**	1953	3	47	6	10.1	4	20	33
30	1965	3	28	6	6.0	4	20	33	**68**	2010	4	168	6	210	6	20	36
31	1983	2	22	4	13.0	4	20	30	**69**	1980	2	74	6	17.5	4	20	32
32	1963	3	27	6	10.0	4	24	37	**70**	1989	2	32	6	12.5	4	20	32
33	1973	3	82	6	90.0	6	20	35	**71**	1986	2	58	6	15.8	4	24	36
34	1984	2	29	6	103.7	6	20	34	**72**	1971	3	10	2	5.9	4	20	29
35	1965	3	20	4	8.7	4	20	31	**73**	1973	3	61	6	28.0	4	20	33
36	1987	2	15	4	55.8	4	20	30	**74**	1960	3	62	6	6.3	4	20	38
37	1978	2	43	6	1290	6	20	34	**75**	1986	2	32	6	8.6	4	20	28
38	1980	2	20	4	0.3	2	16	24	**76**	1988	2	32	6	7.9	4	20	35

Dam ID	Year	ARF	H m	HRF	V hmc	CRF	DHF	SF	Dam ID	Year	ARF	H m	HRF	V hmc	CRF	DHF	SF
77	1977	2	50	6	2.5	4	20	25	**118**	2010	4	23	4	6.8	4	20	32
78	1973	3	10	2	13.3	4	20	26	**119**	1990	2	29	6	78.0	6	20	34
79	2010	4	125	6	96.0	6	20	25	**120**	1980	2	26	6	19.2	4	20	32
80	1963	3	41	6	15.1	4	20	26	**121**	1978	2	33	6	225	6	20	34
81	2010	4	27	6	5.7	4	20	27	**122**	1988	2	21	4	12.3	4	20	30
82	1976	2	36	6	50.0	4	20	28	**123**	1979	2	30	6	50.0	4	20	32
83	1984	2	78	6	21.0	4	20	38	**124**	1990	2	20	4	7.4	4	20	30
84	1970	3	21	4	32.8	4	20	31	**125**	1966	3	34	6	0.7	2	5	16
85	1969	3	31	6	4.8	4	12	25	**126**	1968	3	18	4	1.7	4	20	31
86	1972	3	56	6	5.3	4	20	33	**127**	1980	2	12	2	3.9	4	20	28
87	1910	5	27	6	1.0	2	20	33	**128**	1968	3	33	6	0.3	2	5	16
88	1979	2	17	4	50.2	4	20	30	**129**	1970	3	19	4	1.1	2	24	33
89	1981	2	62	6	39.0	4	20	32	**130**	2010	4	32	6	375	6	20	36
90	2010	4	25	6	2.9	4	20	34	**131**	2010	4	23	4	53.0	4	12	24
91	1984	2	30	6	600	6	20	34	**132**	1967	3	20	4	1.8	4	20	31
92	1977	2	31	6	3.4	4	20	32	**133**	1984	2	105	6	69.0	6	5	19
93	1971	3	60	6	2100	6	24	39	**134**	1987	2	120	6	60.0	4	12	24
94	1984	2	35	6	600	6	24	38	**135**	1992	2	22	4	5.2	4	16	26
95	1996	2	25	6	0.9	2	24	34	**136**	1982	2	44	6	13.0	4	24	36
96	1989	2	24	4	9.0	4	20	30	**137**	1966	3	24	4	0.2	2	16	25
97	2010	4	25	6	2.9	4	20	34	**138**	1965	3	166	6	465	6	24	39
98	1989	2	25	6	4.8	4	20	32	**139**	1989	2	20	4	4.3	4	16	26
99	2010	4	51	6	305	6	20	36	**140**	1973	3	29	6	13.3	4	24	37
100	1973	3	121	6	340	6	20	35	**141**	1979	2	12	2	4.8	4	20	28
101	1980	2	31	6	43.4	4	20	32	**142**	1970	3	21	4	5.3	4	24	35
102	1996	2	23	4	10.8	4	20	30	**143**	1985	2	55	6	18.0	4	20	32
103	1978	2	33	6	59.7	4	20	32	**144**	1976	2	11	2	4.6	4	20	28
104	2010	4	23	4	5.3	4	20	32	**145**	1978	2	33	6	54.9	4	24	36
105	1981	2	29	6	4.6	4	24	36	**146**	1936	4	9	2	13.1	4	24	34
106	1976	2	29	6	11.2	4	20	32	**147**	1973	3	10	2	4.4	4	20	29
107	1988	2	34	6	76.0	6	24	38	**148**	1983	2	13	4	10.4	4	20	30
108	1980	2	32	6	40.0	4	24	36	**149**	1983	2	22	4	142	6	20	32
109	1989	2	30	6	96.0	6	20	34	**150**	1996	2	22	4	55.0	4	24	34
110	1975	3	26	6	18.5	4	24	37	**151**	1976	2	12	2	23.5	4	20	28
111	1986	2	26	6	5.4	4	24	36	**152**	1983	2	32	6	78.5	6	24	38
112	1978	2	34	6	24.9	4	20	32	**153**	1982	2	12	2	14.2	4	24	32
113	1986	2	31	6	110	6	20	34	**154**	1985	2	20	4	55.8	4	20	30
114	1996	2	29	6	7.4	4	20	32	**155**	1975	3	11	2	267	6	20	31
115	2010	4	23	4	26.7	4	20	32	**156**	1987	2	15	4	19.4	4	24	34
116	1974	3	34	6	19.0	4	24	37	**157**	1994	2	75	6	60.0	4	20	32
117	1977	2	29	6	7.3	4	20	32	**158**	1982	2	20	4	38.5	4	20	30

Dam ID	Year	ARF	H m	HRF	V hmc	CRF	DHF	SF	Dam ID	Year	ARF	H m	HRF	V hmc	CRF	DHF	SF
159	1998	2	18	4	19.0	4	20	30	**199**	1982	2	48	6	4.8	4	18	30
160	1987	2	18	4	76.3	6	24	36	**200**	1971	3	8	2	6.2	4	12	21
161	1954	3	16	4	0.0	0	20	27	**201**	1981	2	21	4	7.9	4	18	28
162	1997	2	13	4	7.6	4	20	30	**202**	2006	1	75	6	35	4	18	29
163	1971	3	108	6	53.7	4	20	33	**203**	1984	2	6	0	3.4	4	16	22
164	1971	3	21	4	4.8	4	24	35	**204**	2013	1	52	6	8.3	4	2	13
165	1976	2	31	6	8.0	4	24	36	**205**	1909	5	26	6	1.0	2	2	15
166	1975	3	45	6	18.3	4	24	37	**206**	2014	1	105	6	43	4	18	29
167	1930	4	27	6	0.6	2	20	32	**207**	1985	2	16	4	2.5	4	18	28
168	1989	2	26	6	54.1	4	20	32	**208**	1968	3	15	4	148	6	16	29
169	1976	2	35	6	54.8	4	20	32	**209**	2000	1	90	6	26	4	16	27
170	1988	2	20	4	16.1	4	20	30	**210**	1942	4	17	4	0.3	2	22	32
171	1976	2	7	2	3.6	4	12	20	**211**	1905	5	18	4	0.2	2	18	29
172	2005	1	15	4	1.5	4	12	21	**212**	1956	3	62	6	6.3	4	2	15
173	2014	1	67	6	1.7	4	22	33	**213**	1982	2	11	2	3.4	4	12	20
174	2005	1	20	4	110	6	18	29	**214**	1973	3	6	0	4.4	4	18	25
175	1981	2	6	0	11.4	4	16	22	**215**	2003	1	19	4	0.1	0	12	17
176	1975	3	10	2	41.4	4	16	25	**216**	1982	2	21	4	0.6	2	18	26
177	1974	3	16	4	29	4	18	29	**217**	2005	1	20	4	1	2	12	19
178	1981	2	13	4	7.2	4	22	32	**218**	2010	1	16	4	1.8	4	12	21
179	1972	3	6	0	20	4	2	9	**219**	1984	2	21	4	0.8	2	18	26
180	1981	2	15	4	1.8	4	16	26	**220**	1986	2	31	6	2.4	4	8	20
181	1974	3	10	2	10.1	4	18	27	**221**	1975	3	10	2	4.2	4	18	27
182	2015	1	63	6	191	6	2	15	**222**	2014	1	27	6	4400	6	22	35
183	1984	2	8	2	4.2	4	16	24	**223**	1987	2	93	6	29.4	4	12	24
184	2013	1	62	6	13.8	4	12	23	**224**	1979	2	118	6	124	6	12	26
185	1975	3	11	2	11.9	4	12	21	**225**	1984	2	22	4	25	4	16	26
186	2003	1	48	6	1	2	22	31	**226**	1983	2	19	4	1.5	4	16	26
187	1969	3	15	4	0.4	2	16	25	**227**	1998	2	15	4	1.2	2	22	30
188	1983	2	20	4	8.5	4	22	32	**217**	2005	1	20	4	4.8	2	12	19
189	2000	1	40	6	6.5	4	18	29	**218**	2010	1	16	4	6.2	4	12	21
190	2013	1	13	2	350	6	8	17	**219**	1984	2	21	4	7.9	2	18	26
191	1965	3	18	4	0.2	2	18	27	**220**	1986	2	31	6	35	4	8	20
192	1973	3	8	2	6.6	4	18	27	**221**	1975	3	10	2	3.4	4	18	27
193	1977	2	50	6	0.4	2	2	12	**222**	2014	1	27	6	8.3	6	22	35
194	1985	2	9	2	9.5	4	18	26	**223**	1987	2	93	6	43	4	12	24
195	1973	3	7	2	10.2	4	12	21	**224**	1979	2	118	6	2.5	6	12	26
196	1966	3	19	4	0.9	2	18	27	**225**	1984	2	22	4	148	4	16	26
197	2011	1	34	6	10.3	4	12	23	**226**	1983	2	19	4	26	4	16	26
198	1987	2	29	6	6.3	4	12	24	**227**	1998	2	15	4	0.3	2	22	30

Source: Authors' elaboration based on RRMB data

3.3.1. Expected ground motion values in dams' sites

The expected ground motion parameters were computed using the machine code EQRISK (McGuire, 1976) improved by Leydecker et al. (2008), a code usually used for probabilistic hazard assessment in Romania (Moldovan, 2007; Moldovan et al., 2008; Moldovan et al., 2012; Moldovan et al., 2016b).

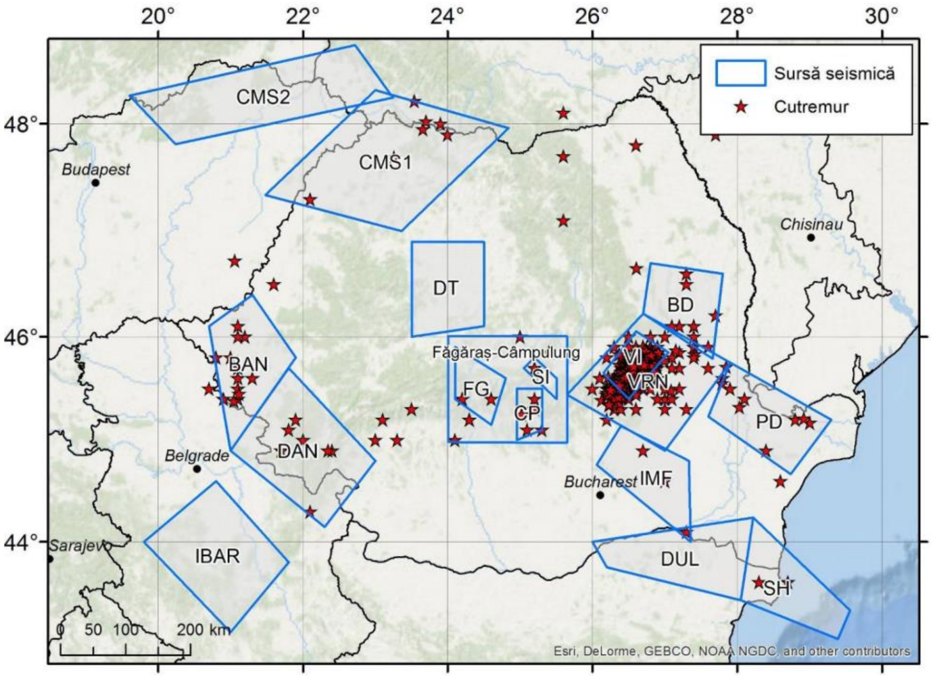

Figure 8. Seismic zoning: seismicity was represented only for earthquakes with Mw>3.5 for the period 2000-2016.
Source: Authors' elaboration

Figure 8 shows the geographical characteristics of all seismic sources used for probabilistic evaluation of hazard (Leydecker et al., 2008; Moldovan et al., 2016a).

The authors estimated seismic hazard values (with the input parameters as defined in Table 7 for 16 seismic sources which likely affect the Romanian dam sites) for different return periods (Tr = 1, 50, 100, 475, and 1000 years) and also the expected Modified Mercalli Intensity (MMI) values for the same time intervals in the sites of dams from Table 5.

The macroseismic intensity values that are expected to be observed for a return period of Tr = 1000 years, due to normal and intermediate depth earthquakes are represented in Figures 9 and 10.

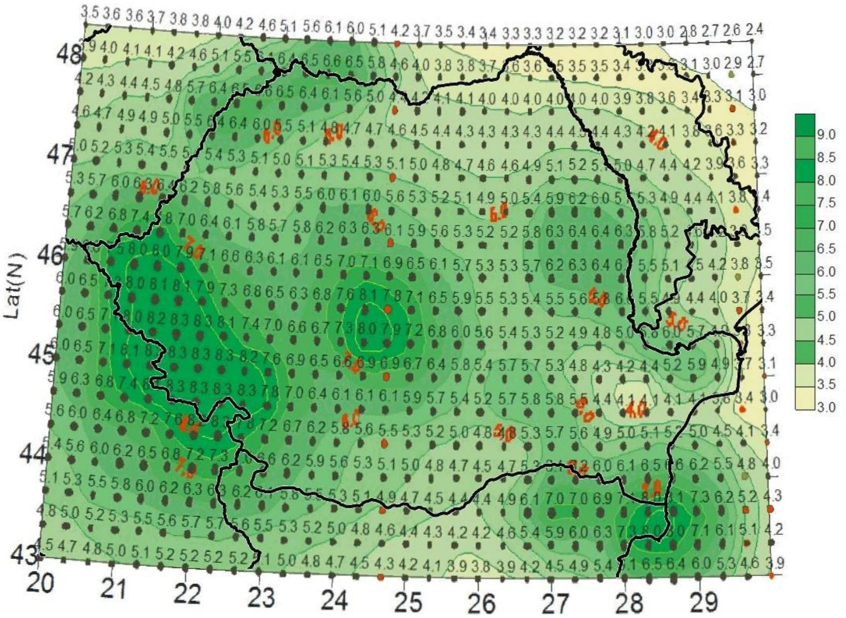

Figure 9. Seismic hazard map in terms of macroseismic intensity, using only normal depth sources (h<60 km depths) from Table 7 for Tr = 1000 years
Source: Moldovan et al., 2008

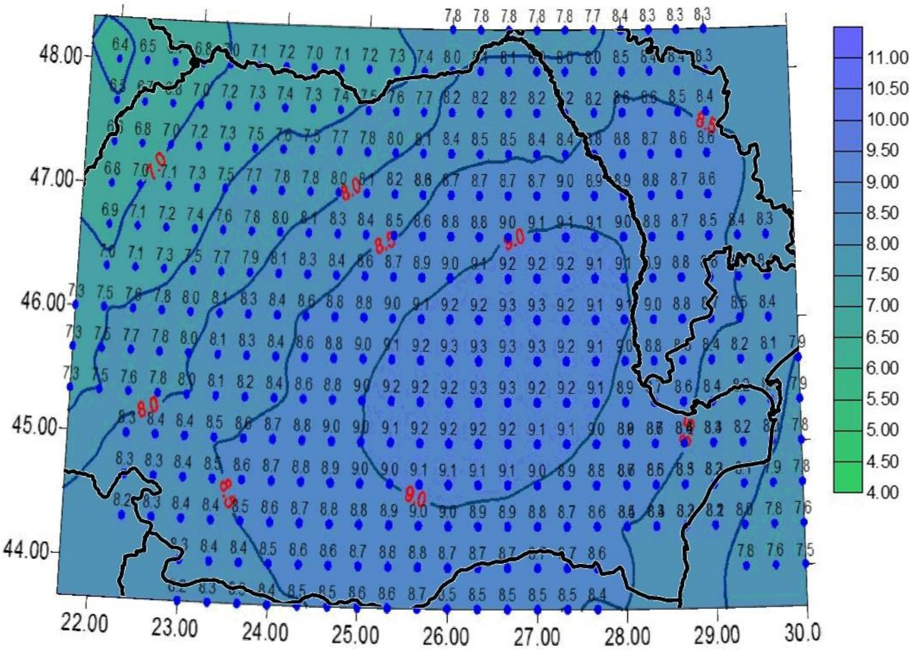

Figure 10. Seismic hazard map in terms of macroseismic intensity for Tr = 1000 years, using only Vrancea intermediate depth seismic source
Source: Authors' elaboration

The conversion between intensity (*I*) and peak ground acceleration (*PGA*) is given for Vrancea intermediate earthquakes by Sørensen et al., 2008:

I = 4.48 log (PGA) + 6.55 where PGA is expressed in m / s^2. (5)

Table 7. The statistical parameters used for the probabilistic evaluation of regional and local seismic hazard

Sources		h (km)	M min	M max	b	I min	I max	bi	β i= bln10	Seismic activity rate
VI		130	5.0	7.7	0.85	4.0	10	0.48	1.12183	1.762380
VRN		30	3.0	5.9	0.95	2.5	7.0	0.6	1.38155	0.514526
BD		10	2.5	5.5	0.75	2.0	6.5	0.49	1.12826	1.534712
PD		10	3.0	5.5	0.81	3.0	6.5	0.53	1.22405	0.360254
IMF		15	3.0	5.4	0.46	3.0	6.5	0.3	0.69077	0.034600
BG	DUL	15	3.0	7.2	0.46	3.0	9.0	0.3	0.69077	0.028000
	SH	16.4	3.0	7.2	0.32	2.5	9.0	0.21	0.48354	0.165137
CMP	FG	15	4.0	6.5	0.76	5.0	8.5	0.50	1.15325	0.247403
	CP	15	4.0	5.0	0.66	5.0	6.0	0.44	1.01820	0.0865384
	SI	15	4.0	4.9	0.65	4.5	6.0	0.43	0.98781	0.076923
DT		10	4.0	6.5	0.89	5.0	7.0	0.59	1.36774	0.010254
CM	CMS1	15	4.0	6.5	0.56	4.5	8.0	0.56	1.29815	0.3762
	CMS2	15	4.0	6.5	0.46	5.0	8.0	0.46	1.06699	0.1027
BA	DAN	15	4.0	5.6	0.71	5.5	8.0	0.43	0.98091	0.276700
	BAN	10	4.0	5.6	0.82	5.5	8.0	0.50	1.16056	0.128800
IBAR		14	3.7	6.6	0.87	4.5	9.0	0.54	1.24340	0.556203

Source: Authors' elaboration

3.3.2. Estimation of risk factors due to the seismic ground motion

The first step is to compute the ESI index from equation (4): ESI = $PGA \times (M_w - 4.5)^3$. The seismic ground motion acceleration values were computed for a recurrence period of 475 years which corresponds to a exceeding probability of 10% in 50 years or of 0.2% in a year, and for 1000 years. The expected peak ground acceleration (PGA) for 1000 years return period are presented in Table 8. The maximum possible accelerations (for Tr = 1000 years) in 227 dam sites in Romania are also presented in Figure 11.

Mw was chosen to be 7.7 degrees, a magnitude corresponding to the largest earthquake in Vrancea (intermediate depth zone). It was concluded that Vrancea intermediate earthquakes has the most important contribution to the seismic hazard for most of the 227 studied dams.

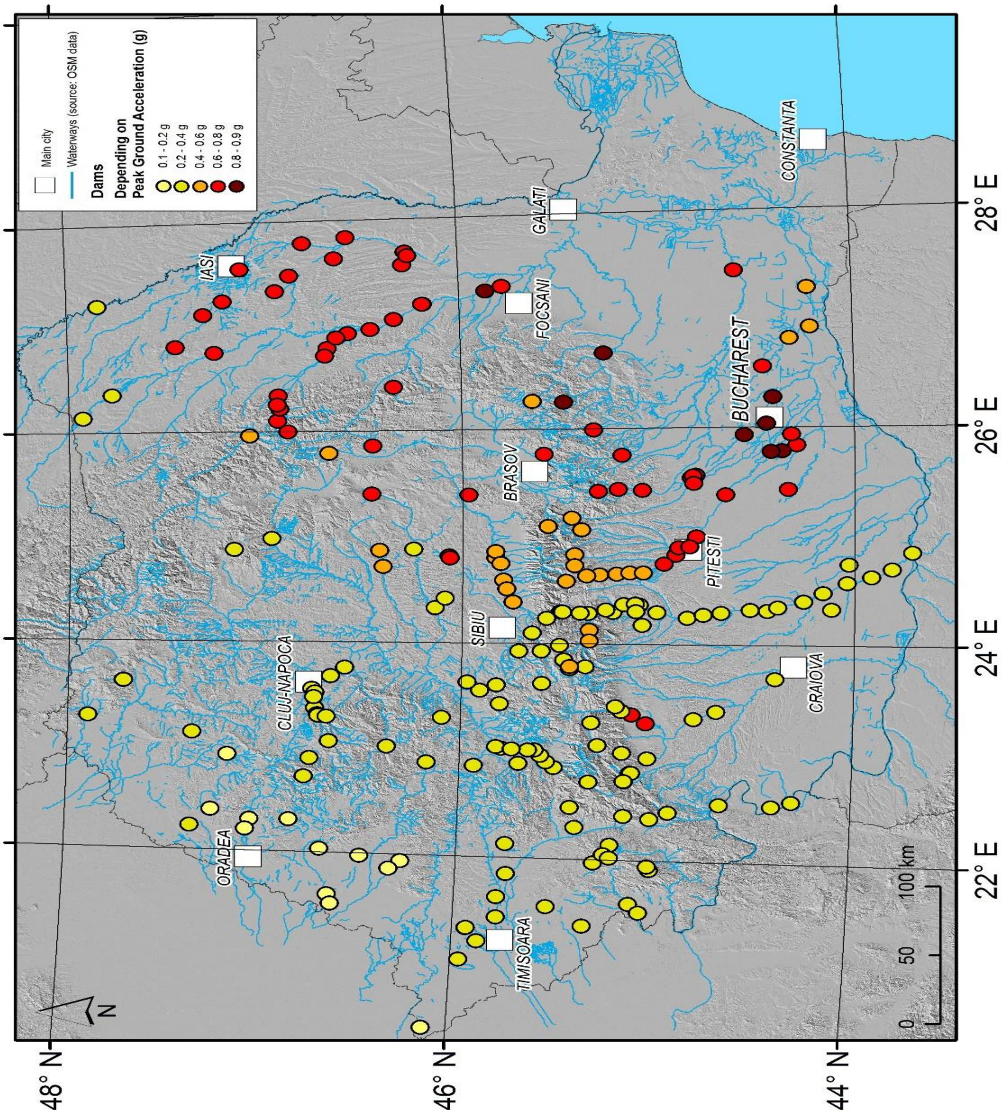

Figure 11. Maximum possible accelerations (Tr=1000 years) in sites for 227 large dams in Romania
Source: Authors' elaboration

Considering the type of dam from Table 8, the PDI indices were found from the graphs in Figure 3.

