APPLYING *DPSIR* MODEL TO SUSTAINABLE TERRITORIAL DEVELOPMENT, IN SOUTH-MUNTENIA REGION

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Abstract. Generally speaking, conceptual models are used to identify the relationships between key-factors of a system (economic, social, environmental, etc.) and they represent the methodological basis for the development of some programs and strategies.
The DPSIR Model (Drivers–Pressures–State–Impact-Responses Model), designed in the late 1990s, is considered one of the most useful tools for reporting and analysing environmental issues and its appliance varies from global systems to specific areas of interest (river basins, protected areas, etc.). Frequently, international organizations apply it in the framework of the evaluation of sustainable development initiatives, in order to identify the existing relationships between different processes and phenomena. After 1999s, the DPSIR Model was taken over by the Environmental European Agency (EEA) and was widely used in environmental studies and reviews in EU regions and Member States.
This article aims to synthesize the constituent elements of the DPSIR Model. Also, it presents an application of the model in the South-Muntenia region.

Keywords: DPSIR Model, Territorial Development, Sustainability, Inequalities

1. INTRODUCTION

The modern society's problems (for example, pollution, urban sprawl, environmental equity, etc.) are complex and often exceed the spatial and temporal dimension. The multi and trans-disciplinary character of these problems causes the scientific approaches and assessments to not be confined to a single domain (economic, social, environmental, etc.) or to a single organizational level. The involved policymakers try to find solutions and implement appropriate strategies in order to cover and to solve a greater range of issues. Typically, individual actions do not have success, but rather, by their combination it can be achieved an improvement of the given situation. One aspect which must be seen with interest by both the decision-making environment and the scientific community is the connectivity between actions and measures that can lead to a better understanding of the system and its interactions, either directly or indirectly.

In addition, a structured process on multiple issues/information or management options may facilitate the emergence of alternatives, and also the harsher realities. In the context of complex systems, which are facing, in turn, with complex issues, there are useful those conceptual models that can be developed for the purpose of capturing the nature of relations between key factors for assessing the consequences (economic, social, environmental, etc.) and promoting some appropriate measures. To these models can contribute both mathematics and statistics, which, on the basis of some predictive relations can help to analyze and solve those complex and multi-disciplinary issues (regional and sustainable development, etc.) [1].

At present, we are witnessing unprecedented changes in climate, which poses complex and multi-disciplinary problems and sometimes with a major impact on the evolution of global society. To solve these problems, the experts have developed several models that try to unify and connect environmental issues to economic or social sciences, etc. [2]. One of these models is the DPSIR (Drivers-Pressures-State-Impact-Responses), which allows the description of environmental issues by defining the relationship between human activities and the environment. This model provides a conceptual framework that integrates different types of indicators, opening up the possibility of taking into account not only the environmental impact, but also the socio-economic impact resulting from changes in the status of systems. It also places the environmental aspects and socio-economic problems together, and, with the help of environmental data and information, the DPSIR Model brings forward strong scientific recommendations that will increase the effectiveness of management actions.

In this article we intend to highlight the potential of the DPSIR model as a complex tool to organize scientific research. It will also be an application of the DPSIR model at the level of South Muntenia region.

2. THE BACKGROUND OF THE DPSIR FRAMEWORK

The origins of the DPSIR model are reported in the year 1970, being developed as a framework for analyzing the so-called Stress-Response in Statistics from Canada (Rapport and Friend 1979). This first framework was later expanded in the 1990s by the Organisation for Economic Cooperation and Development (OECD 1991, 1993) and the United Nations (UN 1996, 2001), resulting the model called PSR (Pressures, States and Answers).

DPSIR is an analysis model of a response to a specific stress, evolving over time. The first form of the model was the type of pressure-state-response (Pressures-States-Response) (OECD, 1994). PSR model evolved into the DPSIR model, at European level, after the European Environment Agency (EEA, 1993; 1995) [3] added two new components: the forces and impacts (Driving Forces and Impact), in an attempt to identify the causes and effect of the relationship between human and natural systems. After 1990, this paradigm has been extended further to the current form of the DPSIR model (EEA 1995). The objective of this model was to clarify multisectoral relationships and to highlight the dynamics and characteristics of ecosystems and socio-economic changes [4].

The model distinguishes between (i) the forces acting on the environment, (ii) the changes recorded in the environment and (iii) the modern society's reaction to these changes. DPSIR follows the same general pattern as the earlier ones, but differs in the sense that distinguishes several stages of the process [5]. There are some differences between these models in terms of terminology and level of detail, even though all of them are based on the concept of causal chain (Fig. 1).