Table 8. The type of studied dams

ID	Type	ID	Type	ID	Type	ID	Type	ID	Type	ID	Type
1	PG/TE	39	PG/TE	77	VA	115	PG/TE	153	TE	191	PG/TE
2	PG/TE	40	PG/TE	78	TE	116	PG/TE	154	TE	192	TE
3	TE	41	TE	79	ER	117	PG/TE	155	TE	193	VA
4	PG/TE	42	TE	80	CB	118	PG/TE	156	PG/TE	194	TE
5	TE	43	TE	81	PG/TE	119	PG/TE	157	TE	195	TE
6	TE	44	TE	82	ER	120	PG/TE	158	PG/TE	196	ER
7	TE	45	ER	83	VA	121	PG/TE	159	TE	197	PG/TE
8	PG/TE	46	PG/TE	84	TE	122	PG/TE	160	VA	198	TE
9	TE	47	VA	85	ER	123	PG/TE	161	PG	199	TE
10	BM/TE	48	ER	86	ER	124	PG/TE	162	PG/TE	200	TE
11	TE	49	PG/TE	87	PG	125	VA	163	VA	201	TE
12	TE	50	PG/TE	88	TE	126	PG/TE	164	PG/TE	202	VA
13	TE	51	TE	89	VA	127	TE	165	PG/TE	203	TE
14	ER	52	PG/TE	90	PG/TE	128	VA	166	TE	204	ER
15	TE	53	ER	91	PG/TE	129	PG/TE	167	PG	205	PG
16	TE	54	PG	92	PG/TE	130	PG/TE	168	BM/TE	206	ER
17	TE	55	VA	93	PG/TE	131	PG/TE	169	PG/TE	207	TE
18	TE	56	CB	94	PG/TE	132	PG/TE	170	PG/TE	208	TE
19	PG/TE	57	PG/TE	95	PG/TE	133	ER	171	TE	209	ER
20	PG/TE	58	VA	96	PG/TE	134	ER	172	PG/TE	210	ER
21	BM/TE	59	PG/TE	97	PG/TE	135	PG/TE	173	VA	211	PG
22	PG/TE	60	PG/TE	98	PG/TE	136	PG/TE	174	PG/TE	212	VA
23	VA	61	VA	99	TE	137	VA	175	TE	213	TE
24	TE	62	ER	100	ER	138	VA	176	TE	214	TE
25	PG/TE	63	ER	101	PG/TE	139	PG/TE	177	TE	215	PG/TE
26	PG/TE	64	VA	102	PG/TE	140	PG/TE	178	TE	216	PG
27	PG	65	TE	103	PG/TE	141	TE	179	TE	217	PG/TE
28	PG/TE	66	VA	104	PG/TE	142	PG/TE	180	TE	218	
29	VA	67	ER	105	PG/TE	143	ER	181	TE	219	PG/TE
30	PG/TE	68	ER	106	PG/TE	144	TE	182	ER	220	ER
31	PG/TE	69	CB	107	PG/TE	145	PG/TE	183	TE	221	TE
32	PG/TE	70	PG/TE	108	PG/TE	146	TE	184	ER	222	PG/TE
33	CB	71	VA	109	PG/TE	147	TE	185	TE	223	ER
34	PG/TE	72	TE	110	PG/TE	148	TE	186	VA	224	ER
35	PG/TE	73	ER	111	PG/TE	149	TE	187	TE	225	PG/TE
36	BM/TE	74	VA	112	PG/TE	150	TE	188	TE	226	PG/TE
37	PG/TE	75	PG/TE	113	PG/TE	151	TE	189	ER	227	TE
38	PG/TE	76	PG/TE	114	PG/TE	152	PG/TE	190	PG/CB		

Source: Authors' elaboration

Table 9. Expected maximum acceleration values (PGA in *g* units) in dam locations, for Tr = 1000 years, and the calculated values of ESI, PDI and PDF [see Equations (3) and (4) and Figure 4]. Dam risk classes.

Dam ID	PGA (g)	ESI	PDI	PDF	TRF	Risk	ID	PGA (g)	ESI	PDI	PDF	TRF	Risk
1	**0.821**	**26.90**	**2.56**	**6.400**	**243**	**III**	**36**	0.320	10.49	2.35	5.875	176	**III**
2	0.821	26.90	2.10	5.250	147	**III**	**37**	0.320	10.49	1.92	4.800	163	**III**
3	**0.730**	**23.92**	**2.45**	**6.125**	**214**	**III**	**38**	0.669	21.92	2.05	5.125	123	**II**
4	0.821	26.90	2.10	5.250	131	**III**	**39**	0.510	16.71	1.99	4.975	139	**III**
5	0.785	25.72	2.49	6.225	162	**III**	**40**	0.670	21.95	2.06	5.150	170	**III**
6	0.695	22.77	2.44	6.100	153	**III**	**41**	0.695	22.77	2.44	6.100	195	**III**
7	0.730	23.92	2.45	6.125	159	**III**	**42**	0.669	21.92	2.43	6.075	170	**III**
8	0.800	26.21	2.09	5.225	141	**III**	**43**	0.595	19.50	2.42	6.050	169	**III**
9	0.670	21.95	2.43	6.075	170	**III**	**44**	0.669	21.92	2.43	6.075	170	**III**
10	**0.695**	**22.77**	**2.45**	**6.125**	**233**	**III**	**45**	0.395	12.94	1.75	4.375	149	**III**
11	0.695	22.77	2.44	6.100	165	**III**	**46**	0.270	8.85	1.86	4.650	163	**III**
12	0.750	24.58	2.48	6.200	167	**III**	**47**	0.270	8.85	1.40	3.500	119	**II**
13	**0.785**	**25.72**	**2.49**	**6.225**	**212**	**III**	**48**	0.315	10.32	1.71	4.275	145	**III**
14	0.821	26.90	1.90	4.750	143	**III**	**49**	0.315	10.32	1.92	4.800	134	**III**
15	0.730	23.92	2.45	6.125	214	**III**	**50**	0.290	9.50	1.90	4.750	147	**III**
16	0.695	22.77	2.44	6.100	159	**III**	**51**	0.350	11.47	2.35	5.875	165	**III**
17	0.730	23.92	2.45	6.125	159	**III**	**52**	0.200	1.60	1.71	4.275	128	**III**
18	0.785	25.72	2.49	6.225	149	**III**	**53**	0.380	12.45	1.73	4.325	147	**III**
19	**0.785**	**25.72**	**2.55**	**6.375**	**223**	**III**	**54**	0.315	10.32	1.91	4.775	153	**III**
20	0.510	16.71	1.99	4.975	149	**III**	**55**	0.290	9.50	1.41	3.525	106	**II**
21	0.340	11.14	2.40	6.000	168	**III**	**56**	0.250	2.00	1.40	3.500	116	**II**
22	0.785	25.72	2.08	5.200	156	**III**	**57**	0.185	1.48	1.70	4.250	94	**II**
23	0.785	25.72	1.64	4.100	139	**III**	**58**	0.290	9.50	1.41	3.525	123	**II**
24	0.730	23.92	2.45	6.125	196	**III**	**59**	0.200	1.60	1.71	4.275	120	**II**
25	0.750	24.58	2.08	5.200	156	**III**	**60**	0.175	1.40	1.70	4.250	102	**II**
26	0.730	23.92	2.07	5.175	160	**III**	**61**	0.375	12.29	1.45	3.625	109	**II**
27	**0.669**	**21.92**	**2.1**	**5.25**	**205**	**III**	**62**	0.230	7.54	1.62	4.050	138	**III**
28	0.730	23.92	2.07	5.175	160	**III**	**63**	0.250	8.19	1.65	4.125	140	**III**
29	0.380	12.45	1.46	3.650	117	**II**	**64**	0.270	8.85	1.40	3.500	116	**II**
30	0.670	21.95	2.06	5.150	170	**III**	**65**	0.750	24.58	2.48	6.200	174	**III**
31	0.380	12.45	1.95	4.875	146	**III**	**66**	0.365	11.96	1.45	3.625	120	**II**
32	**0.670**	**21.95**	**2.5**	**6.25**	**231**	**III**	**67**	0.250	8.19	1.65	4.125	136	**III**
33	0.785	25.72	1.90	4.750	166	**III**	**68**	0.250	8.19	1.65	4.125	149	**III**
34	0.785	25.72	2.08	5.200	177	**III**	**69**	0.395	12.94	1.75	4.375	140	**III**
35	0.730	23.92	2.07	5.175	160	**III**	**70**	0.290	9.50	1.90	4.750	152	**III**

ID	PGA (g)	ESI	PDI	PDF	TRF	Risk	ID	PGA (g)	ESI	PDI	PDF	TRF	Risk
71	0.25	8.19	1.38	3.45	124	**II**	**110**	0.37	12.12	1.95	4.875	180	**III**
72	0.25	8.19	2.3	5.75	167	**III**	**111**	0.395	12.94	1.95	4.875	176	**III**
73	0.25	8.19	1.65	4.125	136	**III**	**112**	0.37	12.12	1.95	4.875	156	**III**
74	0.395	12.94	1.46	3.65	120	**II**	**113**	0.34	11.14	1.93	4.825	164	**III**
75	0.26	8.52	1.85	4.625	148	**III**	**114**	0.32	10.49	1.92	4.8	154	**III**
76	0.27	8.85	1.86	4.65	149	**III**	**115**	0.34	11.14	1.93	4.825	154	**III**
77	0.375	12.29	1.45	3.625	116	**II**	**116**	0.395	12.94	1.95	4.875	180	**III**
78	0.25	8.19	2.3	5.75	167	**III**	**117**	0.395	12.94	1.95	4.875	156	**III**
79	0.267	8.75	1.69	4.225	152	**III**	**118**	0.395	12.94	1.95	4.875	156	**III**
80	0.2	6.55	1.6	4	132	**III**	**119**	0.32	10.49	1.92	4.8	163	**III**
81	0.29	9.5	1.9	4.75	162	**III**	**120**	0.34	11.14	1.93	4.825	154	**III**
82	0.25	8.19	1.65	4.125	132	**III**	**121**	0.34	11.14	1.93	4.825	164	**III**
83	0.27	8.85	1.4	3.5	112	**II**	**122**	0.44	14.42	1.96	4.9	147	**III**
84	0.23	7.54	2.29	5.725	177	**III**	**123**	0.37	12.12	1.95	4.875	156	**III**
85	0.21	6.88	1.6	4	100	**II**	**124**	0.44	14.42	1.96	4.9	147	**III**
86	0.29	9.5	1.7	4.25	140	**III**	**125**	0.445	14.58	1.5	3.75	60	**II**
87	0.25	8.19	1.89	4.725	156	**III**	**126**	0.44	14.42	1.96	4.9	152	**III**
88	0.2	1.6	2	5	150	**III**	**127**	0.4	13.11	2.39	5.975	167	**III**
89	0.455	14.92	1.5	3.75	120	**II**	**128**	0.44	14.42	1.49	3.725	60	**II**
90	0.546	17.9	2	5	170	**III**	**129**	0.435	14.25	1.96	4.9	162	**III**
91	0.319	10.44	1.92	4.8	163	**III**	**130**	0.445	14.58	1.96	4.9	176	**III**
92	0.476	15.59	1.98	4.95	158	**III**	**131**	0.4	13.11	1.95	4.875	117	**II**
93	0.32	10.49	1.92	4.8	187	**III**	**132**	0.44	14.42	1.96	4.9	152	**III**
94	0.319	10.44	1.92	4.8	182	**III**	**133**	0.485	15.89	1.81	4.525	86	**II**
95	0.603	19.76	2.01	5.025	171	**III**	**134**	0.48	15.73	1.81	4.525	109	**II**
96	0.353	11.56	1.94	4.85	146	**III**	**135**	0.435	14.25	1.96	4.9	127	**III**
97	0.603	19.76	2.01	5.025	171	**III**	**136**	0.395	12.94	1.95	4.875	176	**III**
98	0.603	19.76	2.01	5.025	161	**III**	**137**	0.445	14.58	1.5	3.75	94	**II**
99	0.376	12.33	2.36	5.9	212	**III**	**138**	0.44	14.42	1.49	3.725	145	**III**
100	0.476	15.59	1.8	4.5	158	**III**	**139**	0.44	14.42	1.96	4.9	127	**III**
101	0.34	11.14	1.93	4.825	154	**III**	**140**	0.44	14.42	1.96	4.9	181	**III**
102	0.44	14.42	1.96	4.9	147	**III**	**141**	0.788	25.81	2.49	6.225	174	**III**
103	0.395	12.94	1.95	4.875	156	**III**	**142**	0.595	19.5	2.01	5.025	176	**III**
104	0.395	12.94	1.95	4.875	156	**III**	**143**	0.792	25.95	1.89	4.725	151	**III**
105	0.395	12.94	1.95	4.875	176	**III**	**144**	0.788	25.81	2.49	6.225	174	**III**
106	0.395	12.94	1.95	4.875	156	**III**	**145**	0.665	21.79	2.02	5.05	182	**III**
107	0.34	11.14	1.93	4.825	183	**III**	**146**	0.839	27.48	2.5	6.25	213	**III**
108	0.37	12.12	1.95	4.875	176	**III**	**147**	0.788	25.81	2.49	6.225	181	**III**
109	0.32	10.49	1.92	4.8	163	**III**	**148**	0.726	23.79	2.45	6.125	184	**III**

ID	PGA (g)	ESI	PDI	PDF	TRF	Risk	ID	PGA (g)	ESI	PDI	PDF	TRF	Risk
149	0.595	19.5	2.42	6.05	194	III	188	0.29	9.5	2.3	5.85	187	III
150	**0.713**	**23.36**	**2.45**	**6.125**	**208**	III	189	0.28	9.18	1.7	4.33	125	III
151	0.67	21.95	2.43	6.075	170	III	190	0.22	0.29	1.5	3.85	65	II
152	**0.792**	**25.95**	**2.55**	**6.375**	**242**	III	191	0.27	0.36	1.8	4.45	120	II
153	**0.893**	**29.26**	**2.59**	**6.475**	**207**	III	192	0.22	0.29	1.8	4.4	119	II
154	0.836	27.38	2.57	6.425	192	III	193	0.31	0.41	1	2.38	29	II
155	0.495	16.22	2.41	6.025	187	III	194	0.22	7.21	2.3	5.73	149	III
156	0.892	29.22	2.1	5.25	179	III	195	0.13	0.17	1.7	4.13	87	II
157	**0.8**	**26.21**	**2.56**	**6.4**	**205**	III	196	0.43	14.1	1.8	4.55	123	II
158	0.665	21.79	2.02	5.05	152	III	197	0.25	8.19	2.3	5.75	132	III
159	0.51	16.71	2.41	6.025	181	III	198	0.25	0.33	1.8	4.43	106	II
160	0.736	24.1	1.6	4	144	III	199	0.23	7.54	2.3	5.75	173	III
161	0.73	23.92	2.1	5.25	142	III	200	0.22	7.21	2.3	5.73	120	II
162	0.893	29.26	2.1	5.25	158	III	201	0.36	11.8	2.4	5.93	166	III
163	0.785	25.72	1.64	4.1	135	III	202	0.23	7.54	1.4	3.43	99	II
164	**0.792**	**25.95**	**2.55**	**6.375**	**223**	III	203	0.22	7.21	2.3	5.73	126	III
165	0.73	23.92	2.07	5.175	186	III	204	0.22	7.21	1.7	4.23	55	II
166	**0.8**	**26.21**	**2.49**	**6.225**	**230**	III	205	0.25	8.19	1.9	4.8	62	II
167	0.75	24.58	2.14	5.35	171	III	206	0.33	10.8	1.8	4.4	128	III
168	**0.788**	**25.81**	**2.5**	**6.25**	**200**	III	207	0.28	9.18	2.3	5.85	164	III
169	0.665	21.79	2.02	5.05	162	III	208	0.27	8.85	2.3	5.83	169	III
170	0.735	24.08	2.07	5.175	155	III	209	0.23	7.54	1.7	4.25	115	II
171	0.21	0.28	1.73	4.325	87	II	210	0.28	9.18	1.7	4.33	138	III
172	0.25	0.33	1.77	4.425	93	II	211	0.33	10.8	2	4.88	141	III
173	0.28	2.24	1.21	3.025	100	II	212	0.31	10.2	1.4	3.55	53	II
174	0.25	2	2.08	5.2	151	III	213	0.22	7.21	2.3	5.73	115	II
175	0.22	1.76	2.05	5.125	113	II	214	0.22	7.21	2.3	5.73	143	III
176	0.22	1.76	2.05	5.125	128	III	215	0.45	14.8	2.4	6.03	102	II
177	0.22	7.21	2.29	5.725	166	III	216	0.22	7.21	1.9	4.78	124	II
178	0.28	2.24	2.09	5.225	167	III	217	0.25	8.19	2.3	5.8	110	II
179	0.2	0.27	1.73	4.325	39	II	218	0.25	8.19	1.9	4.8	101	II
180	0.2	0.27	1.73	4.325	112	II	219	0.25	8.19	2.3	5.8	151	III
181	0.2	0.27	1.73	4.325	117	II	220	0.23	7.54	1.7	4.25	85	II
182	0.52	0.69	1.24	3.1	47	II	221	0.23	7.54	2.3	5.75	155	III
183	0.2	6.55	2.28	5.7	137	III	222	0.28	9.18	2.3	5.85	205	III
184	0.23	7.54	1.7	4.25	98	II	223	0.25	8.19	1.7	4.28	103	II
185	0.3	0.4	1.8	4.5	95	II	224	0.23	7.54	1.7	4.25	111	II
186	0.29	0.39	0.93	2.325	72	II	225	0.4	13.1	2.4	6	156	III
187	0.2	0.27	1.73	4.325	108	II	226	0.33	10.8	2.4	5.93	154	III
							227	0.22	7.21	2.3	5.73	172	III

Source: Authors' elaboration

All four graphics were digitized for quick calculation of the ESI – PDI correspondence. Using PDI values obtained from the graph in Figure 3, the PDF of every dam was calculated using the relation 4. PDI and PDF are both given in Table 9.

3.4. Dam rating in seismic risk classes

After finding all the risk factors and the PDF value (Tables 7 and 8), the total risk factor, TRF (Table 9) was calculated with equation (1).

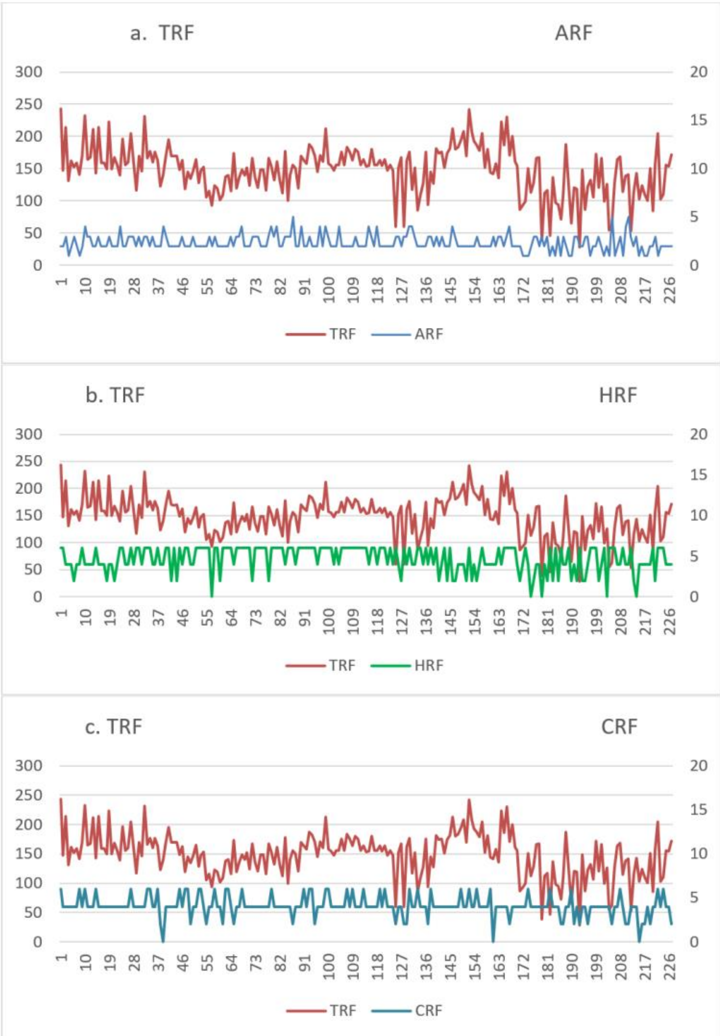

Figure 12. Correlation between structure risk factors a. ARF, b. HRF, and c. CRF and total risk factor TRF
Source: Authors’ elaboration

Using risk class definitions in Table 4, the 227 studied dams were rated in seismic risk classes (Table 9).

In Figures 12 and 13 are presented some correlation between different risk factors and the risk class expressed by TRF. While it seems that the structure risk factors do not have a clear influence one by one on the TRF (Figure 12), their sum (S1) or SF are following the final trend of the TRF (Figure 13, graphs a and b). The high values of PGA in dams' sites are responsible for high TRF. The high risk classes are obtained in dam sites situated inside Vrancea intermediate depth seismic source zone. This can be seen in graph c, of Figure 13, in the zone marked with a blue circle.

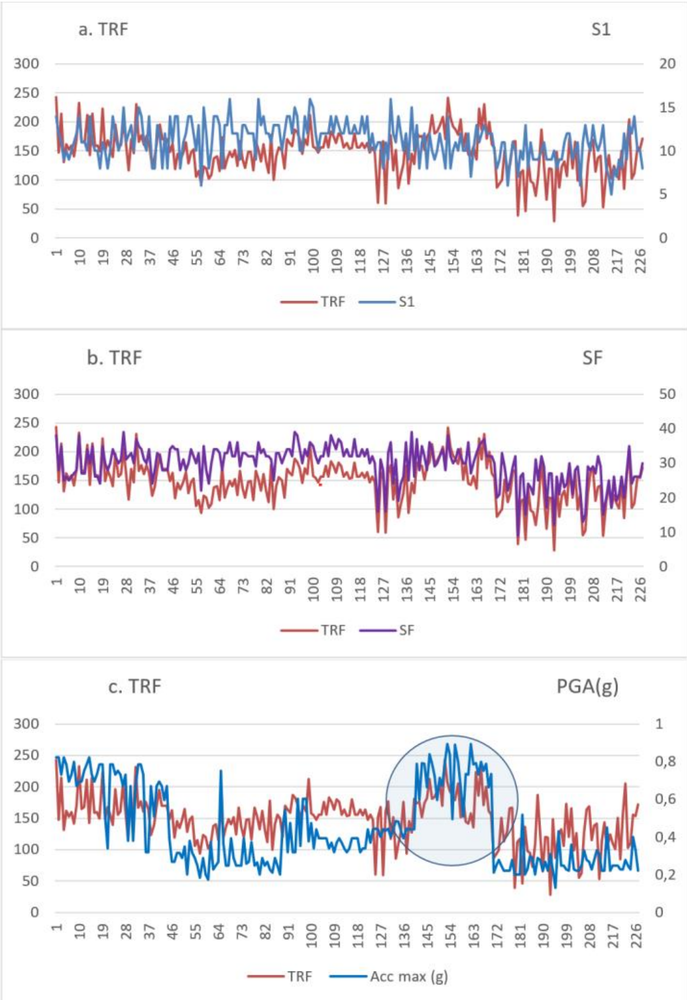

Figure 13. Correlation between S1, SF, PGA and TRF
Source: Authors' elaboration

4. Conclusions

From 227 dams studied in this article, 57 are ranked in the moderate seismic risk class (II), with TRF with values higher than 24 but lower than 125. The rest are rated in the high seismic risk class (III) with the total risk factor values between 125 and 243.

None of the dams from Romania was included in the extreme seismic risk class, which would have been obtained for a TRF larger than 250. However, 18 dams have TRF higher than 200 (Table 10), and two of them have the total risk factor very close to 250, namely: Beresti on Siret river (ID 1) and Golesti, on river Arges (ID 152).

Table 10. Dams with TRF larger than 200

ID	DAM	Long	Lat	River	TRF	Risk class
168	VACARESTI	25.4895	44.8219	Dambovita	200	III
27	IZVORUL MUNTELUI	26.103	46.938	Bistrita	205	III
222	TR.MAGURELE	24.849	43.708	Dunarea	205	III
157	MANECIU	25.989	45.33	Teleajen	205	III
153	GRADINARI	25.784	44.371	Ilfovat	207	III
150	FUNDULEA	26.561	44.463	Mostistea	208	III
13	RAPA ALBASTRA	27.685	46.267	Simila	212	III
99	VALEA SADULUI	23.382	45.1828	Jiu	212	III
146	BUFTEA	25.934	44.563	Colentina	213	III
3	CAZANESTI	27.485	46.861	Durduc	214	III
15	SOLESTI	27.791	46.789	Vasluet	214	III
19	BACAU	26.9261	46.5714	Bistrita	223	III
164	PITESTI	24.904	44.8445	Arges	223	III
166	SACELE	25.766	45.583	Tarlung	230	III
32	PIATRA NEAMT	26.343	46.932	Bistrita	231	III
10	PASCANI	26.76	47.254	Siret	233	III
152	**GOLESTI**	**24.9962**	**44.8083**	**Arges**	**242**	**III**
1	**BERESTI**	**27.19**	**46.186**	**Siret**	**243**	**III**

Source: Authors' elaboration

Seismic risk calculations were performed for return period of 475 years, corresponding to a probability of 0.2% per year, and for 1000 years, as presented in this paper.

If we had evaluated the risk for Tr = 10,000 years, as for nuclear power plants, all the 18 aforementioned dams would have passed into a higher class of risk. As the legislation does not require return high periods like Tr = 10,000 years, for dams it is sufficient to calculate estimations for Tr = 475 years or, in the worst case, Tr = 1000 years.

Taking into account the risk classes, the dams with high TRF, should be included in a priority list for inspecting, and increasing their seismic capacity, repaired or strengthened, if necessary. The existing dams might be modified to better resist ground motion, or in the worst case of dams with extreme risk classes, they should be converted to flood control instead of water storage.

Acknowledgement

This work was supported from PCCA 2013 Project DARING 69/2014, financed by UEFISCDI, Romania and PN 30 01 03/2009.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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Building a Resilient Society through Better Protected Consumers. A Cross-EU Analysis of the "Paternal" Intervention of Public Authorities

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Abstract
Empowering our rights, improving our situation and the effective protection of the safety and economic interests through procedural instruments have become undeniable challenges, especially in a context of an exacerbated bureaucracy which consumers are dealing with. The present paper sustains that the co-operation of national courts with the Court of Justice of the European Union must be valued as way to react and to build resilience of social systems in front of disturbing mechanisms from the market (e.g., monopoly or misleading advertising) or from the public administration sector (e.g., incorrect or lack of harmonization between national and EU laws). The research objective was to reveal the image of the European Union consumer law application and interpretation process. The novelty is given by the fact that this is the first analysis of consumer protection through the use of preliminary ruling procedure (PRP). The analysis was made on 192 cases register in Curia database, from 2010 to 2016. The results bring up mainly the need to shorten the PRP duration in order to serve better consumer interests. These efforts, interconnected to those concerned with environmental protection and economic efficiency, create the path towards a more sustainable society.

Keywords: consumer, law, protection, preliminary ruling, market, European Union.

1. Introduction

It is undeniable that we are living in an era of consumer domination and each of us is part of it. New insights on consumer protection, viewed in its broader sense which refers to the laws and regulations that ensure fair interaction between service providers and consumers (Ardic et al., 2011) were provided by the present study. The focus of the analysis is becoming relevant in a context where an effective consumer protection framework relays on the uniform application and control of law.

European consumer policy is vital for the proper functioning of the internal market. Consequently, the paper assumes that the general EU consumer policy objective of effective enforcement should rely on the uniform and clear interpretation of EU law. Because we are all consumers, empowering our rights, improving our situation and the effective protection of the safety and economic interests through procedural instruments have become undeniable challenges, especially in a context of an exacerbated bureaucracy which consumers are dealing with.

Within this context, the research objective was to reveal the image of the European Union (EU) consumer law application and interpretation process according to the variables that best characterized it. The novelty of the study stems from the fact that this is the first one that analyses consumer protection through the use of preliminary ruling procedure (PRP). PRP is an adjudicatory process by which national courts make references over questions of EU law to the CJEU.

A comprehensive understanding of the complex process of consumer protection requires the consideration of aspects belonging to various areas, such as consumer perceptions, creation, implementation, and use of soft and hard law instruments, and, last but not least, involvement of institutions through existing procedures. Among these, for the present analysis, the use of a judicial procedure – the preliminary ruling – was considered relevant to express how public authorities (national courts) can play a shielding, paternal, role in securing consumers interests. The awareness of institutions in charge with the interpretation and application of legislation on consumer rights increases the resilience of the society in front of inherent malfunctions generated by economic, social, or administrative systems. Moreover, the ability of national and EU authorities to design and implement functional mechanisms to support consumer protection increase the effectiveness of their protection.

2. Methodological framework

The aim of the current research was to reveal how consumer protection is implemented through the intervention of CJEU, in particular, through the use of PRP. For this purpose, primary research was carried on based on the analysis of CJEU jurisprudence. This study was an exhaustive one from the point of view of consumer protection causes brought in front of CJEU, due to the fact that Curia was used as data source and it contains all cases. The variables taken into account were selected based on their capacity to characterize consumer protection process and due to the format of the data supplied by Curia; these were: procedure type, duration of finalized procedure, and type of country (according to political regime and market type they belonged to in the second half of the 20th century). The interactions between these variables were taken into account and a short to medium timeframe was selected: 01.01.2010-31.12.2016. Case duration was analyzed for the period 2010-2014 because all cases from this period were finalized, while for the years 2015 and 2016 only 63% and 9%, respectively, of the cases were finalized at the date of the analysis (January 31, 2017). The variable “procedure” had two categories: preliminary ruling and infringement but most of the analyses were made on PRP because infringement appeared only three times. Regarding the infringement procedure, only the cases that were brought in front of the court were retained. Consequently those that ended in the pre-litigation stage of the infringement procedure were not included. One case was assigned only to one category of the variable. For the present study, the variable “type of country” had two categories. One was “old free market countries” (OFMC), composed by the following EU countries: Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Luxembourg, Malta, Netherlands, Italy, Portugal, Spain, Sweden, and United Kingdom. The other referred to “former communist countries” (FCC) and included: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. This classification was born from the need to investigate if the historical background (that affected political, economic, social organization and cultural background) influenced the number of cases and procedure duration. Again, one case was assigned only to one category of the variable. The criteria used in the Curia search form were: for subject matter: “consumer protection” and for the period: 01.01.2010 – 31.12.2016 (***, 2017).

The research questions were: “Which is the frequency of cases by procedure type for the 2010-2016 period?”, “Which is the frequency of cases by country for the 2010-2016 period?”, “Which is the evolution of the number of cases by country type during 2010-2016?”, “Which is the average duration (months) of cases by country type during 2010-2014?”, “Which is the average duration (months) of all cases during 2010-2014?”, “Do former communist countries and old free market countries differ in terms of preliminary ruling duration within the 01.01.2010 – 31.12.2014 period?”.

The statistical analysis was carried out using the software Excel and SPSS version 21. Independent-samples t-test was applied to compare differences regarding a continuous variable between two independent groups. The level of statistical significance was set at $p<0.05$.

3. Results and discussions

3.1 Pro-consumer procedural instruments: the uniform application and interpretation of law

Consumer protection is one of the main engines of European economic integration for "it brings into very sharp relief the dialectic of open borders, protectionism, and *bone fide* intervention of the Member States to safeguard common values and legitimate interests" (Bourgoignie, 1987), even if this is done by altering the free flow of goods on which the idea of a common marketplace is grounded on (Bourgoignie, 1987). In fact, most of legislative activity conducted by EU which affects consumer has been pursued in the name of economic integration achieved by harmonizing national laws (Weatherill, 2013). The reality we are living in confirms these truths. A legitimate question may appear: "If there were many policies targeting economic and social aspects in numerous fields (i.e., transportation, agriculture, and industry), was it necessary to design and develop a consumer policy at EU level?" Consumer protection was included by the Maastricht Treaty (entered in force in 1993) which introduced, for the first time, consumer protection as a formal EU legislative competence.

Nowadays, Treaty of Functioning of the European Union (TFEU; it came in force in 2009) provides (in article 12) that "Consumer protection requirements shall be taken into account in defining and implementing other Union policies and activities" (***, 2012). Consequently, based on this requirement, consumer protection is a transversal policy within EU, meaning that the provisions regarding consumer protections are viewed as mainstreaming clauses that should be taken into account whatever it is about EU environmental policy, agricultural policy, transportation, and so on. In addition, art 169 (1) of TFEU (***, 2012) commits the Union "to promote the interest of consumers and to ensure a high level of consumer protection", while article 38 of Charter of Fundamental Rights, with legal binding force conferred in Lisbon, says that "Union policies shall ensure a high level of consumer protection". Article 114 of TFEU (***, 2012), which is the main instrument for EU legislative harmonization, states that EU adopts the "measures for the approximation of the provisions laid down by law, regulation or administrative action in Member States, which have as their object the establishment and functioning of the internal market".

The key point is that harmonization of national laws has been conducted, according to Stephen Weatherill (1994), in the name of promoting the establishment and development of EU internal market. A great impediment to market integration was the variation between national laws in the field of consumers' protection, increasing the need for harmonization at EU level, and going even further by considering harmonization as a pro-consumer policy (Weatherill, 2013). This is because, on the one hand, harmonization sets common rules for the European market and, on the other hand, it implies a choice of the appropriate common standard of regulatory protection. One of the most visible manifestations of the legislative harmonization and consumer protection bounding is that the directives, which lack of direct effect and applicability, may generate rights for consumers in the case when Member States (MS) fail to apply the envisaged protective regime. In the mentioned context, individuals are becoming an important vehicle for EU law enforcement within the MS (Timmermans, 1994). Harmonization measures have the role to contribute in removing distortion of competition, eliminating obstacles to the free movement of goods, provision of services, or capital, and the Court of Justice of the European Union (CJEU) has a major role in oversighting market functioning through the infringement procedure (together with the European Commission) or through the PRP. Therefore, the essence of preliminary ruling is embedded in the uniform interpretation of EU law, the pre-condition of uniform application, another essential element for consumer protection. Thus, CJEU states the paramount importance of the uniform application for the good functioning of the internal market: "Any weakening, even if only potential, of the uniform application and interpretation of Community law throughout the Union would be liable to give rise to distortions of competition and discrimination between economic operators, thus jeopardizing equality of opportunity as between those operators and consequently the proper functioning of the internal market. One of the Court's essential tasks is to ensure just such a uniform interpretation, and it discharges that duty by answering the questions put to it by the national courts" (CJEU, 1995). Moreover, uniformity is like a magic formula, preventing many proposals on decentralization of the preliminary ruling procedure (Komárek, 2007).

3.2 The era of a smart consumer in a time of globalization

The achievement of internal market implies the legal prohibition of national measures and practices that impede trade across borders, serving consumer's interests (Weatherill, 2013). Shifting from the status of being consumer in a small national market to the status of internal market consumer brings along a change of behavioral and competition paradigms, in which the law plays its crucial role. This new models have to match to global trends, so no country can knowingly or unknowingly disregard the interest of the consumers (Sahoo & Aman, 2009).

A less common vision on globalization, but which can be integrated into the present approach, is offered by Philip Cerny. He suggests that globalization redefines the relationship between territoriality and authority, shifting authority from the level of the state to supranational and subnational units (Cerny, 1997). By extrapolation, we may look at PRP also as a manifestation of globalization. Worldwide, a trend towards employing similar instruments of consumer protection is increasingly present due to the need of having appropriate responses to common challenges introduced by global economic relations. Moreover, consumer and consumption are more and more mobile, moving fast and easy from one country to another (physically and electronically), and consumers are better informed and educated, which demand more performant institutional and procedural consumer protection means. PRP is central to the legal, and thereby economic and political integration of EU MS because it allows national courts to enforce EU law over national law (Carrubba & Murrah, 2005).

3.3 Consumer protection through "paternal" intervention of public authorities

Consumer policy is largely formulated and implemented by public actors. European consumer policy is a partnership between the EU, MS, and citizens (Comisia Europeană, 2014). The power of the CJEU, ruling over MS, has been attributed to the compelling legal and functional logic of its decisions (Mancini, 1991; Ulrich, 1984, *apud* Conant, 2002), to its strategic accommodation of national interests (Garrett, 1992, *apud* Conant, 2002) and to the support of national courts (Burley & Mattli, 1993, *apud* Conant, 2002). The relationship between national courts and the CJEU is generally described as a "co-operative relationship" characterized by dialogue (Sickerling, 2012). The power of the CJEU to promote European integration through law has been broadly acknowledged (Blauberger, 2014). The preliminary reference procedure of article 267 of TFEU (***, 2012), that enables national courts to request the CJUE to provide a ruling on the interpretation or validity of an EU legal act, is widely considered to be the jewel in the crown of EU law (Broberg & Fenger, 2013). With respect to the preliminary ruling procedure, according to article 267 TFEU (***, 2012), the CJEU shall have jurisdiction over: (a) interpretation of the Treaties; (b) validity and interpretation of acts of the institutions, bodies, offices or agencies. In case law which are subject to settlement, the national courts frequently resort to preliminary ruling on matters regarding, for example, distant contracts, repair of products, aggressive sales techniques, and contractual clauses on clear sales prices.

Practical transposition of consumer protection through "paternal" intervention of public authorities was revealed by the hereinafter described analysis of the CJEU PRP case law. This indicated that there were 192 cases related to consumer protection brought in from of the CJEU, during 2010-2016. Among all Member States, 61% of them used the PRP (Figure 1) in consumer protection area, while the following ones did not: Bulgaria, Croatia, Cyprus, Estonia, Finland, Greece, Ireland, Latvia, Luxembourg, Malta, and Portugal.

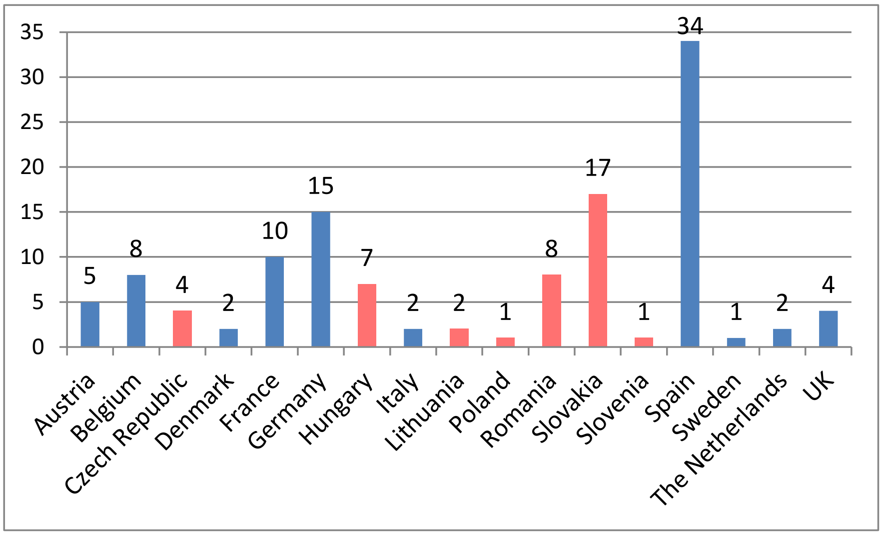


Figure 1. Number of times that MS used the PRP during the 2010-2016 period in consumer protection field
Source: Authors' elaboration based on Curia data

Among all cases related to consumer protection, 189 were preliminary ruling and three were infringement cases. The infringement cases took place in 2010, 2011, and 2012 and two were finalized with a judgment of the Court that found that a Member State failed to fulfil obligations and it was ordered to pay the costs, while in one case no infringement was found in the end. Two of them involved OFMC (Belgium) and one FCC (Poland) and their average duration was 19.7 months, higher than the average duration of PRP cases (15.75 months). Among the PRP cases, 123 were finalized (Table 1, Figure 2).

Table 1. Situation of PRP cases for the 2010-2016 period

		2010	2011	2012	2013	2014	2015	2016	Total
Pending cases	OFMC	0	0	0	0	0	15	16	31
	FCC	0	0	0	0	0	1	5	6
	All	0	0	0	0	0	16	20	37
Finalized cases	OFMC	14	13	12	15	29	18	2	103
	FCC	5	6	9	10	10	9	0	49
	All	19	19	21	25	39	27	2	152
Total	OFMC	14	13	12	15	29	33	18	134
	FCC	5	6	9	10	10	10	5	55
	All	19	19	21	25	39	43	22	189

Source: Authors' calculations based on Curia data

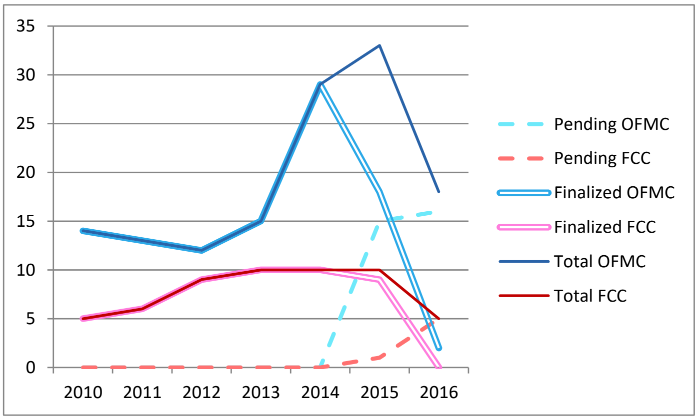


Figure 2. Number of cases by country type (OFMC, FCC, and total) and status (finalized, pending, and total) during 2010-2016
Source: Authors' elaboration based on Curia data

For the entire 2010-2016 period, the total number of cases introduced by OFMC was 2.4 times higher than the one introduced by FCC. In each year of the 2010-2016 period, the number of PRP where OFMC were involved in was higher compared to the number of PRP cases where FCC were involved in (Table 2). Possible causes may be a more dynamic market and a more active behavior of national courts or a higher degree of prudence towards the interpretation of EU consumer protection legal framework in the case of OFMC.

Table 2. Comparison regarding the number of PRP cases between OFMC and FCC (how many times the number of PRP assigned to OFMC is higher than the number of PRP assigned to FCC)

		2010	2011	2012	2013	2014	2015	2016	Total
Pending cases	OFMC	0	0	0	0	0	*x 15*	*x 3.2*	*x 5.2*
	FCC	0	0	0	0	0	1	1	1
Finalized cases	OFMC	*x 2.8*	*x 2.2*	*x 1.3*	*x 1.5*	*x 2.9*	*x 2.0*	*2vs.0*	*x 2.1*
	FCC	1	1	1	1	1	1	1	1
Total	OFMC	*x 2.8*	*x 2.2*	*x 1.3*	*x 1.5*	*x 2.9*	*x 3.3*	*x 3.6*	*x 2.4*
	FCC	1	1	1	1	1	1	1	1

Source: Authors' calculations based on Curia data

As expected, there was no statistically significant difference (p>0.05) between OFMC (*M*=16.27, *SD*=6.10) and FCC [(*M*=14.65, *SD*=5.30; *t*(121)=-1.44, *p*=.15] regarding the duration of PRP for the 2010-2014 period (Table 3). The statistically significant difference was also missing for each year of this period.

Table 3. Results of the independent-samples t-test for assessing the difference between PFMC and FCC regarding duration of PRP

(A) Group Statistics

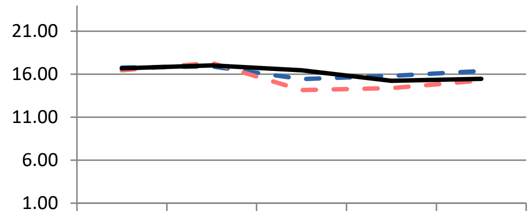
	Country_type	N	Mean	Std. Deviation	Std. Error Mean
Duration	FCC	40	14.652	5.298	.8380
	OFMC	83	16.275	6.104	.670

(B) Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Differen.	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differ.	Std. Error Differen.	Lower	Upper
Duration	Equal variances assumed	.697	.405	-1.439	121	.153	-1.623	1.127	-3.854	.609
	Equal variances not assumed			-1.513	87.770	.134	-1.622	1.073	-3.754	.509

Source: Authors' calculations based on Curia data

The average duration of the PRP was relatively similar for each year and country type and was around one year and a half (Figure 1) during the 2010-2014 period (when all cases were finalized). Authors consider that, from the point of view of consumers' interests that resorted to the use of judicial procedures and taking into account the principle of celerity (the speedy resolution of cases and the simplified judicial proceedings, when appropriate) this duration is extremely high. Thus, it further determines delays in the resolution of the national causes that wait for the CJEU response. The fact that the number of PRP almost doubled from 2010 to 2014 can be an explanation for the lack of a remarkable decrease of the response time, which would be beneficial to consumers. However, a small improvement of about one month is visible in 2014 compared to 2010 (Figure 3).



	2010	2011	2012	2013	2014
Average duration for OFMC	16.75	16.89	15.43	15.81	16.35
Average duration for FCC	16.47	17.32	14.14	14.39	15.25
Average duration for all countries	16.68	17.03	16.45	15.24	15.46

Figure 3. Average duration of PRP for each year of the 2010-2014 period for OFMC, FCC and all countries (months)
Source: Authors' elaboration based on Curia data

4. Conclusions

Preliminary ruling shows how national courts should apply the consumer protection EU law in the national legal system, while the infringement procedure represents the CJEU procedural instrument to determine whether a Member State fulfills its obligations under the Union law (Petrescu-Mag et al., 2015). The analyses of the consumer protection case law that used PRP depicted the intensity to which national courts of OFMC and FCC resorted to PRP and the average finalization time. Highlighting such features of the CJEU functioning brings up mainly the need to adapt PRP duration in order to serve better consumer interests: the necessity to shorten its duration. A synthesis of the answers to the research questions is displayed in Table 4.

Table 4. Research questions and their answers presented in the study

Research question	Answer
"Which is the frequency of cases by procedure type for the period 2010-2016?"	PRP: 189 (134 OFMC, 55 FCC) I: 3 (2 OFMC, 1 FCC) Total: 192
"Which is the frequency of PRP cases by country for the period 2010-2016?"	Figure 1
"How is the number of PRP cases where OFMC are involved in compared to the number of PRP cases where OFMC are involved in?"	Table 2
"Which is the evolution of the number of PRP cases by country type during 2010-2016?"	Table 1, Figure 2
"Which is the average duration (months) of PRP cases by country type during 2010-2014?"	Figure 3
"Which is the average duration (months) of all PRP cases during 2010-2014?"	Figure 3
"Do former communist countries and old free market countries differ in terms of preliminary ruling duration within the period 01.01.2010-31.12.2014?"	They do not differ: Table 3

Source: Authors' elaboration

Consequently, the present study sustains that the co-operation of national courts with CJEU must be valued as way to react and to build resilience of social systems in front of disturbing mechanisms from the market (e.g., monopoly and misleading advertising) or from the public administration sector (e.g., incorrect or lack of harmonization between national and EU laws). These efforts, interconnected to those concerned with environmental protection and economic efficiency, create the path towards a more sustainable society.

Acknowledgement

This study was partially developed through the research program "The creation of a model for the evaluation of food quality from the point of view of consumer health and environmental protection", 2016-2018, selected within the bilateral cooperation between the Romanian Academy and Wallonia – WBI, FRS-FNRS. "La présente publication a été rendue possible grâce à l'Accord qui lie WBI, le FRS-FNRS et l'Académie Roumaine."

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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The Elite-Driven Energy Policy in Romania. Why Negotiate for Renewables and Support Energy Crops?

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Abstract
The central objective of this paper is to add a new perspective on energy policy of Romania, that of a policy which reflects the interests and values of a governing elite – "the blue eyed smart guys". The analysis is developed on four coordinates (evolution of society; institutions, social structure and social capital; social, political, and economic order; and cultural imprint), following a research framework based on Garrido Vergara model. Greening the sector is valued as the "common interest", transforming the debate into an open script for the elite-driven energy policy dissolution in Romania. The study is arguing that politics surrounding policymaking process is one of the most influencing factors for policy enactment. Additionally, better coverage of masses' interests in a negotiation process can be achieved though discovery and use of shared interests and through more efficient appliance of power sources, such as partnerships, better organization, or capitalization of legitimacy. Consequently, the endowment of the political class with common interests with those of the governed masses is considered as prerequisite for a successful and sustainable energy policy.

Keywords: energy; policy; elite theory; renewables; environment; negotiation; legislation.

1. Introduction

At European Union (EU) level, the worsening of problems associated with global warming transformed the environment into the control element of EU policy and energy into its main instrument (Leca & Musatescu, 2010) Energy issues, whether it was about climate-friendly energy, supply, transportation, or affordability of prices, were already classified as defining concerns of this century. The increased focus on energy is explained on the basis of its multi valences: energy is not viewed only as a valuable resource and as a major player in climate change, but also as a public good that requires special protection, as a commodity that enhances our daily living standard, and last but not least, as a product with a high political and strategic value. It is noteworthy that Romania is an EU border country and an important player in the vicinity of the Russian Federation, which makes these geopolitical elements to boost its role as potential regional stability pole in the energy sector. Energy efficiency is a term widely present within the energy policy with a very broad spectrum that covers the various modalities that we may resort to obtain the same benefit by using less energy. For Romania, as for all states, saving energy means saving money, therefore energy efficiency can be very profitable. It is estimated that energy efficiency converted in savings could cover the existing 35% of Romania's primary energy imports (Leca & Musatescu, 2010). After Turkey (which ranks the first), Romania has the largest electricity market in the region and the importance of this position increases in the light of the fact that Romania is only the 14th largest country out of the 35 Member States of the European Network of Transmission System Operators for Electricity (ENTSO) (Romanian Ministry of Energy, 2016a). These are just a few factors that make Romania's energy sector a bidder area for researchers from economical, technological, environmental, legislation, or policy fields.

The central objective of this paper is to add a new perspective on energy policy of Romania, that of a policy which reflects the interests and the values of a governing elite – "the blue eyed smart guys". The green sector of energy was valued as the "common interest" transforming the debate on energy into an open script for the elite-driven energy policy dissolution in Romania.

2. The elite theory and the research strategy for elite study within the Romania's energy context

A research framework based on Garrido Vergara (2013) model was developed (Figure 1) in order to capture more accurately the elite-driven specificity of Romania's energy context.

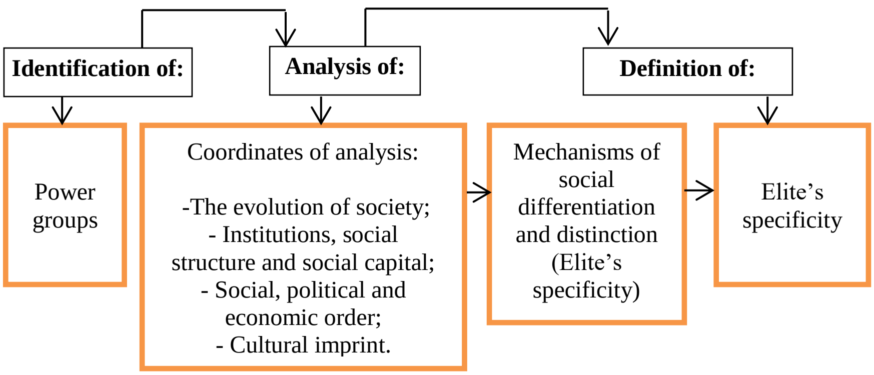

Figure. 1. A model of research strategy for elite studies
Source: Adapted from Garrido Vergara, 2013

The analysis is conducted on four coordinates:

i) The evolution of society. In this section, historical circumstances and determinants influencing the creation of elites are described.

Romania occupied and still occupies a strong position, at European level, in terms of availability of resources, being the fifth largest producer of oil and gas and having an enviable energy mix which makes this sector one of the best deals in terms of political power and economic wealth. Unfortunately, none of these attributes have turned it into a real energetic force. Privatization of the sector, made piece by piece, penal rich casuistry, or the long delays in implementing various sectorial policies are some explanations of the deplorable state of the energy industry. During 2004-2005, Romania went through the most important wave of privatizations in the energy sector, opening the gate to foreign investors.

ii) Institutions, social structure and social capital. These aspects are essential in encouraging the creation of the elite.

The whole philosophy of the present study is based on the principle of international best practices of corporate governance field which expresses the unequivocally separation between the state's role as regulator and policy maker, on the one hand, and as stockholder in companies, on the other hand. It is undeniable that, by developing strategies, promoting public policies and regulatory decisions, the state holds powerful levers for steering investments towards energy resources and all these should be done to fulfill the national strategic objectives and the obligations laid down in EU and international agreements. As a regulator, the state is the main player in promoting the support schemes and in monitoring the implementation of investments through these (support schemes) (Romanian Ministry of Energy, 2016a). Notwithstanding the important privatizations in the energy sector, undertaken after the fall of communism, the Romanian state still holds substantial assets in the electricity sector – both in the segments of natural monopoly (transmission and distribution of electricity) and in that of competing areas (generation and supply) – situation justified on economic, social (public service), structural, and national security considerations. Consequently, by minority and controlling stakes that the state holds in most large energy companies, it plays a crucial role in the electricity market. In Romania, the Governmental Ordinance no.109/2011 on corporate governance of public enterprises is in force (Government of Romania. 2011), issued in light of the principles of corporate governance of state enterprises (developed by the Organization for Economic Cooperation and Development, OECD), framed within the most advanced legislative standards and best practice of corporations.

Based on this reality, a question appears naturally “Who is the state when it comes to energy?” This section is aimed to be rather an invitation to debate than an attempt to display a theoretical framework where to place the analysis. To answer the aforementioned question, a foray into the character of public policy of Romania’s energy policy, and into its public dimension was undertaken and the answer to the question “What a public policy should be?” was also sought for.

It is commonly agreed that the policy of energy normally refers to the behavior of some actor or set of actors, such as an official, a governmental authority, or a legislature in the area of energy (Anderson, 2003), encompassing what a government intends to do about a public problem – that of energy, in the present case. While some definitions emphasize the public good, as stated aforetime by Robert Burger (1986), who said that a public policy was a policy made by governments on behalf of their citizenry, others avoided completely this nuance: “public policymaking is the combination of basic decisions, commitments, and actions made by those who hold of affect government positions” (Gerston, 2015). Accordingly, a public policy should always impact the public but not necessarily on the benefit of all. Because it is related to the public interests, affecting a substantial number of people in different ways, energy policy is a public policy, irrespective of “charity” character.

iii) Social, political and economic order. It refers to the way in which different types of power are distributed in society.

The leitmotif of the good of the masses transforms itself, at least in Romania, into a cyclical desideratum, which appears as a political commitment during the election campaigns. The age of “l’État-providence” of Dogan and Pelassy (1992), who assigned the state the role of a general supplier of resources and material security was not yet born for Romania and, willy-nilly, the nation arrived in the era of the “elitism that takes the place of the state”. Hence, it is asked “Does the national energy policy reflect our interests as ordinary citizens?” Our interests are based on economic, social, and environmental reasons, because energy policies are deeply linked to several broad areas, such as welfare, resource security, energy diplomacy, ecological performance or commitments for achieving national sustainable development targets (Wang et al., 2016).

iv) Cultural imprint is the fourth coordinate and it incorporates the local construction of reality that determines and defines social interaction (Berger & Luckmann, 1966). Most Romanians recognize that systemic corruption is part of their cultural heritage and consider that it was born back in time, during the Fanariots — the Greeks who ruled Moldova and the Romanian Country between 1711 and 1821, under license of the Ottoman

Empire (Deletant, 2007), and survived until present. With the advent of the modern state in the mid-nineteenth century, the bureaucracy was developed. Salaries of the civil servants were hardly enough for a decent living, which encouraged corruption. This habit of producing illegal incomes continued in the interwar period and then during the communist regime, and it is also present in nowadays Romania.

3. Toward elite's specificity: "the blue eyed smart guys"

Energy public policy of Romania reflects the interests, preferences, and the values of a governing elite (Anderson, 2003), being not determined by the actions or demands of the "mass", but rather by the so-called "the blue eyed smart guys". They are in majority members of the national information system "elite" whose economic and political interests are carried into effect by public servants and institutions and who have the flexibility to set the political agenda to which the masses will respond (Parry, 2005). As Mills (1956) was writing in his famous book "The power elite", quoting Jacob Burckhardt, they are "all that we are not".

The author assuredly does not award to political elite "a certain material, intellectual, or even moral superiority", as Gaetano Mosca did (1939), but a certain adaptability to using the two modes of political rule, force and persuasion, and endowment with benefits such as inherited wealth and family connections (Higley, 2008). For the present analysis, the adoption of Higley definition of elites was considered to be the most appropriate one: "persons who, by virtue of their strategic locations in large or otherwise pivotal organizations and movements, are able to affect political outcomes regularly and substantially" (Higley, 2008).

Based on Dye and Zeigler (1996) synopsis of the elite theory, several iconic elements for Romanian energy sector have been highlighted in the following:

a) Division of the society into those few who have the power and the many who do not;

b) Those few who govern do not fold on the features of governed masses and they come from the upper socioeconomic level of society;

c) Energy public policy does not reflect the interests and the demands of the non-elites, but the prevailing interests of the elite. Moreover, with elitism the access to the policy process or the enactment of the change is cut off from the masses (Massey & Huitema, 2016).

d) Elites share a consensus on the basic values of the social system and the preservation of the system.

The superposition between the Romanian state's role as regulator and policy maker, on the one hand, and as stockholder in companies where political interests often determine the economic consequences, on the other hand, involved an important sector of national security in one of the biggest corruption scandals and in the largest economic losses. Table 1 gives an overview of the situation of 14 selected energy companies where the state is a controlling stockholder versus six companies where the state is minority stockholder. The provided data show that more limited state participation is, much better the results are, at least from the perspective of economic efficiency.

Table 1. Situation of energy companies where the state is either a controlling or a minority stockholder

Companies where the state is a controlling stockholder	Share in capital stock	Profit for 2014 (RON)	Companies where the state is a minority stockholder	Share in capital stock	Profit for 2014 (RON)
Oil Terminal SA	59.62%	565.475	OMV Petrom S.A.	20.64%	1,837,149,580
CONPET SA	58.72%	51,434,194	Compania Rompetrol Rafinare SA	44.70%	1,074,861,979
SNGN Romgaz SA	70%	1,409,881,221	Engie România S.A.	37%	390,626,811
Electrocentrale Grup SA	100%	625,387	E.ON Energie România S.A.	31.82%	93,997,521
Electrocentrale București SA (ELCEN)	97.51%	134,546,141	E.ON Distribuție România S.A.	13.51%	83,032,132
Complexul Energetic Hunedoara SA (in insolvency)	100%	– 352,308,913	Societatea Energetică Electrica S.A.	48.78%	362.700.000
Complexul Energetic Oltenia	77.15%	693,635,725			
Institutul de Cercetări Științifice și Proiectări Mine pe Lignit SA (ICSITPML)	90.39%	– 227,793			
Regia Autonomă pentru Activități Nucleare (RAAN)	bankrupt				
Societatea Națională a Cărbunelui Ploiești	bankrupt				
Termoelectrica S.A	voluntary dissolution and liquidation				
Societatea Miniera Banat SA Anina	bankrupt				
S.C. Petrotrans S.A	bankrupt				
Comapnia Nationala a Huilei SA	bankrupt				

Source: Romanian Ministry of Energy, 2016b

From the perspective of the elite theory, in the Romania's energy sector, the compromise among leading groups is the prevailing style of decision making and not the competition and the conflict which may generate beneficial change to all (Dye & Zeigler, 1996). The considerations of professors Thomas Dye and Harmon Zeigler (1996) fit like a glove on the Romanian energy sector: they explained that the transformations in public policy are incremental rather than revolutionary, allowing several minor changes, such as undertaking public-regarding programs and initiating reforms, but without a happy ending, as a response to the concern of not threatening the elite system. All of these are targeting the preservation of the system and elite's place in it. In Romania, the reform of the energy sector has become like a water-diluted wine, meant to dizzy masses, preaching for the new wave in energies, renewables, as the cleanest, most efficient, and convenient ones.

4. The "common" interest: an open script towards renewables

The rationale of this chapter lies in the assertion that the absence of a coherent, stable, and common interest in any large community is an elite-driven element (Higley, 2008). The section is designed to argue that renewables are and should be viewed as a common interest both for elites and for masses, even if the motivation behind it could be different: profitability in the first case, and a cheaper energy with a low environmental impact, in the second one. The mere fact that a common interest can be still spotted, regardless of its resorts, represents a hope in a possible de-structuring process of elites, even on long-range term, which allows a discussion about an open script for the elite-driven energy policy dissolution in Romania.

In formulating the energy strategies, all countries face the same challenge – addressing the "trilemma": energy security, economic efficiency, and environmental protection at the same time (Keay, 2016). The behavior of a country, both within its borders and outside them, is shaped by interests, goals, and ability to work for achieving and implementing them, which, obviously, generates different trends in the strategic global and regional environment (Mokhtari, 2005). As respects Romania, the national energy strategy aims at delivering the key objectives of the new EU energy - environmental policy targets:

a) Energy security;
b) Sustainable development;
c) Competitiveness.

In the following, references to these three objectives will be made, in terms of green energy. First, the concept of energy security does not have the same connotation for all the states, being linked to the political practice of different actors. Some states place the transportation in the center of defining the energy security, other the price or the security of demand, as Russia does (Hlihor, 2008). More and more, the political and public discourses on energy security are directed on questions related to the access to resources and geopolitical and geoeconomic challenges (Goldhau & Witte, 2010). For Romania, energy security comprises the ability to cover uninterruptedly energy needs, on short term and long term, for all consumers on its territory, from diversified sources and to affordable prices (Romanian Ministry of Energy, 2016a). The principal means of ensuring energy security is the energy diplomacy, of course, besides having an efficient energy market (with specific regulatory framework) and international trade (on which the first has a significant impact). In a general sense, energy diplomacy refers to the act of foreign policy that states (or blocks of states, as is the case of EU) promote their energy interests. A generally accepted definition of energy diplomacy does not exist. Andreas Goldhau (2010) appreciates that it would be more appropriate to define the term as the use of foreign policy to secure access to energy supplies abroad and to promote cooperation in the energy sector. Another dimension of energy diplomacy is linked to environmental diplomacy which aims at raising awareness and promoting common interests in the "management and protection of the shared natural heritage of humanity" (Stefu, 2013), especially in the context of an international regime of climate policies. Second, the transition of energy systems toward sustainability presents profound challenges to policy-makers all over the world (Ngar-yin Mah & Hills, 2014), where the renewable energy, energy conservation, and energy efficiency are the master components of transition to a green economy (Shah & Niles, 2016). Therefore, the sustainability of energy policy performance is determined, according to Chapman et al. (2016), by "a combination of environmental, economic, and equity impacts on society". In Romania, for the last 5 years, the discussions on energy security have moved toward renewables, judged by many as a strategic energy policy formula, disregarded in the past. Currently, Romania aims to promote renewables so as to reach a share of 24% of these in the consumption of 2020. Largely, the green energy contributes to enhancing energy security by reducing dependence on imports of fossil fuels, but one should not overlook that the concept of energy security should be distinguished from the energy independence, concept with which it is often confused. Energy independence refers to the national energy self-sufficiency and determines insularity, being politically counterproductive and economically inefficient. Of course, this does not mean that the Member States should be limited in their efforts of assigning priority to the development of indigenous energy resources (Romanian Ministry of Energy, 2016a). Third, competitiveness may refer to the development of competitive markets for electricity, natural gas, oil, uranium, green certificates, greenhouse gas emissions allowances, and energy services (Ministry of Energy, 2011).

Consequently, by applying and adapting the general concept of sustainable development in the energy sector, five strategic components are obtained: 1. Enhancement of the efficiency in the use of energy; 2. Development of a balanced portfolio of domestic energy resources; 3. Investments in advanced technologies; 4. Rethinking the environmental protection; and 5. Higher participation in the international market (Leca, 1997).

It is undeniable that politics surrounding policymaking process is one of the most influential factors for policy consideration and enactment (Golden & Moreland-Russell, 2016), and, therefore, the endowment of the political class with interests that are common with those of the governed masses is a prerequisite for a successful policy. The questions are if this is really possible and which are the ways to adapt the existing rules of global energy relations to the realities of Romanian consumers – affordability, safety, and environmental protection – while there is a very pronounced energy elitism that acquires more and more an external dimension. One solution for such adaptation is negotiation, which can take place between different types of parties: public-public, private-private, or public-private, belonging to the same or to different industries. For example, negotiation can be developed between elite and masses, between local and central decision makers, between environmental protection activists and resource exploitation companies, or any combination of these. The result of the negotiation depends on a series of factors such as parties' interests and goals (Petrescu, 2016) and their negotiation power – given by their resources (money, decision power, etc.), allies, determination, the best alternative a negotiator has to a negotiation (i.e., solving the solution alone, negotiation with another partner), etc. (Petrescu, 2007). As mentioned, in the case of Romania's energy policy, interest are different between elite and masses and the power of the first is usually higher than the one of the later, resulting in disadvantageous solutions for the masses. A better coverage of masses' interests in a negotiation process can be achieved though discovery and use of common interests and through more efficient appliance of power sources, such as partnerships, better organization, or capitalization of legitimacy.

5. Energy crops

The production of energy crops is currently one of the main European Union priorities, as far as for 2020 one fifth of the energy consumed in the EU should come from renewable sources. Consequently, energy crops are becoming more common all over the Europe. Based on Eurostat database, almost 60% of renewable energy from primary biomass sources in agriculture consists of biofuels (48% or 8 457 ktoe from biodiesel energy crops and 12.2% or 2140.8 ktoe from ethanol energy crops) and of agricultural biogas (39.8% or 7 008.7 ktoe) (Eurostat, 2017). Like other crops (i.e., corn and sunflower), energy crops are eligible both for direct payment schemes from EU funds and for national transitional aid funded from Romanian budget. The amount of these payments per ha is set annually by Governmental Decision (of Romanian Government) after the Agency for Payments and Intervention in Agriculture establishes the eligible areas for payment.

Energy crops are used for obtaining biofuels or electric and thermal energy produced from biomass. These crops have the capacity to produce large volume of biomass, they have high energy potential, and can be grown in marginal soils (Dipti & Priyanka, 2013). The energy crops include a wide range of crops, from conventional food ones, such as oil seed rape through to short rotation coppice and new forestry plantations (Allen et al., 2014). Many of energy crops are experimental, while others are commercial. In general, energy crops are classified in two categories: woody plants (e.g., willow, poplar, and paulownia) or grass plants, the latter including annual plants (rapeseed, soybeans, camelina) and perennials (e.g. pampas grass, elephant grass). The contribution of forestry to the total energy production is very high in Estonia (97 %) and Latvia (81.9 %) and the share of agriculture in the total production of primary energy is highest in Luxembourg (9.8 %), Lithuania (8 %), and lowest, for example, in the United Kingdom (0.2 %), Greece (0.3 %), and Romania (0.4 %) (Figure 2) (Eurostat, 2017).

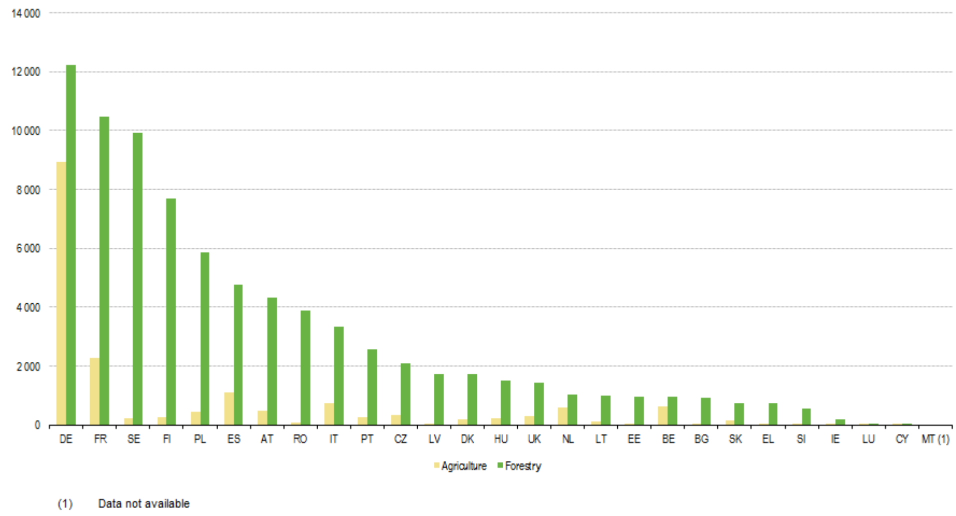

Figure 2. Production of renewable energy from agriculture and forestry by country (ktoe), 2010, EU-27
Source: Eurostat, 2017

In Romania, the best known energy crop is the rape culture. In 2014, according to Romanian Ministry of Agriculture, the highest rape production since 1970 was recorded: 1.089 billion tonnes from a cultivated area of 423 237 hectares (MADR, 2014). The most important economic factor for energy crop production is the result measured through energy productivity per hectare (Grupul Bancii Mondiale, 2014). Although there are critics of energy crops, such as those related to the contribution to loss of biodiversity or inequitable transfer of land to other purposes than food production, energy crops remain an attractive option from economic and ecological points of view. Due to their high production per hectare, energy crops have a high degree of recognition for the production of bioenergy.

6. Conclusions

The paper argues that for Romania too, the energy sector is a matter of national security which has entered the political mainstream, demanding, besides a political response, a policy one at all levels of governance (Jordan et al., 2010). These responses should reflect the interests of the citizens in terms of price, accessibility, and environmental protection. Currently, in Romania, the absence of public confidence in the management of the energy sector is an undeniable reality by cause of the lack of integrity and transparency in decision making, suspicions and evidence of corruption and fraud, and failure of the performance indicators. This is the consequence of two main facts. The first one refers to policymaking process which is political and involves politics (Anderson, 2003), being even more visible in key sectors of economy, such as the energy. It is a policymaking process perceived by the masses as matter of persuasion and bargaining, which means conflict, negotiation, the exercise of power, compromise — and sometimes “nefarious practices as deception and bribery” (Anderson, 2003). The second one has to do with the lack of citizens’ capability to act and react and of the masses coagulation toward common interests, which is often explained through a path-dependency of community of not getting involved.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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The Role of Greenhouse Gases Emissions Reduction in Building Green Economy and Resilience of Social-Ecological Systems

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Abstract

The green economy emerged as a response of the social-ecological systems to environmental problems. The article is based on the premise that green economy is a social-ecological system, where a constant interrelation between people and the environment is present. Vulnerable social-ecological systems lose their resilience, thus affecting people and the rest of the environment. Green economy is viewed as a social-ecological system that contributes to better management of resilience and to prevention of a drift towards unwanted configurations. Green growth can be achieved by maintaining systems' capacity to self-organize and adapt to external interventions. Study of different aspects that lead to loss of resilience increases the adaptation capacity of the system. From this point of view, the article focuses on greenhouse gas (GHG) emissions which have negative effects both on human health and on the atmosphere, soil, water, and vegetation. Measures to decrease and eliminate pollution sources contribute to the restoration of the ecological balance.

Keywords: green economy; resilience; greenhouse gas emissions; adaptability.

1. Introduction

1.1. Conceptual framework and paper objective

At EU level, it is desired that the European economy becomes smart, sustainable, and inclusive. These goals are set out in the Europe 2020 Strategy (European Commission, 2010). In this document, which represents the European Union's strategy on economic growth, the five European goals for 2020 are specified. One of these goals relates to sustainable energy use and climate change. A 20% reduction of greenhouse gas (GHG) emissions is desired, compared to levels recorded in 1990. At the same time, energy efficiency should increase by 20%. The share of renewable energy sources is aimed to increase by up to 20%, as well. It is recommendable for economic growth not to be based on excessive use of resources. Common efforts of organizations both public and private are necessary in order to achieve this requirement. The actions to be undertaken aim at increasing the quality of life by reducing environmental risks and social deficit. By adhering to these goals, Romania seeks a transition to green economy, as well. Consequently, various documents from public or private organizations address issues related to reduction of the negative effects of human activity on the environment and to climate change adaptation. Strategic and programmatic initiatives refer to sustainable development and target, e.g., economic development, infrastructure improvement, education and training, employment, and social inclusion (Green Jobs, 2014b).

Ecosystem dynamics is permanently modified by humans, the changes manifest themselves from local environments to the biosphere as a whole (Folke, 2006; Kirch, 2005; Steffen et al., 2004; Redman, 1999), due to pollution and resourse depletion, which have dramatic consequences on environment (Hoekstra & Wiedmann, 2014; Petrescu-Mag & Petrescu, 2010; Ringler et al., 2013). In response, green economy is an economy dedicated to reducing environmental risks and ecological scarcities, thus, to achieving sustainable development. According to the United Nations, it is both efficient and fair, where fairness implies "recognising global and country level equity dimensions, particularly in assuring a just transition to an economy that is low-carbon, resource efficient, and socially inclusive" (UNEP, 2011).

Resilience theory can provide the conceptual basis of sustainable development (Folke et al., 2002; Carpenter et al., 2005). Resilience is understood as "the capacity of a system to absorb shocks and disturbances, while still maintaining the same functions, structure and feedbacks" (Walker & Pearson, 2007). It can be accepted that social-ecological resilience is the amount of disturbance a system can absorb while it still remains within the same state or domain of attraction. It, also, relates to the degree to which the system is capable to self-organize (Carpenter et al., 2001; Folke, 2006). Resilience also refers to social processes and these include social learning and social memory, mental models and knowledge–system integration, visioning and scenario building, leadership, agents and actor groups, social networks, institutional and organizational inertia (Folke, 2006).

Any socio-ecological system has its specific adaptation capacity which is under constant influence by a variety of factors – internal or external to the system. Thus, reduction in GHGs emissions is a requirement to build green economy and improve resilience. In this context, the objective of the paper is to present how decreasing GHGs emissions helps in creating a green economy and increasing resilience of the social-ecological systems.

1.2. Institutional and policy framework for a green economy

The Organization for Economic Cooperation and Development (OECD) states that green growth is a new approach to economic growth. Through this approach, human welfare is central to development and it is desired to ensure that natural assets are able to provide the necessary resources and environment services. Extension of the traditional definitions of green growth allows a reconsideration of the importance of the environment and of the value of natural assets in ensuring welfare, growth, and development. OECD believes that the concept of green growth cannot replace sustainable development because sustainable development is the way to achieve this growth. Green growth proposes the rational and optimal use of resources, and this will determine a selection of sustainable production and consumption patterns. The implementation of action programs focused on green growth could lead to advances in the fields of economy and development. Poverty reduction is part of the social component. From this point of view, progress in developing countries may be influenced by the green increase. In these circumstances, we can talk about sustainable development (MEDDE, 2015). Smaller enterprises have higher opportunities for development and mobility. Thus, it can be asserted that they have higher possibilities for expressing innovation and creation of new jobs.

The use of indicators based on internationally comparable data is required to monitor progress on green growth. They should be selected on the basis of clearly defined criteria and should take into account the conceptual provisions. Indicators must be able to provide all the necessary information in order to enable stakeholders to make the right decisions. One indicator is the environmental quality of life. Another is the environmental and resource productivity of a given area, which characterize the efficiency level of the use of the natural capital. The risks generated for the economic growth by the decline of the resource base should also be taken into account. The effectiveness of policies related to green growth can be highlighted based on the created economic opportunities and on the offered politic responses (OECD, 2011).

The measures taken for green growth include certain policy measures. Such measures could refer to tax reform policies, legislative amendment policies in the educational, research, and innovation areas, strategies regarding employment, instruments to mitigate climate change, and energy efficiency measures. The assembly formed by these elements allows the establishment of a conclusive framework (OECD, 2011). The production of goods and services would be achieved through participation of public authorities or private companies (profit-oriented or non-profit). In these circumstances, using paid labor must lead to value creation. Therefore, both in the cultural area and in the health field, there is the possibility of providing goods and services to the local markets, in order to pursue activities that require both public and private resources. At the same time, certain goods and services can alternatively be produced by the private or the public sector. Indigenous renewable energies can be included in this category (EGP, 2016).

Growth refers to the process by which workers, equipment, materials, and technologies contribute to the production of goods and services. Green growth contains the same elements, but also four additional ones (OECD, 2011). Two of the additional elements relate to natural capital: the dual role played by it and the need for public investment in the natural capital. The third element is the importance of further changes of the economic activities. The fourth element relates to the need for additional innovations that aim to create the necessary balance between natural capital and increased consumption. Green growth should occur by strategically completing environmental and economic policies. Thus, green growth will be found in the midst of the economic strategies (OECD, 2011).

Green economy requires the allocation of additional funds to support activities that do not harm the environment, seeks to protect it and to increase the quality of life. Maintaining social cohesion in a green economy can be activated through measures aimed at the creation of new jobs and at boost in economic growth. These measures may be imposed through actions of environmental protection and a more efficient use of natural resources (EC, 2014). Such measures are analysed in the following paragraphs.

2. Green economy and resilience of the social-ecological systems

2.1. Transition to green economy – basic characteristics

The new concept of green economy imposes changes in the skills necessary for the next period. For this, analyses on the transforming economies are made in various countries and high priority for occupations will be considered by future policies. The adaptation of educational and training systems in the area of green economy should take into account increasing the number of businesses with high degree of novelty (MEEM, 2012).

Transition to green economy can have consequences like the elimination of some jobs. Also, other jobs may be transferred between industries and others will be assigned to the newly created job categories. These economic changes can affect those industries that use renewable resources and manage waste: transport, energy, construction, agriculture and forestry, and tourism. From this point of view, green economy includes traditional economic activities and eco-activities. The activities from the first category are considering cleaner processes and lower power consumption. Eco-activities have to ensure both environmental protection and natural resource management. Thus, promoting sustainable development in the medium and long term is one of the objectives of green growth (CEDEF, 2015).

One of the goals of environmental policies is to improve human well-being and to ensure environmental sustainability. To measure environmental policies in OECD member countries, an indicator on the strictness of environmental policies was adopted. This indicator showed that in the last twenty years, environmental policies have become stricter (OECD, 2016).

An evaluation of resilience becomes necessary in order to transpose theory into practice (Carpenter et al., 2001; Carpenter et al., 2005). From a practical perspective, there is little experience with estimating the resilience of social–ecological systems, and little understanding of the sensitivity for adapting to changes in social–ecological systems (Carpenter et al., 2005). The social-ecological system framework includes resource systems, resource units, governance systems, actors, action situations, and exogenous influences from related ecological systems and from social-economic-political settings (McGinnis & Ostrom, 2014). Changes in the efficiency of the ways in which the resources are used lead to a significant improvement of the environment. However, an effective use of resources that enables long term transition to a green economy largely depends on financial resources. Success is also determined by the capacity to recognize the multiple problems that transition faces. Strategies, long-term actions, and a framework for promoting innovation and new financing initiatives are necessary (EEA, 2014).

The restructure of existing systems is based on public participation as a great source of responsibility. This will require expenditures on monitoring the effects of decisions and the flexibility to respond to the results of monitoring. At the same time, people are dependent on the ability of the ecological systems to serve their interests. Taking into account the complexity of social-ecological systems, we can appreciate that proper management of the interaction between humans and ecosystems allows the society to implement necessary reforms (Cosens, 2013).

The extent to which green economy is implemented depends on the regulations and programs adopted by each country and on the country development level. Improvements in the state of the environment are a win for people health. Economic prosperity is influenced by the extent to which environmental issues are integrated into sectoral policies, as well. Environmental impact and pressure on the environment are influenced by the application of sectoral policies. From this point of view, environmental issues can be addressed in a number of sectors, such as agriculture, industry, tourism, transport, fisheries, energy, and regional development. For some of them higher investments are required (e.g., housing, food, and energy), but such investments in technology and infrastructure will protect people against environmental pressures and health and welfare risks. The frequency and intensity with which climate changes occur will lead to urban areas being more and more affected. Thus, it is considered that resilience regarding urban use of energy will become increasingly more important (Sharifi & Yamagata, 2016).

Transforming industries affects local and regional ecosystems. Some of the positive changes they generate are job creation, skills development, and the development of green entrepreneurship. Transition to a low carbon emissions economy can be accompanied both by loss of jobs and by creation of new jobs, depending on the characteristics of the certain area where transition takes place. Often, activities taking place due to low carbon emissions are used as an indicator of the economic progress and such data collected can be used by local and regional communities to develop policies and strategies (Martinez-Fernandez, 2015). Thus, in the context of regional development, resilience can be considered as the capacity of a region to withstand and recover from shock. A region is a system composed of several different components, which are combined in different forms of relationships. Considering these aspects, we can appreciate that regional resilience is identified as the capacity of all components' in the sum to withstand and recover from the shock (Palekiene et al., 2015). Also, if we quantify the resilience of a system we can better understand the strength and resilience of that system. Thus, it is possible to determine how best to improve the system to withstand shocks in the future (D'Lima & Medda, 2015).

The importance of resource efficiency and of a society with low carbon dioxide brought these issues at the core of national and international concerns (UNEP, 2015). The efficient use of resources offers the possibility of protection, conservation, and improvement of natural capital, contributing to the success of the transition to a green and competitive economy, with low-carbon emissions. Also, adoption of legal measures in favor of environmental protection and an orderly resolution of local and regional problems can improve urban sustainability and effectiveness in dealing with climate and environmental challenges (European Parliament & Council, 2013). The environmental pressure generated by the increasing demand for food, energy and water constantly raises the need to find more efficient solutions for resources use and ecosystems conservation. Such solutions can come from very divers activities, like land use, carbon sequestration, water use, production of mineral fertilizers and pesticides, food production and consumption. The EU supports these efforts of creating a sustainable and competitive economy through dedicated funding. Thus, for instance, from the EU budget, at least 20% of allocated funds were planned for the areas of research, agriculture, maritime policy and fisheries (EEA, 2015). The results of such investments and the progress towards green growth must be monitored taking into account the specificity of each situation (Martinez-Fernandez, 2015). Thus, the impact of climate changes differs from one area to another and responses to it vary accordingly, the economic development level is not the same in every place, and social variables (such as number of population, skills and education) are also different.

Measures of transition to energy produced with fewer carbon emissions, creation of new jobs, and new industries can be incorporated in the category of reactions to climate change. Geothermal energy, hydro energy and other solutions that can reduce environmental pressure are increasingly implemented and the results are evaluated from the point of view of their economic, social and environmental costs and benefits (Gullberg et al., 2014; Li et al., 2013; Petrescu-Mag et al, 2009; Tie & Tan, 2013). The new opportunities will make labor markets to manifest differently from one region to another. Also, both individuals and organizations will behave differently in the process of transition to an economy based on low carbon emission. Because such transition requires a long period of time, it is desirable to ensure that authorities' support is also extended in time (Miranda et al., 2012).

One of the measures that can be applied to foster green growth is to build partnerships at local and regional level. These partnerships should be used to mitigate carbon emissions occurrence. Thus, the transition to a low carbon emission economy can lead to changes in the labor markets. Competitiveness of industries with high carbon emissions can decrease and the competitiveness of low-carbon industries may be growing. Consequently, the labor force employed in the latter sectors will increase. This mechanism will require new skills and education and training programs. Also, the development of green entrepreneurship will need the identification and use of specific skills and competence (Martinez-Fernandez, 2015).

Differences in the level and approaches of the economic development of regions are reflected in particularities of transition process to a low carbon emission economy, specific to each region. In these circumstances, local authorities have a high importance. They can act simultaneously as quality regulators, evaluators, and potential consumers of green economy (Martinez-Fernandez, 2015). Strengthening local capacities can be achieved by adopting certain strategies that take into account resilient and self-sustaining structures. These must have sufficient capacity to grow and sustain failure in what is a risky environment (Pratt, 2015).

Current production and profit increases are based on investments in activities with high CO2 emissions and pollutants, which generate waste and damage the ecosystems. Reducing carbon emissions can be achieved through investments in improved technologies which generate lower emissions and waste and in strategies that improve the ecosystems. In time, they will generate positive effects in terms of increased environmental goods and services, and improvement of the environment and jobs (UNEP, 2012). Through these economic changes, the efficiency with which resources are used will improve and the workforce employability will increase. If persons occupying certain jobs, through their work, reduce the negative impacts on the environment and contribute to environment conservation or restoration, then it can be said that these people occupy green jobs. Such jobs are, for instance, those that include solutions that lead to the replacement of non-renewable or pollutant resource consumption (Green Jobs, 2014b). Green jobs are based on activities that produce goods or services that protect the environment. These activities have an influence on the harmful effects of human activity on the natural environment. Activities that lead to the production of goods and services that protect the environment can be considered as activities that refer to green jobs. They support the production processes of the green economy and reduce the harmful effects of human activity on the natural environment. The presence of aspects of the green economy in different sectors of the economy determines the need for new skills and qualifications for their jobs. The promotion and development of the green economy can be influenced by public authorities. Eliminating subsidies granted to activities that affect the environment may allow the redistribution of funds towards green economy. Also, implementing a toll system, such as eco-taxes, results in fewer greenhouse gas emissions and greenhouse pollution. In this case as well, the funds obtained by applying these fees may be directed to green economy activities. Another positive influence on the development of green economy is given by the application of and compliance to the environmental legislation. At the same time, the acquisition of skills and qualifications needed for new green jobs through participation in education and training programs can be financially supported by public institutions. Similarly, the funds necessary for such education and training programs may be attracted by the development of projects financed from European funds (Green Jobs, 2014a). Also, we must bear in mind that for a number of countries the growth potential of the population depends largely on immigration from other countries. This process has consequences for the level of skills of the employees, as well as for the economic environment of the countries concerned.

An ecological crisis has developed in recent years, amid the financial and economic crisis. The development design which may help maintain an overall natural and social balance is the green economy. Through the green development of consumption and production new opportunities may arise for companies and jobs (MEEM, 2016). Green industries can be developed by using natural resources, with low-carbon emissions. In this way, new jobs can arise in areas like energy, environmental engineering, water treatment, or waste.

Generally speaking, the green economy aims to increase the welfare of the population. It is envisaged that this increase does not have a negative impact on the environment, that it does not increase the utilization of resources, but, instead, is more efficient. So, to preserve the value of the natural systems, technological innovation measures are necessary. From this point of view, policies and innovations should generate more value. Businesses have the opportunity to change their organization method. Changes are also needed regarding the structure and organization of cities, as well as the way people lead their lives (EEA, 2012).

At EU level, a vision for a society with low carbon emissions, green economy, circular and resilient ecosystems was formulated for 2050 through the Seventh Environment Action Programme, “Living well, within the limits of our planet” (European Parliament & Council, 2013). This is regarded as the foundation for the citizens’ well-being. As such, measures are necessary to make a shift toward a more integrated approach that can provide answers to the challenges in environment and health fields, too, besides the ones usually considered, like economy (EEA, 2015). To meet the vision for 2050, two conditions must be met: the environmental policies must be applied and the economic efficiency must be increased by the new technologies. Within the process of achieving the vision 2050, resilience is a characteristic of various systems (economic, social, etc.) that can significantly contribute to the achievement of the established aims. Regarding resilience, besides the function of shock absorption, there are also other functions related to the capacity for renewal, reorganization and development (Berkes et al., 2003; Folke, 2006; Gunderson & Holling, 2002). According to Folke (2006) and Walker et al. (2004), resilience is currently defined in the literature as the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks. Also, Adger (2000) and Folke (2006) define social resilience as the ability of human communities to withstand external shocks to their social infrastructure, such as environmental variability or social, economic and political upheaval.

Systems of production and consumption put pressure on the environment and climate. Usually, to become green, and, thus, resilient, it is necessary to go through certain stages of transition of these systems. The transition to a green economy is influenced by the balance between various approaches which depend on the types of knowledge and governance mechanisms. The green economy implies changes in terms of institutions, practices, technologies, policies, lifestyle, and today's way of thinking (EEA, 2015) and its implementation is based on the interrelation and complementarity of policies. Identifying ways of greening while still obtaining economic development can be achieved through the integration of education and training programs for green jobs in the formal and informal education systems (WTO, 2009). In doing so, a particular attention must be paid to the poor and the vulnerable groups, including women and youth. Measures aimed simultaneously at the efficient use of resources, resilience of ecosystems and human well-being can lead to accelerating the transition to a green economy. Thus, additional leverage may be offered by the approaches that involve citizens, NGOs, businesses and cities in these measures (EEA, 2015). Measures cope with one of the major challenges.

The manifestation of extreme events and natural disasters cannot be stopped. However, by planning and preparation measures, the frequency, extent and duration of disasters can be reduced. These measures could make socio-ecological systems more resilient. Thus, the concept of resilience plays an increasing role in addressing various threats (Lin & Bie, 2016). Greenhouse gases emissions and other pollution sources affect not only human health, but also all components of the environment (i.e., atmosphere, soil, water, and vegetation), therefore the conservation of the functions of life support systems requires an integrated approach (Ioan et al., 2009).

2.2. Overview of GHGs emissions in EU

The intensity of environmental degradation generated by each country, as well as the impact of its consequences at national level, are different. Thus, for example, higher dependency on agriculture and on the use of other natural resource increases population vulnerability. As this usually happens in poor countries, the negative effects multiply. A part of the solution is global cooperation for the mitigation of climate changes (OECD, 2011). Such agreements have contributed, at EU level, to the reduction in the amount of CO2 emissions (Table 1). In the cases where the solution applied was the termination or restriction of activities of companies in energy-intensive industries (i.e., metallurgy, building materials, and chemical industry), a reduction in the level of pollution was observed. Measures taken against pollution sources had good results for air, soil and underground water. In the case of carbon dioxide emissions, a way to decrease them is the reduction of the amount of electricity used in industry. Thus, it appears that negative environmental impacts can be reduced by intervening in the way electricity is used and produced. At the same time, it is estimated that, in agriculture, a decrease in quantity of chemical fertilizers and pesticides reduce pollution of soil and groundwater.

Table 1. The evolution of CO2 emissions in EU countries between 2008 and 2013 (millions of tonnes)

Countries	2008	2009	2010	2011	2012	2013
European Union	3,505.9	3,159.2	3,252.2	3,183.5	3,115.6	3,012.2
Austria	56.4	51.0	54.8	54.2	51.6	51.0
Belgium	91.4	79.5	85.3	79.4	76.3	75.7
Bulgaria	51.4	43.4	45.5	50.7	45.8	40.5
Croatia	18.6	16.3	15.7	15.4	13.6	13.6
Cyprus	7.5	7.2	6.8	6.3	5.7	5.1
Czech Republic	103.6	96.5	98.3	95.0	90.6	88.5
Denmark	85.9	79.5	77.7	76.3	70.0	68.9
Estonia	17.2	13.9	17.6	17.7	17.0	19.3
Finland	56.1	52.4	61.3	54.5	49.1	50.7
France	283.9	264.5	271.1	257.7	253.5	252.2
Germany	728.5	663.0	701.1	690.5	698.3	709.0
Greece	88.3	81.7	76.9	73.9	74.0	68.3
Hungary	43.5	38.3	39.0	38.2	35.5	33.6
Ireland	32.5	27.6	27.2	24.8	25.4	24.2
Italy	370.6	316.5	327.2	320.3	299.7	270.7
Latvia	8.5	7.1	8.4	7.5	7.2	6.9
Lithuania	15.0	12.3	13.3	14.3	14.5	14.2
Luxembourg	7.4	7.4	7.5	6.7	6.7	6.7
Malta	4.8	5.4	4.9	5.6	5.4	5.2
Netherlands	170.9	166.1	174.2	167.1	163.7	161.1
Poland	292.3	276.1	290.0	293.2	284.4	270.2
Portugal	52.9	49.4	46.2	43.7	42.6	41.2
Romania	92.6	75.7	70.8	74.9	71.8	63.2

Countries	2008	2009	2010	2011	2012	2013
Slovakia	36.4	32.8	33.1	33.2	30.8	30.5
Slovenia	15.4	13.8	13.7	13.9	13.3	12.8
Spain	271.9	233.8	219.7	225.9	223.9	197.3
Sweden	49.5	45.8	51.2	47.5	45.2	43.1
United Kingdom	452.9	402.2	413.4	394.9	399.8	388.6

Source: Authors' elaboration based on EUROSTAT 2015 data

Data in Table 1 also reveal that the highest CO2 emissions are recorded in the following countries: Germany, United Kingdom, Italy, Poland, France, Spain, and the Netherlands. The amount of CO2 emissions from these countries account for approximately 75% of all CO2 emissions in the European Union. The countries where CO2 emissions had the most significant decreases in 2013 compared to 2008 were Romania and Cyprus.

In 2013 compared to 2008, there was a decrease in CO2 emissions by approximately 14% (Figure 1).

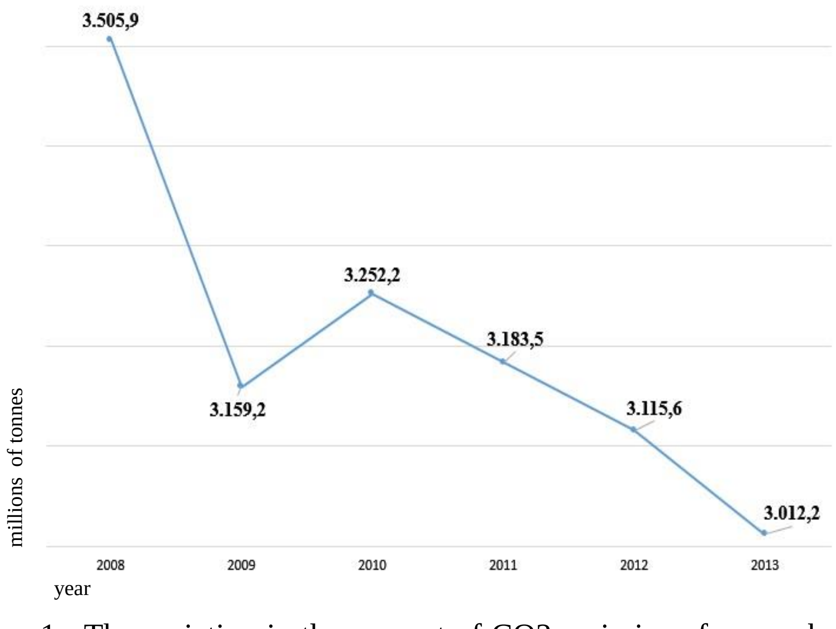

Figure 1. The variation in the amount of CO2 emissions for member states of the European Union, for the period 2008-2013 (millions of tonnes)
Source: Authors' elaboration based on EUROSTAT 2015 data

For Romania, the variation of total CO2 emissions in the air, for the period 2008-2013, in millions of tonnes, is shown in Figure 2.

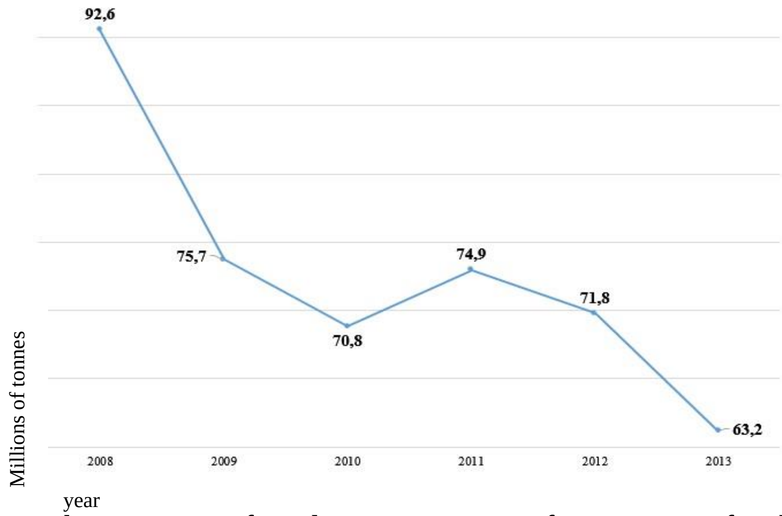

Figure 2. The variation of total CO2 emissions, for Romania, for the period 2008-2013 (millions of tonnes)
Source: Authors' elaboration based on EUROSTAT 2015 data

It is noted that compared to 2008, in 2013 the total CO2 emissions fell by over 30%. In 2013, compared to 2008, certain sectors have recorded high values of total CO2 emissions. These sectors include agriculture, hunting and related services, and construction. For other sectors, CO2 emissions fell. Significant decreases were registered for manufacture and supply of electricity, gas, steam and air conditioning, metallurgical industry, manufacture of chemicals and chemical products, manufacture of coke, and refined petroleum products.

In Romania, in 2013, the total emissions of CO2 from households had the sources shown in Figure 3:

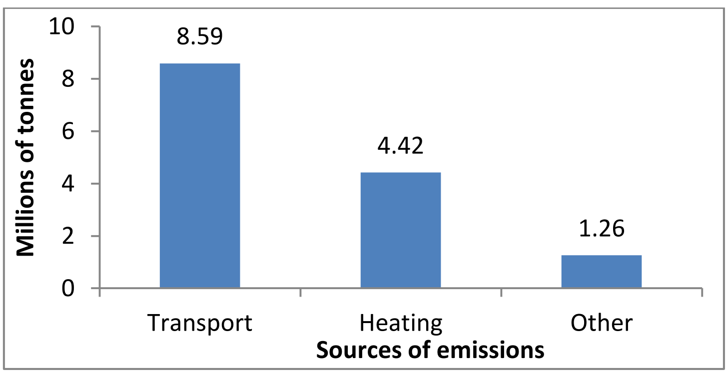

Figure 3. The total emissions of CO2 from households (millions of tonnes)
Source: Authors' elaboration based on Romanian National Institute of Statistics data (2015)

In relative terms, the above mentioned figures indicate that about 60% of CO2 emissions from households are generated by transport activities, 30% of them by heating activities, and 10% by other activities. Another group of highly reactive gases, which are responsible for acid rain, deteriorating water quality and reduced visibility in urban areas, are nitrogen oxides. Table 2 presents the evolution of nitrogen oxides emissions in European Union countries, between 2008 and 2013.

Table 2. The evolution of nitrogen oxides emissions in European Union countries, between 2008 and 2013 (thousands of tonnes)

Countries	2008	2009	2010	2011	2012	2013
European Union	868.26	819.35	784.45	772.70	761.69	758.5
Austria	11.65	10.91	10.22	10.49	10.34	10.28
Belgium	23.46	23.9	25.75	21.73	21.43	20.8
Bulgaria	9.47	8.22	9.26	8.45	8.47	9.09
Croatia	7.9	7.11	7.36	7.59	7.11	5.38
Cyprus	1.41	1.36	1.34	1.31	1.24	1.09
Czech Republic	16.94	15.99	15.39	15.87	15.73	15.32
Denmark	20.66	19.33	19.16	19.41	18.8	19.04
Estonia	2.43	2.27	2.32	2.32	2.54	2.51
Finland	19.70	16.86	15.54	15.16	15.08	15.3
France	152.86	148.37	140.28	135.24	135.43	134.68
Germany	149.96	147.16	120.04	124.5	122.18	123.15
Greece	18.21	17.42	18.06	17.45	16.15	15.31
Hungary	13.91	12.92	12.69	13.27	13.08	14.37
Ireland	23.50	24.23	24.76	23.38	24.51	23.62
Italy	66.22	62.68	60.10	60.33	60.97	57.86
Latvia	5.5	5.55	5.72	5.76	6.08	6.20
Lithuania	18.29	11.22	10.99	12.07	11.27	10.40
Luxembourg	0.87	0.86	0.87	0.87	0.83	0.86
Malta	0.25	0.27	0.24	0.27	0.25	0.26
Netherlands	28	27.7	26.71	26.11	25.57	25.7
Poland	76.32	65.72	64.59	65.76	66.03	66.39
Portugal	12.5	11	11.5	10.6	11	11
Romania	22.60	20.17	20.71	21.75	19.61	19.51
Slovakia	10.95	10.01	9.51	8.0	7.84	7.69
Slovenia	2.45	2.48	2.44	2.5	2.46	2.37
Spain	58.10	57.47	59.5	56.30	54.00	55.64

Countries	2008	2009	2010	2011	2012	2013
Sweden	16.92	16.39	16.9	17.15	15.64	16.19
United Kingdom	77	71.31	72.50	69.12	68.51	68.77

Source: Authors' elaboration based on EUROSTAT 2015 data

The data in Table 2 reveal that the highest values emissions of nitrogen oxides were recorded in the following countries: France, Germany, Great Britain, Poland, Italy, Spain, and the Netherlands. The amount of nitrogen oxides emissions from these countries represent approximately 70% of total emissions of nitrogen oxides registered in European Union. EU's independence from imported oil and gas can be achieved by applying measures that lead to the development of clean technologies and energies with low or even zero carbon emissions. These could provide the premises for economic growth and the creation of new jobs. In this way investments can pave the way for the transition to a low carbon society (EC, 2016).

Resilience is an approach that provides a perspective for guiding and organizing thoughts. It also provides a valuable framework for the analysis of social–ecological systems (Folke, 2006; Folke et al., 2002).

One of the greatest challenges humanity faces is transition toward more sustainable development paths. The application of the resilience concept, based on outcomes of integrative scientific approach and transdisciplinary and interdisciplinary collaborations, offers the possibility to manage this transition (Lambin, 2005).

3. Conclusions

The present paper discusses the idea that due to the limited amount of natural resources, these cannot be considered the basis of economic growth anymore. Therefore, economic green growth should be sustained by economic activities characterized by real and fair increases which, obviously, are not based on the depletion of natural resources. Consequently, it is not possible anymore to strictly correlate the increasing exploitation of raw materials and energy to economic growth. Earth is no longer able to sustain high levels of GHG emissions and waste. Also, current development pattern cannot sustain the consumption of large quantities of raw materials. Therefore, in order to address global challenges, new approaches are needed and they must be different from those used so far (EGP, 2016).

The actual economic system causes loss of resilience of social-ecological systems, which means loss of adaptability and recovery capacity. The dependence of human societies and economies on ecosystems services (Folke, 2006; MEA, 2005) impose the consideration of strategies and policies for transition to green economy, where mitigation of, adaptation to, avoidance of, and recovery from environmental damages are targeted (EEA, 2015). In order to respond to the current environmental problems, analyses and measures must extend to broader spatial and temporal scales than they traditionally did and to identify instruments capable of generating a flexible and adaptive management of the local and regional social–ecological systems.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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Resilience of Mining Communities to Long-Term Environmental Stress in the Apuseni Mountains Area (NW of Romania)

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Abstract
The vulnerability of mining communities is one of great interest to governments, mining companies, non-governmental organizations and other stakeholders, becoming an acute issue of current sustainable development strategies. The question how to address the vulnerability of these particular settlements and communities impelled us to analyze the concept of resilience in the sustainable development context. Resilience is to communities all over the world a dominant concept which plays an essential role in guiding their sustainable development policies and strategies. The purpose of this chapter is to identify the specific aspects of the "resilience" term applied to the context of vulnerable mining communities. The research includes the theoretical background of the resilience of mining communities and identifies the most relevant resilience building factors. The present study is particularly important since the recently adopted 2030 United Nations Agenda for Sustainable Development focuses on enhancing community resilience. The findings may set the basis for more in-depth analysis and field research to identify and address the factors that affect the mining communities' abilities to be resilient.

Keywords: resilience, vulnerability, mining communities, environmental impact, sustainable development.

1. Introduction

The "resilience" concept has multidimensional aspects, being used in various scientific disciplines, such as physics, risk management, and social sciences. Generally, resilience is defined as "the capacity of a system to absorb shocks and disturbances, while still maintaining the same functions, structure and feedbacks" (Walker & Pearson, 2007). The term was introduced in ecological systems by Holling in 1973, who defined resilience as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973). Over the last decades, the concept was frequently used in disaster risk management, due to its meaning of returning to an original state and Coles & Buckle (2004) defined it as "community's capacities, skills, and knowledge that allow it to participate fully in recovery from disasters".

Starting from the resilience concept, the purpose of this chapter was set to identify the specific aspects of the term applied to the context of vulnerable mining communities. The research includes the theoretical background of the resilience of mining communities and identifies some of the most relevant resilience building factors.

To achieve this purpose, the authors find Ganor & Ben-Lavy's (2003) definition most appropriate to the specific research context: "the ability of individuals and communities to deal with a state of continuous, long-term stress; the ability to find unknown inner strengths and resources in order to cope effectively; the measure of adaptation and flexibility". Taking this definition as a reference point and considering the large differences between the urban and rural setting of a mining area, the best conceptual clarifications of resilience were searched for in the specific context of the mining settlements in the Apuseni Mountains, NW of Romania.

Analyzing the literature addressing the concept of urban resilience, the most relevant definition considered by the authors was that referring "to the ability of an urban system –- and of its constituent socio-ecological and socio-technical networks across temporal and spatial scales – to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" (Meerow et al., 2016). In the disaster risk reduction framework, urban resilience is seen as "a sustainable network of physical systems and human communities, capable of managing extreme events; during disaster, both must be able to survive and function under extreme stress" (Godschalk, 2003).

In terms of rural settings, resilience is "the capacity […] to adapt to changing external circumstances in such a way that a satisfactory standard of living is maintained. This also includes the capacity to recover from management or government mistakes" (Heijman et al., 2007). By analogy to urban resilience (Colding, 2007; CSIRO, 2007) the rural resilience concept "determines the degree to which a specific rural area is able to tolerate alteration before reorganizing around a new set of structures and processes" (Heijman et al., 2007).

The 2030 Agenda for Sustainable Development which was recently adopted by the United Nations highlights the importance of enhancing community resilience, aiming at "making cities and human settlements inclusive, safe, resilient, and sustainable" (UNSDG, 2015).

2. Measuring and assessing urban and rural resilience

Any territorial, social or economic system defining an urban or rural settlement has certain levels of vulnerability, risk, adaptive capacities, flexibility and resilience, which define that particular system, making it unique. Given the dynamics, the complexity, and the evolution of the settlements, these have shown an increasing trend towards development and resilience building.

The main factors shared both by urban and rural resilience refer to climate changes, natural and technological risks (including Natech – natural hazards triggering technological accidents), technological progress, people mentality, economic dynamics and evolution, and internal and external socio-political phenomena. There are many researches approaching the urban resilience assessment by use of mathematical formulas and resilience indexes in a more complex, holistic, pragmatic, and empirical manner (ARUP, 2016; ARUP, 2014; Attoh-Okine et al., 2009; Barbat et al., 2015; Cole, 2014; Flax et al., 2016; Pisano, 2012). We only mention here the City Resilience Framework and the City Resilience Index developed by Arup, which address urban resilience in terms of "four key dimensions" (Arup, 2016; Arup, 2014):

1. People: health and well-being;
2. Organization: in terms of economy and society, including all the social and financial systems which ensure the operation of urban systems;
3. Place: infrastructure and environment; and
4. Knowledge: good governance based on informed, inclusive, integrated, and iterative decision-making.

These four critical dimensions of urban resilience are based on 12 goals. These are minimal human vulnerability, diverse livelihood and employment, effective safeguards to human health and life, collective identity and community support, comprehensive security and rule of law, sustainable economy, reduced exposure and fragility, effective provision of critical services, reliable mobility and communications, effective leadership and management, empowered stakeholders, and integrated development planning. The City Resilience Index comprises 52 resilience indicators which are assessed based on both qualitative and quantitative data. Until now, the Index has been tested in five cities: Shimla (India), Concepcion (Chile), Arusha (Tanzania), Hong Kong (China), and Liverpool (United Kingdom) (Arup, 2015).

Although, from the quantitative point of view, there are more theoretical and empirical research outcomes on the identification of methods and mathematical formulas to calculate or measure urban resilience, the rural resilience also receives a relatively high attention, as there are some analysis and assessment methods available (Quaranta & Salvia, 2014; Schouten et al., 2009). The scientific literature includes some rural resilience assessment methods depending on various aspects or components, such as communities, households, agriculture, food safety, health, education, transport, climate changes, natural hazards, ecology, land use, energetic efficiency, natural resources, and economy. Unlike the urban environment, a Rural Resilience Index complex enough to approach in an integrated manner a sufficient number of indicators to cover all fields specific to rural areas has not been yet identified.

3. Environmental stresses in the Apuseni mining area

The mining communities under study are located in the NW part of Romania, in the Apuseni Mountains, which represent the most complex mountainous sector in the Western Carpathian Mountains (Figure 1). The landforms include relatively small mountains (less than 1850 m) and intramountainous depressions, resulting from several tectonic cycles, the last one being the Alpine cycle. The geological context was favorable to the formation of large mineral ores, such as gold, silver, iron, copper, zinc, and lead (Popescu et al., 1995), which have been mined since Roman times.

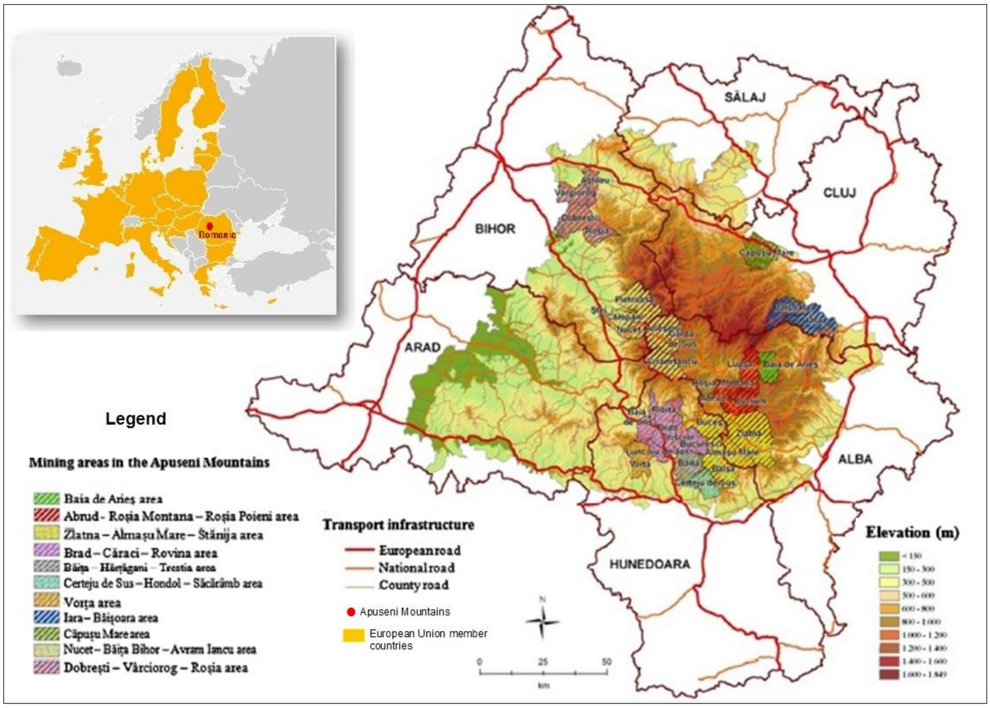

Figure 1. Location of the mining areas in the Apuseni Mountains
Source: Adapted from Constantin et al., 2015

Eleven mining areas were identified in the study perimeter, where mining of metalliferous ores (ferrous and non-ferrous) was conducted, with major environmental impact and development of a specific anthropogenic landscape. These mining areas can also be grouped by the type of the main ore mined (Table 1): 7 gold-silver and polymetallic ores mining exploitations in the Golden Quadrilateral (Alba and Hunedoara counties), 2 iron mining exploitations (Cluj county), 1 uranium exploitation (Alba and Bihor counties), and 1 bauxite exploitation (Bihor county) (Constantin, 2011). Among the metalliferous (ferrous and non-ferrous) exploitations in the Apuseni Mountains, the most scientifically attractive are those located in the Golden Quadrilateral, which includes the Northern part of the Hunedoara county and the Western and North-Western parts of the Alba county, hosting the largest gold deposits in Europe (Vlad, 2005).

Table 1. Mining areas in the Apuseni Mountains based on administrative-territorial criterion

No	Mining area	Mining exploitation	Main ores mined
1	Baia de Arieş	Baia de Arieş	gold, lead, zinc
2	Abrud - Roşia Montana - Roşia Poieni	Roşia Montana	gold
		Roşia Poieni	copper
3	Zlatna - Almaşu Mare - Stănija	Zlatna	gold, lead, zinc
4	Brad - Căraci - Rovina	Brad	gold, copper
5	Certeju de Sus – Hondol – Săcărâmb	Certeju	gold
6	Băiţa – Hărţăgani – Trestia	Băiţa	gold, lead, zinc
7	Vorţa	Vorţa	gold
8	Iara - Băişoara	Iara Băişoara	iron, lead, zinc, gold
9	Căpuşu Mare	Căpuşu Mare	iron
10	Nucet - Băiţa Bihor - Avram Iancu	Băiţa Bihor	uranium
11	Dobreşti - Vârciorog - Roşia	Dobreşti	bauxite

Source: Constantin, 2011

The past and present metalliferous mining exploitations activities have determined the physiognomy of the region. The anthropogenic landforms resulting from mining are defined especially by blowholes, waste heaps, and tailing dams.

The area includes few active mines, while most of them are closed and/or abandoned. The pollution problems did not disappear once the mining activity ceased. The abandoned mining sites include large amounts of wastes with a high content of mobile metals and particulate matters, which, through their drainage by the rivers or rainfall waters, are carried away and introduced into the aquatic circuit. That is the reason the abandoned mining sites represent large scale environmental pollution sources, especially of the hydrographical networks. The scientific literature mentions the acid mining drainage as the main source of pollution in the hydrographical basin of the Arieş River, as well as in the sub-basins of its tributaries (Forray, 2002).

The natural potential to generate acid drainage adds to these anthropogenic sources. The rocks with the highest potential to generate acid waters in the area are the volcanic breccia. The pH values decrease below 2, thus driving a massive mobility of heavy metals in the rock (Baciu, 2007).

By the lixiviation of the rainfall waters through the tailing dams, the latter charge with pollutants, especially heavy metals. High levels of some metals (Pb, Cu, Cd, Zn) concentrations in Arieş water and its tributaries and the low pH values due to the significant metallic sulphur content of tailings and sediments suggest that, even when closed, the mines and tailings dams from the area represent continuous pollution sources of natural waters, even after the mining activities have ceased (Ozunu et al., 2009).

Taking into consideration the long history of mining in the area, one can speak of historical soil pollution. This phenomenon has been greatly amplified during the last 4-5 decades due to the low technological level and to the inadequate exploitation/processing methods, as well as to the intense pace of exploitation. The pollution was considerably enhanced by the storage of tailings on unprotected terrains, under the circumstances of high levels of heavy metals and toxic substances used in the processing of metals. The affected areas have extended along the time by their subjection to the natural processes (precipitations, frost/defrost, wind, and water seepage). The close connection between the environmental media water and soil has led to the situation that the water pollution sources mentioned above constitute also soil pollution sources.

The presence in the study area of 20 tailing dams storing some of the 36 million tonnes of mine tailings in Romania (Modoi et al., 2009) containing toxic heavy metals, combined with the soil erosion issues (Ștefãnescu et al., 2011) increase the landslide and Natech risk in the area. The highest risk induced by tailing dams is represented by the unexpected collapse/breach. Past events such as Baia Mare mining disaster in January 2000 or Borșa incident in the same year, as well as the 1971 failure of the tailings dam just upstream of Certeju de Sus are regrettable examples (Bird et al., 2008; Modoi et al., 2009; Zobrist et al., 2009). These are typical examples of Natech incidents, when natural phenomena (heavy rainfall and sudden snow melting) caused dam failures.

4. The resilience building factors in the studied mining areas

Considering the above-mentioned aspects, the region's evolution and socio-economic development was determined by the mining activities developed here since ancient times. The dominant feature of these mining areas is the environmental, social, and economic vulnerability of the mining settlements and communities. Stress resistance or resilience is the antonym of "vulnerability", which generates persistent dysfunction, an alternative outcome to renewed and adapted functioning (Norris et al., 2008). The persistent dysfunction of a certain region or community can be caused by natural resource degradation, loss of agricultural production, urbanization, demographic changes, climate change, political instability, and economic decline.

Previous studies (Alexandrescu, 2011; Botezan et al., 2015, Constantin et al., 2015; Surd et al., 2007; Sorocovschi, 2010) in the rural parts of the study area have shown a rather high vulnerability degree determined mainly by the intensification of the depopulation and demographic aging phenomena, low degree of resource capitalization or limited access to information regarding the development opportunities. To these, one may add the poor governance translated into the shallowness or negligence of the decision-makers regarding the rapid environmental degradation of the mining areas; this is caused by the presence of abandoned mining sites which continue to pose threats to the environmental factors and exposed communities (Constantin et al., 2015).

In order to identify the resilience building factors, community resilience can be addressed as a set of networked adaptive capacities identified by Norris et al. (2008) and tailored to the specific mining context. These adaptive capacities are: social capital, economic development, community competence, and information and communication.

Considering the complexity of the defining aspects of the mining settlements, some specific socio-economic features of the mining areas in the Apuseni Mountains are mentioned below. In terms of **social capital,** the mining settlements, especially the rural ones, present a series of negative demographical phenomena as a result of mine closure. The most serious of these are: enhanced depopulation and demographic aging phenomena, increased unemployment rate among the young population, low natality, low percentage of active population, etc. Another restrictive aspect in the socio-economic regeneration of the settlements after the closure of mining activities is represented by the mentality of the population characterized by reluctance, rigidity, and resistance to changes and opportunities which can determine economic development and society progress. This was the fate of the former mono-industrial towns, particularly the mining ones, which are faced with a high poverty rate. The same situation can be seen in the small, agricultural, or newly founded towns.

Economic development of mining areas is translated into resource management, infrastructure, resource equity and social vulnerability, investment opportunities, and economy diversity. The configuration of the mining settlements is the result of both spontaneous development closely connected to the mining exploitation (most of the rural mining settlements) and of the development based on urban planning documentation and land use planning (e.g., the small towns of Ștei and Nucet in Bihor county were built especially for the mining activities and have a relatively new history).

Given the geologic and metallogenetic features, the metalliferous resources (ferrous and non-ferrous) are located in the mountainous area; hence, low accessibility is one of the biggest problems of the mining areas in the Apuseni Mountains. Therefore, many rural mining settlements are remote, with poor road infrastructure. The mining towns in the Apuseni Mountains are small and have medium accessibility. The settlements, especially the rural ones, are also characterized by a poor, little functional insufficient or, in some areas, even inexistent public infrastructure. This makes the settlements unattractive both for residents, and for possible investors. Moreover, these are also poorly equipped in terms of social services (education, health, culture, recreational activities, etc.). From the land use planning point of view, there are many fragmented properties, while the mentality of the residents is one of reluctance regarding possible economically beneficial enterprises.

Last, but not least, as previously mentioned, one of the most important actions following mine closure should have been the resolution of the environmental problems, ecological rehabilitation of the affected areas, and post-mining works in compliance with the related regulations. Unfortunately, although funds have been assigned for rehabilitation, there actually has been, with few exceptions, a high degree of ignorance on behalf of the decision-makers in addressing the environmental issues responsibly. In addition, there are still many areas where the pollution rates are high due to both the lack of impact mitigation, assessment and monitoring system, and the shallowness of rehabilitation activities. Analyzing the last decade, we can say that decision-makers in the Apuseni Mountains and, in general, in Romania, have proven a low capacity of managing the accession of new funds and resources and of efficiently using the existent ones. Moreover, the funds from the programs dedicated to the training and active re-integration of unemployed miners were also inefficiently managed.

Before the mine closure, most of the mining areas in the Apuseni Mountains were acting as demographic convergence areas. The policies and projects meant for the development of the settlements in the Apuseni Mountains after mine closure till now clearly indicate the fact that there is no strategic vision for the integrated sustainable development and no culture regarding partnerships in developing and implementing viable projects. Furthermore, the "spatial conflict between the uses of the environment has negative economic implications" (Alexandrescu, 2011). These implications are highly visible in Roşia Montană, where several economic sectors such as mining, agriculture, and forestry have long provided good income to the local community, while the development of the new mining project would make the local economy dependent on a sole income source: mining (Alexandrescu, 2011). However, there are many development opportunities of the mining settlements in the Apuseni Mountains translated into resilience building factors, such as investments and encouraging entrepreneurship to be reflected in the development of the local economy.

Such opportunities can be pursued in the following fields of activity: (i) tourism and especially agritourism (the Apuseni Mountains have a rich natural heritage – caves, gorges, natural reservations, natural monuments, etc., as well as anthropic heritage, which is favorable to promotion of local values; (ii) capitalization and promotion of crafts and traditional occupations; (iii) exploitation of construction rocks (the Apuseni Mountains are highlighted as a "petrographic mosaic"); (iv) organic agriculture (especially the development and expansion of the zootechnical sector, cultivation of local fodder crops, etc.); (v) wood processing (which is a tradition for the residents; however, the raw material is not used in an efficient manner and many of the small companies limit their activity to primary processing of the wood, without producing end products); (vi) capitalization of industrial sites; (vii) development of light industries, especially the manufacturing of clothes, shoes, and leather goods (considering the high unemployment rates among the female population, but also the presence of workforce which can be easily re-trained and actively re-integrated).

Community competence includes collective action and decision-making, capacities that arise from collective engagement and consultation. Collective action is complex and challenging in the face of environmental threats (Norris et al., 2008) and it is proven in our study area by the powerful conflict generated by the Roșia Montană mining project. This conflict led to massive street protests known as the 2013 "Romanian autumn" movement (Goțiu, 2013). Among the community skills that can build resilience one could mention engaging constructively in group process, resolving conflicts, collecting and analyzing data, and resisting undesirable influences (Goodman et al., 1998). Environmental threats also activate and enhance collective action, when local groups formed mainly by directly affected residents oppose bad political decisions. Starting from local NGOs opposing a dangerous and disadvantageous mining project in Roșia Montană, there was a growing power of international NGOs which militated against corporate misconduct and spoke against the exploitation of the lands and of powerless communities (Alexandrescu, 2011). This is another community competence resilience building factor, which deals with the capacity to recover from management or government mistakes (Heijman et al., 2007).

Information and communication of the communities conducted in a fair and correct manner is another resilience building factor which contributes to collective efficacy and empowerment. A powerful and engaged community is an informed one. Proper risk communication is essential for community resilience (Ganor & Ben-Lavy, 2003) and it should be based on solid scientific knowledge on local environmental risks and on the needs of the communities.

5. Conclusions

The studied region lacks neither resources (natural potential, touristic potential, ethnographic heritage, crafts and traditional activities, etc.), nor the adaptive capacities to enhance resilience, as they were highlighted in this research.

With a more efficient management of existing resources and better decision-making in terms of funds accession and project implementation, the resilience of the studied mining area would significantly improve. Moreover, this would be enhanced by the proper re-training and active re-integration of unemployed people who lost their jobs following the mine closure. Despite the high vulnerability degree determined mainly by the intensification of the depopulation and demographic aging phenomena, low degree of resource capitalization or limited access to information regarding the development opportunities, the region is clearly one of great development potential, due to its valuable natural and anthropic heritage.

The long-term environmental stress induced by the mining activities has not only affected the quality of life and landscape, but it has also increased the overall vulnerability of the region. The improperly closed or abandoned mines are still a threat to the environment and health of population and require immediate rehabilitation measures.

In economic terms, despite the long-established mining profile of the region, the problem of high poverty rate can only be addressed by economic diversity. Agriculture, tourism, agritourism, light industry, and wood processing activities are good income sources to the local community, while the economic dependency on mining, however profitable it may seem, would only lead to increased social and economic vulnerability in the long run.

Conclusively, the main factors that make the region resilient are the rich resource legacy, skilled and entrepreneurial workforce, diversified economy, better access infrastructure, development of supportive financial system to provide funds, competitiveness, and better governance supported by science, and last but not least, enhanced collective responsibility.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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MAPOx (Automatic Modules for Water Potabilization Using Advanced Oxidation and Biofiltration). Case Study: Cruset - Water Potabilization Station, Gorj County

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Abstract

MAPOx modules are designed for water potabilization in a centralized system, using surface water or underground water with complex contamination. The advantage of using the MAPOx module is that it provides a high degree of reduction of pollutants without using chemicals or resulting toxic by-products, based on an eco-friendly technology. The modules provide an advanced potabilization, this technology being composed of: the electrochemical step which uses physico-chemical processes by electrolysis for oxidation with the aim to reduce the size of the organic carbon and phosphorus molecules; the biological step – biofiltration using biochemical processes like nitrification, denitrification and anammox to reduce the compounds of nitrogen; and the final step – disinfection of drinking water by ozone. Groundwater source in the village Cruset (Romania) is polluted with ammonium ion, being classified in the category of „hard for potabilization" according to Romanian norm NP-133/2013. In order to reduce the concentration of ammonium ion, MAPOx-20 module has been mounted in the water potabilization station from Cruset, Gorj county. The tests results showed that ammonium concentration decreased from 14.28 ppm to 3.2 ppm in 5 days, in this time the biofilter stabilizes, and after 10 days, ammonium concentration reached 0.05 mg/l. This value remained constant over a long period. It was also noticed that all nitrogen compounds (ammonium, nitrates and nitrites) are reduced using the MAPOx-20 module.

Keywords: automatic module, MAPOx, ammonium, advance oxidation

1. Introduction

Water source (raw water) in the Cruset village is polluted with ammonium ion. In this case the ammonium ion concentration is in between 12-14 mg/l (wells 1, 2 and 3), and the hydrogen sulphite concentration is between 1.2-2.5 mg/l. If the ammonium ion concentration is higher than 2 ppm in water supply, this water is classified in the category of "hard for potabilization" according to NP-133/2013 (MDRAP, 2014) norm and it is recommended to choose other sources of water for potabilization.

Current techniques for treatment of water which has high concentration for ammonium use chlorination for ammonium reduction (with a dose of chlorine of 8-10 x ammonium concentration), followed by the filtration of water in activated carbon filters to retain bound chlorine. The retention capacity of bound chlorine by activated carbon is reduced after several months of operation, so that the produced water will have a higher concentration of bound chlorine than the legislation demands.

The MAPOx modules provide an advanced potabilization technology which is composed of several steps. The first is the electrochemical step which uses a physico-chemical processes with electrolysis for oxidation destined to reduce the size of the organic carbon and phosphorus molecules; the biological step – biofiltration using biochemical processes of nitrification, denitrification and anammox included in the system to reduce the compounds of nitrogen; and the final step, which refers to disinfection of drinking water with ozone. Additionally, the technical and economic evaluation of the chlorine and of the MAPOx demonstrated higher performances of the latter, showing that it is possible to have both economic efficiency, technical performance, and environmental protection (Petrescu-Mag et al, 2016).

By using MAPOx technique the water quality fits within the Romanian legal norms provided by Law no. 458/2002 (Romanian Parliament, 2002), i.e.:

a) ammonium < 0.5 mg/l;
b) turbidity ≤ 10 NTU;
c) TOC ≤ 3 mg C/dm^3 (TOC= total organic carbon);
d) biological – zero;
e) bacteriological – zero;
f) pleasant taste.

Technological flow of ammonium reduction with bio-filtration (development in the bio-filters of bacterial cultures which use ammonium as food) is made as an alternative for chlorination and it has the advantage of non toxic by-products result (nitrification bacteria are not harmful for humans, animals and fish).

In order to reduce the concentration of ammonium ion, the MAPOx-20 module was mounted in the water potabilization station from Cruset, Gorj county (Figure 1).

Figure 1. MAPOx-20 module from drinking water station Cruset, Gorj county
Source: Photo taken by authors

2. MAPOx module description

The main steps of MAPOx technique are the following:

1. Electrochemical step and pressure aeration (pre-oxidation step)
2. Bio-filtration step in pressure filters
3. Disinfection step with ozone.

2.1 Electrochemical step

The purpose of electrochemical step is to generate in water nonspecific oxidants like hydroxyl radicals, hydrogen peroxide, active oxygen ions, chlorine and hypochlorite ions (Li et al., 2010). The scope is to oxidize the organic matter dissolved in water in order to mineralize or to reduce the size of the molecules, making them biodegradable for the bio-filtration step (Hu et al., 2009). For this purpose, if there is not sufficient chloride in the water to generate free chlorine, brine is added in the water before the electrochemical treatment (Orescanin et al., 2011).

Figure 2. Electrochemical step (pre-oxidation) in MAPOx-20 module from drinking water station Cruset, Gorj county
Source: Photo taken by authors

The electrochemical step is composed of a source for power generation and electrolysis cell.

The source of generating pulsating currents is composed of an inverter iG5A nominal output of 4 kW produced by LG inverter supplied with voltage three-phase 400 V, 50 Hz, which generates an output voltage of three phases between 0 and 400 VAC at a frequency of 0-400 Hz, depending on the control signal.

Electrolysis cell is composed of three groups anod-cathode electrodes which are successively mounted in the flowing water (see Figure 2, Figure 3), each anode being supplied with voltage-current pulses from the source described above.

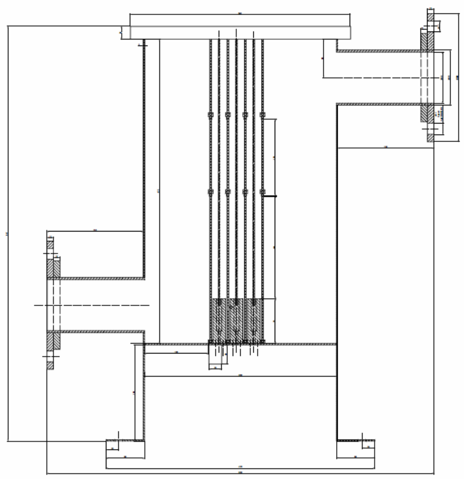

Figure 3. Side view through electrolysis cell of the electrochemical water treatment equipment
Source: Authors' elaboration

Electrolysis cell is made from a parallelepiped tub from stainless steel in which the electrodes are mounted. Water enters in the tub through a port with 80 mm diameter, mounted on the left side, and is distributed in a relatively uniform way in the inlet cell where it meets the first cathode, which is a stainless steel mesh with holes of 1.5 mm diameter. After that, water reaches the first anode, which is a titanium mesh coated with ruthenium and iridium, with a hole of 2.5 mm diameter and sizes of 170 mm x 400 mm x 2.5 mm. In order to isolate the anodes from the stainless steel tub (which is connected to the mass and cathodes), they are mounted in a grill of isolating material, which, in this case, is PVC-U with a minimum thickness of 20 mm. After the first anode, the first cathode follows and the sequence repeats. So, the tub consists of four cathodes connected through a stainless steel tub at the entrance of the terminal and of three anodes supplied with different voltage-current pulses.

Aeration after electrochemical treatment step is used to enrich the water with oxygen and to eliminate unwanted gases dissolved in water (H_2S, CO_2, and so on). Aeration is done in a mixture column with an air compressor of 250 W.

2.2. Bio-filtration step

The purpose of bio-filtration step is to reduce the nitrogen compounds (ammonium, nitrite and nitrate) and organic matter from water by bacterial environment which eats ammonium (nitrogen compounds) and organic carbon, through the biochemical process like nitrification, de-nitrification and anammox (Fish et al., 2012).

The bio-filtration process is composed, in essence, by two superposed processes. One is the physical process of adsorption by filtration of substances dissolved in the water and the other is a biochemical process of reduction of the dissolved compounds through their consumption by specific bacteria which feed on this pollutant (Zhao et al., 2011).

The specific populations of bacteria which are used in bio-filtration process are in the form of clusters on different surfaces (fixed or mobile) which are placed in environments that ensure living conditions favorable to their existence and development (Kelly and He, 2014). By living conditions it is understood the physical and chemical conditions. These cultures of bacteria are known as biofilm. The most important physical conditions in the existence of biofilm include: temperature (which should be optimal for each bacterial culture), water flow through bio-filters (flow rates through layers) and light intensity on biofilm surface. Chemical conditions refer to water pH, oxidation-reduction potential (ORP), and chemical substances dissolved in the water that is necessary for carrying out biochemical reactions in the vicinity of biofilm. When these conditions are met, the biofilm (bacteria) develops on available solid surfaces to a certain thickness, depending on substances concentration. Over a certain thickness, the bacteria living on the inferior part of the biofilm (on the support material) do not receive the chemical substances needed for growth and they die, resulting in biofilm detachment.

Biofilm growth reaches a saturation value that depends on the physical-chemical conditions in the nearby environment. Of course, there are free bacteria in the water, too, but they cannot efficiently process chemicals from water, as bacteria grouped in biofilms do. Because of this, materials with high porosity are used for bio-filters as they able to provide large area per unit volume (Claros et al., 2010; Hanusová, 2015). The amount of biomass (biofilm) that develops in the unit volume of bio-filter layer depends on the chemicals concentration required in the vicinity and on the solid surface needed for their development.

To reduce high concentration of ammonium, it is necessary to introduce nutrients (carbon and phosphorus) in water to allow the biochemical reactions to take places. A controlled dosage of nutrients in the water is necessary to reduce the high concentrations of ammonium and to allow the biochemical reaction to occur (between carbon and phosphorus, and between phosphoric acid and acetic acid). Also, a solution of the nitrification bacteria (biomass) is dosed when the bio-filters are installed for the first time in a water station or whenever it is necessary (White et al., 2012).

Bio-filter step needs the following: pump dispenser for nutrients and biomass, at least two bio-filters connected in parallel, electro-hydraulic valves for filtering or washing, and one air compressor at the base of each filter (Figure 4).

Figure 4. Bio-filtration step
Source: Photo taken by authors

The horizontal surface of the filter is selected so that the nominal speed of filtration in bio-filters is less than 6 m/h (in accordance with the provisions of the NP 133-1/ 2011 norm) and that the water circulates vertically in the filter (upward for nitrification and downward for denitrification). The height of the filter layers is measured from the top level of strainer which collects filtered water. The supporting material is mounted from this level down, supports the filter layers and makes hydraulic flow uniform. The supporting material is made of marble granules with size between 6 and 10 mm. The filter layers are as follows, from bottom to top:

1. Layer of marble granules with size 3-6 mm, and high of 0.2 m;
2. Layer of sand with size 0.8-1 mm, and high 1.2 m;
3. Layer of active carbon (mangal) with size 2-5 mm and high 0.5 m;
4. Layer of marble granules with size 3-6 mm, and high of 0.2 m used for mangal fixation.

Bio-filters volume is calculated according to the pollutant needed to be reduced. Thus, the reduction rate of nitrogen compounds in bio-filter layers at a water temperature of 15 ^{0}C is defined. For other temperatures correction is required. Filter layers are made of sand and charcoal. At the beginning of the process in the filter layers, specific bacteria for pollutant reduction are introduced. During operation, when needed, the solution of bacteria is dosed into the water by the nutrients pump. In Table 1 specific reaction rates are shown. The rate of biochemical reactions depends on the time of operation of the filter, on doping materials with specific bacteria filter (0.1-0.3 kg biomass / m^3), and it is calculated by multiplying the maximum rate of the T / T_A, where T_A is the priming time of the bio-filter (Gimbel et al., 2006; Melin et al. 2006; van der Wielen et al. 2009).

Table 1. Reaction rate in the filter layers

Biochemical reaction type	Reaction rate (μ) [kg nitrogen/m^3 * day]	Priming time–T_A [days]
Nitrification	0.25…0.6	14
De-nitrification	0.1…0.3	30

Source: Authors' elaboration

Biochemical reaction rate is calculated with equation (1):

$$\mu_{REACTION} = \frac{C_{IN}^{NITROGEN} - C_{OUT}^{NITROGEN}}{V} \quad (1)$$

Where: μ = reaction rate; C= concentration; C_{IN}= pollutant concentration at the inlet of the biofilter and it is determined by direct measurements; C_{OUT} = concentration at outlet and it is calculated with equation (2); C_{OUT} must have values below the concentration stipulated in Law no. 458/2002, amended in 2012; V= total volume of filtration materials (total volume of sand layer or of other material used for filtration).

Concentration of the pollutant in layer k, where $0 \leq k \leq n$, is:

$$C_{Layer\ k} = C_{Layer\ k-1} - \mu_{MAX} \cdot \frac{T}{T_A} \cdot \frac{C_{Layer\ k-1}}{\mu_{1/2} + C_{Layer\ k-1}} \cdot \Delta t \quad (2)$$

Where: $\mu_{(MAX)}$ = maximum biochemical reaction rate; T = functioning time; T_A = priming time; $\mu_{1/2}$= half-life reaction rate

In the volume ∆V, water is stationary for a time ∆t, then it instantly moves into the next volume ∆V, and flow direction is from top to down.

$$\Delta t = \frac{\Delta V}{Q_{Flow\ of\ filtered\ water}} \quad (3)$$

Where: Q = flow of filtered water (m3/day)

The concentration of the pollutant which is reduced in biofilter is calculated with the following formulas:

$$\Delta V = \frac{\pi(\frac{\emptyset_{FILTER}}{2})\cdot H_{LAYERS}}{n} \qquad (4)$$

Where: Π = constant (3.14); Ø = filter diameter; H = layer height; n = number of layers.

2.3. Disinfection step

The disinfection step with ozone consists of an ozone generator (Figure 5), which produces ozone from oxygen enriched air (90%). The system consists of an oxygen concentrator, a system of injection of ozone in water, a reaction vessel, a valve degassing, and a destroyer for residual ozone gas.

The ozone generator has a coupled design which includes the ozone generator itself. This contains tubes of quartz which have inside an electrode sheet made of stainless steel and which are mounted inside of stainless steel pipes. There is an area of 0.75 mm between the quartz tube and the metal pipe which allows oxygen to flow by. This oxygen generates ozone when an alternative voltage in the range of 8-14 kVeff is applied on the high tension electrode in relation to the stainless steel pipe which is the electrode mass. The high alternating voltage required for the generation of ozone is cut by a one-phase voltage step up (400 V / 14 kV, 400 Hz) which is fed at its turn by a three-phase inverter, where one of the phases of the output of the inverter is not connected, while the other two reach the one phase adapter through a band-pass filter.

Figure 5. Ozone generator
Source: Photo taken by authors

The goal of disinfection step with ozone and chlorine is to eliminate bacteria and microorganisms from treated water and to confer a proper taste to treated water.

3. Results and conclusions

Tests were performed on MAPOx-20, and the goal was the reduction of target parameters, which were ammonium and organic matter, for the present case.

Functional modules were also separately analyzed to obtain information on their performance and on system calibration. Tests were conducted in the drinking water treatment plant from the village Cruset, Gorj County, where a MAPOx-20 module was placed.

Samples were analyzed according to standardized methods for analysis and were kept at a low temperature of 4 ° C.

Samples were taken from:

- inlet of the MAPOx-20
- outlet of the MAPOx-20

Regarding the frequency of sampling, they were performed daily for a period of 10 days.

Experimental determinations were made on MAPOx-20 prototype and they primarily aimed to target parameter ammonia and nitrogen compounds from water (Table 2, Figure 6).

Table 2. Tests result at the outlet of MAPOx-20 module

Day / Parameter	Inlet	1	2	3	4	5	6	7	8	9	10	CMA according to Law 458/2002
pH	7.92	7.32	7.40	7.68	7.52	7.45	7.55	7.48	7.68	7.69	6.65	6.5-9.5
Ammonium (mg/l)	14.28	11.5	7.12	6.68	3.12	1.01	0.52	0.12	0.08	0.05	0.05	0.5
COD (mg/l)	7.56	0	0	0	0	0	0	0	0	0	0	5
Nitrates	8.96	16.3	9.26	7.05	6.89	6.23	6.52	6.38	4.35	3.82	3.01	50
Nitrites	0.25	0	0	0	0	0	0	0	0	0	0	0.5

Where: COD = chemical oxygen demand; CMA = maximum level allowed
Source: Authors' elaboration

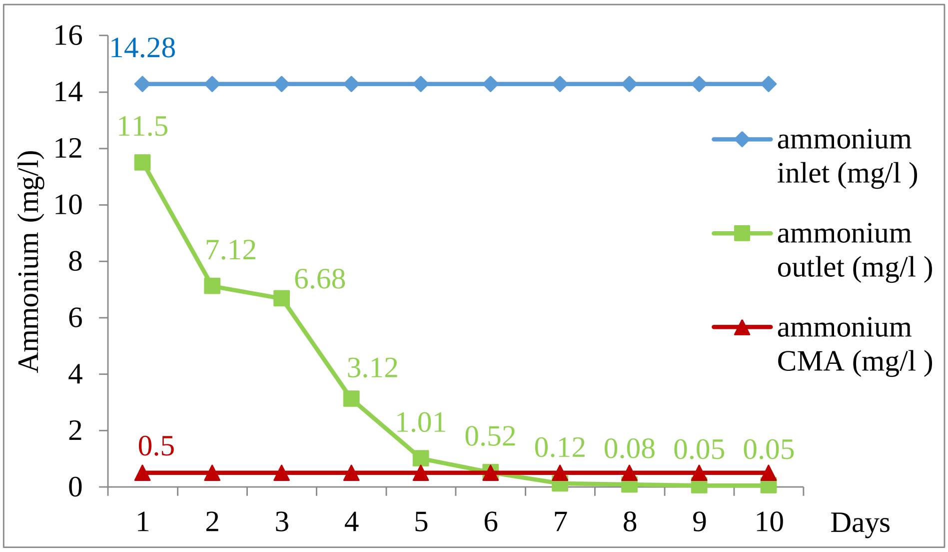

Figure 6. Ammonium variation in the biofiltration step
Source: Authors' elaboration

The following conclusions resulted from the experimental determinations:

- From the analysis of the inlet water and from the treatment steps, it was observed a decreased in all studied parameters;
- Ammonium decreased from 14.28 to 0.05 mg/l in 10 days, which is the period needed by the bio-filter to stabilize; after that, tests continued and showed that the amount of ammonia measured at the outlet of the module remained constant;
- Also, it was noticed that all parameters with nitrogen (ammonium, nitrite, and nitrate) were reduced after water was treated with MAPOx-20 module;
- Free chlorine and oxidated organic substances resulted during the process of electrolysis;
- A good correlation between the experimental data and the predicted values was obtained;
- TOC was zero, which indicates that following ozonisation, organic substances were not found in water, and, therefore, no bacteria;
- The parameters of water treated with MAPOx-20 module fitted with the legal norms of Law no. 458/2002 amended in 2012.

By using the MAPOx-20 in water treatment plant, the water quality complies with the Romanian norm Law no. 458/2002, i.e.:

- Ammonium < 0.5 mg/l;
- Turbidity ≤ 10 NTU;

- TOC ≤ 3 mg C/dm^3;
- Biological: zero;
- Bacteriological: zero;
- Pleasant taste.

The advantage of using the MAPOx module is that, due to an eco-friendly technology, it provides a high degree of reduction of pollutants without using chemicals or generating toxic by-products. The disadvantages of using bio-filtration for ammonium reduction are that it needs a large volume of water (large filters) for filtration and that the priming time is about several weeks.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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Fertilization and Pesticides as Elements of Pressure on Microbial Communities

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Abstract
Evaluation of biological assembly of a terrestrial ecosystem is generally observed from an aboveground quantitative perspective, without taking into account the diversity and extent of microbial functional processes. The use of resources is directly proportional to the microbial community structure and function, which are not reflected in current techniques for data analysis. In order to describe the anthropogenic pressure on ecosystems we focused on microbial communities profiling techniques and we proposed a new functional model in order to describe it, separately on complementary segments of ecological niche. Community level physiological profiling (CLPP) is a technique with high sensitivity to the elements introduced in soil due to anthropogenic activities. The method has the potential to analyze the decomposition of substrates and the ability to identify specific patterns for each ecosystem. The pressure exercised by fertilizers and pesticides is visible in the reduction of microbial functional diversity, through the activation of small microbial groups. The processes of decomposition and mineralization of matter are dependent on the magnitude of the effect of these practices. The analysis of ecological niche by complementary segments leads to a complex analysis of specific associative structures that restrict the spatial-temporal development of microbial functional groups.

Keywords: microbial communities; contaminants; matrix of segmentation; diversity indices; community level physiological profiling.

1. Introduction

Microbial functional diversity is an important component of biological organization of an ecosystem, with high potential in spatio-temporal modelling of internal functional processes and forecasting subsequent transformations (Mason et al., 2005; Rutgers et al., 2016). The highest reserve of biodiversity lives in soil and assembles ecosystems with high spatial and temporal heterogeneity (Hinsinger et al., 2009). Most of current research is focused on the ecosystems productivity, without correlating its stability with the usage of resources and diversity of organisms involved in matter conversion (Eisenhauer & Schädler, 2011). Microbial community structure and function are two essential components of the circuit and conversion of nutrients in soil (Mulder & Lotz, 2009). A series of studies suggest the use of resources as an indicator of microbial groups specialization (Chodak et al., 2015; Komarov et al., 2012; Renault et al., 2013). The use of such an indicator enables internal processes to be connected with appropriate complementary segments of ecological niches. Reaction to external disturbances, microbial groups association or restriction can be seen in the resource use efficiency, which leads to a complex overview on functional communities (Fitter et al., 2005; Zhang et al., 2009). The type of biomass available in soil and organo-mineral inputs affect decomposers, leading to homogeneously distributed processes or inducing the emergence of high activity areas (Crotty et al., 2015; Kitz et al., 2015).

A great accuracy of observations made on changes in microbial communities is required to introduce transformation of farming techniques that will lead to a better folding on ecopedological conditions and to reduction of their environmental impact (Duru et al., 2015). The addition of inputs leads to rapid succession in natural communities (Rivett et al., 2016), which will radically–change the aspect of ecological niche (Nunan et al., 2015; Sradnick et al., 2013). Inputs such as fertilizers or organic matter activate microorganisms to consume extra resources (Kuzyakov, 2002).

2. Physiological profile of microbial communities -- indicator of substrate utilization

Community-level physiological profiling (CLPP) is a powerful technique for assessing and determining the level of soil fertility (Garland, 1997; Islam et al., 2011; Li et al., 2016), with high sensitivity to fertilization and crop rotation. Two methods are considered performant for this type of application: Biolog Eco plates and Microresp^{TM}. Biolog Eco plate has a diverse range of predefined substrates, considered standardized for assessing microbial community reaction to various factors with external pressure on soils (Garland & Mills, 1991; Islam et al., 2011). The method expresses microbial activity as the average well color development (Garland, 1997). Profile of method relies on the identification of microbial decomposition patterns for soil carbon sources, habitat-specific and reproducible, while providing a realistic picture of space-time deviation within communities (Smalla et al., 1998). Microresp^{TM} method is a multiSIR application (Campbell et al., 2003; Swallow & Quideau, 2015), with the difference to Biolog Eco plates that the detection plates are free of substrate, which makes it possible to inoculate the plate with any substrate and desired concentration considered relevant. MicroResp^{TM} is a method for discrimination of changes in microbial community, offering distinctive features of CLPP depending on the pressure of external variables (Bougnom et al., 2010; Chapman et al., 2007). Both methods allow the incubation for a period from several hours to days, with good results on the decomposition of substrate and for the diversity indices. Microbial functional diversity sums ecological processes carried out by different groups of microorganisms, while concentration and availability of substrate act as restrictions in the dynamics and composition of communities and maintain the functioning of terrestrial ecosystems (Pignataro et al., 2012; Zabaloy et al., 2016). Microbial communities are faithful indicators for anthropogenic disturbances, providing valuable indications on the successional trajectory in ecosystem (Banning et al., 2011; You et al., 2014). Spatial organization of soil particles stimulate the formation of micro-ecological niches with increased microbial activity (Lagomarsino et al., 2012).

Identification of dominant and co-dominant groups within communities is a step of utmost importance in ecological studies (Kikvidze & Ohsawa, 2002). Functional and organizational mechanisms of microflora inside an ecosystem are structured especially around powerful groups (Condron et al., 2010; Buscot & Varma, 2005; Strickland & Rousk, 2010). This aspect requires their study in the first stage of assessment and links the results to the internal dynamics of microbial community. The dominance of a group in the soil is due to its adaptation to environmental conditions, which stimulates rapid and strong response to any changes of resources or management (Chandna et al., 2013). On the other hand, co-dominants are weak competitive groups capable of strong fluctuations induced by disturbances (Bever, 2003). Stratified analysis of microbial groups may lead to a better understanding of the assemblage mechanisms of a community and to the identification of a realistic level of functioning (Kim & Liesack, 2015; Miki et al., 2013).

3. Fertilizers and pesticides as pressure factors

Current agronomic techniques involve extensive use of plant protection products and mineral fertilizers, due to the increase of world population and socio-economic pressure caused by this phenomenon. Application of fertilizers or pesticides on soil is rapidly visible in the ecology of this space, altering both form and accessibility of substrates (Soman et al., 2016; Zhao et al., 2016). Application of organic inputs increases metabolic activity of microbial community, but it may induce adverse effects on specialized groups (Bünemann et al., 2006; Insam et al., 2015). Mineral fertilization significantly reduces the population size inside the microbial community, activating especially autotrophic groups. The addition of inhibitors is useful in reducing the loss of nitrogen from mineral fertilizers, in particular for nitrification, but acts directly by reducing the population of nitrifiers and indirectly by destabilizing the entire microbial community (Florio et al., 2016). In general, application of organic fertilizers supplemented with mineral fertilizers increases the value of microbial diversity, a positive aspect caused by the activation of decomposers group (Chen et al., 2015b; Zhong et al., 2010). In this context, long-term balanced fertilization stimulates the increase of diversity and consistency of microbial community functioning (Ge et al., 2008; Hu et al., 2011). The type of plant biomass involves changes in the microbial community, the organic carbon source stimulating the metabolic activity of specialized groups (Creamer et al., 2016; Lerch et al., 2013). Microbial community strategy and transformation potential is directly dependent on substrate consumption dynamics in soil, setting specific functional processes (Brackin et al., 2013; Yu & Steinberger, 2012). A constant addition of mineral fertilizers along with the incorporation of plant residues in soil reduce microbial diversity compared with the situation when only organic fertilizers are applied (Sradnick et al., 2013). Specificity of substrates use, particularly the processes which modify the C:N ratio, provides a good discrimination between geographically distant ecosystems related to their management and addition of nutrients (Zabaloy et al., 2016). A reduction of organic carbon in soil is manifested through a reduction of mineralization processes and associated microbial groups (Lerch et al., 2013).

Incorporation of xenobiotic elements into the nutrient flow leads to a change in the microbial community with a strong impact on the entire ecosystem and changes in the functional mechanisms (Jian et al., 2008). In the economy of ecosystem, accumulation of heavy metals severely reduces metabolic efficiency (Chen et al., 2015a; Wang et al., 2011), with the inhibition of large number of microbial functional groups. Unlike fertilizers, pesticides are a group of substances less studied as elements of pressure on microbial community (Stanley & Preetha, 2016). Pesticides have a cumulative effect with the dose and type of fertilizer applied in agriculture (Chen et al., 2007), microorganisms having a rapid reaction to this type of pressure, which generates the necessity of monitoring the changes over long periods of time in order to assess the resilience of the microbial community (Chaudhry et al., 2012). Conventional analysis of the impacts of pesticides is usually done in single species tests or controlled conditions without producing results applicable and integrated into the mechanisms of a whole ecosystem (Spyrou et al., 2009). In these conditions, it is difficult to assess the action of pesticides on microorganisms outside the range targeted by treatment. Repeated application of fungicides has a cascade effect, reducing processes unrelated to fungal component (Zhang et al., 2016) and being visible in the low values of diversity (Sułowicz et al., 2016). Sulfonylureic herbicides express their toxicity on enzymatic system of microorganisms, by inhibiting the biosynthesis of branched-chain amino acid (Wang et al., 2012). Depreciation and reduction of microbial community diversity was also reported at the application of pesticides based on chlorine compounds (van Bruggen et al., 2006). For these reasons it is necessary to analyze the deviation of entire microbial community present in soil, for the development of plant protection products and fertilizers (Gorlenko et al., 2012).

4. The analysis of the occurrence of the functional communities in ecological niche

Application of classical methods for calculating ecological deviations in the analysis of microbial diversity patterns does not provide a sufficiently high sensitivity in detection of changes in the structure of microbial communities (Doll et al., 2013). A comprehensive analysis of methods for the exploration of microbial ecology was carried out by Ramette (2007). His study presents strong limitations of traditional methods in evaluating microorganisms, steady accumulation of significant data with reduced interpretation, and provides a number of assumptions in developing new methodologies for microbial ecology. Amplification and analysis of the effect at the whole ecological niche level involves observations over all internal functional mechanisms of ecosystem, unexplored completely until now (Zhang et al., 2012; Kuzyakov & Blagodatskaya, 2015).

To increase the performance of CLPP data analysis models, the authors propose a fragmented matrix system (Figure 1). Each matrix is considered the expression of a microbial physiological micro-ecological niche. Matrices are created based on specific equations in order to eliminate noise from the raw data and highlight the unique characteristics of microbial communities. The functional alteration index of community (*Fa%* - eq 1.) was calculated for matrix containing experimental raw data. When results obtained are compared, it is necessary to restructure the data from each community with respect to a control microbial variant (eq 2.). Each functional group was transformed based on the degree of substrate consumption and was modified according to the percentage of participation in its own systematic community. Once functional, groups were converted and restructured, and community was compared to a control community. For this purpose the authors propose the community functional resemblance (*Cfr%*) as an indicator for assessing the degree of overlap between the two communities [equation (3)].

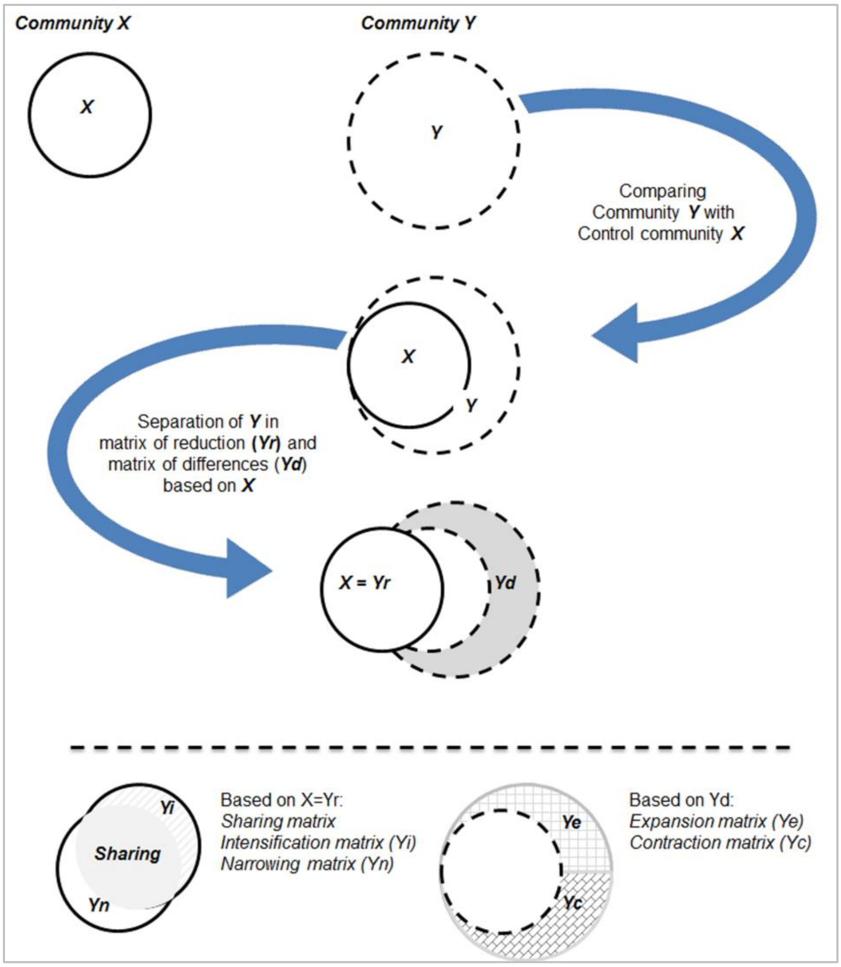

Figure 1. Flow of the fragmented data analysis system
Source: Authors' elaboration

Common segments between restructured and control communities, taken as the minimum value of the functional groups, are grouped into a sharing matrix. The next stage of data analysis involves grouping of different sections from restructured matrix in order to identify the level of growth intensification [equation (4)] or narrowing of the microbial community [equation (5)] due to experimental pressure. Initial differences between microbial communities created by pressure variables and control community represent functional expansion [equation (6)] and contraction [equation (7)] segments of micro-ecological niche; both matrices have the purpose to identify microbial community substructures. In order to use matrices with positive values only, the results of equations (5) and (7) are transformed into absolute values.

(1) $$Fa\% = \left(\sum_{k=1}^{n} Sy_k - \sum_{k=1}^{n} Sx_k\right) * 100/\sum_{k=1}^{n} Sx_k$$

(2) $$Sy_r = Sy - \frac{Sy}{\sum_{k=1}^{n} Sy_k} * \left(\sum_{k=1}^{n} Sy_k - \sum_{k=1}^{n} Sx_k\right)$$

(3) $$Cfr\% = \sum_{k=1}^{n} \min\left(Sy_{r_k}, Sx_k\right) * 100/\sum_{k=1}^{n} Sx_k$$

(4) $$Sy_i = Sy_r - \min(Sy_r, Sx)$$

(5) $$Sy_n = |Sy_r - \max(Sy_r, Sx)|$$

(6) $$Sy_e = Sy - Sx; > 0$$

(7) $$Sy_c = |Sy - Sx|; < 0$$

where: S - substrate; x - control community; y – compared community; min - minimum value; max - maximum value; | | - absolute values.

5. Dominance assessment of functional groups *vs.* external pressure

Matrix analysis is more efficient to set the level of importance of functional groups by converting all respiration data to percent (%) and applying a scheme of microbial community abundance, similar to those found in plant communities (Simpson, 2010), in: *dominant* functional groups, > 50% in the community; *co-dominant* functional groups, 25-50% in the community; *ordinary* functional groups, 10-25% in the community.

On each matrix, Shannon and Simpson diversity indices can be calculated. The scale described by Wu et al. (2014) was adapted by authors for Shannon index (*H*) and the scale contained 4 levels of magnitude of the experimental pressure effect on microbial community diversity:

H = 0,0-1,0 – strong effect;
H = 1,0-2,0 – medium effect;
H = 2,0-3,0 – low effect;
H = 3,0-4,5 – negligible effect.

Simpson (*D*) index interpretation is performed on a scale with three levels of heterogeneity (homogeneity):

D = 0,0-0,2 – low heterogeneity (high homogeneity);
D = 0,2-0,7 – medium heterogeneity (homogeneity);
D = 0,7-1,0 – high heterogeneity (low homogeneity).

The calculation of diversity indices separately for each matrix provides a clear image of unilaterally or synergistic effect of the applied pressure. Shannon index has a greater applicability in assessing the impact of pressors, while Simpson index shows the dynamics of heterogeneity separately on each level of analysis. For reduction and sharing matrices, low fluctuations of indices are expected. At this level the complete developments of primary community are analyzed, without a clear individualization of successional stages and disruptions inside micro-ecological niches.

This analytic approach is selective, highlighting the groups at the edge of the ecological niche. The data fragmentation has great potential in a realistic assessment of microbial community changes. The methodology proposed in this paper can be used on a large number of substrates and samples, for the analysis of functional segments, and it helps to avoid chaotic images resulted from microbial activity overlap.

6. Conclusions

Fertilization stimulates specific groups in soil microbial communities, activating conversion processes of nutrients but reducing the diversity of populations. Pesticides act directly to inhibit a reduced range of microorganisms and indirectly on a large number of groups by locking microbial food webs.

Community-level physiological profiling is a useful technique in the detection of changes in microbial communities due to an increase in the pressure produced by additional substrates. Stratified analysis of data allows filtering microbial community response to perturbations and highlights the tolerant and sensitive functional groups. Modelling matrices eliminates noise from experimental raw data and provides a clearer, enhanced image of microbial activity.

Conflict of interest

The authors declare they have no conflict of interest in relation to this paper.

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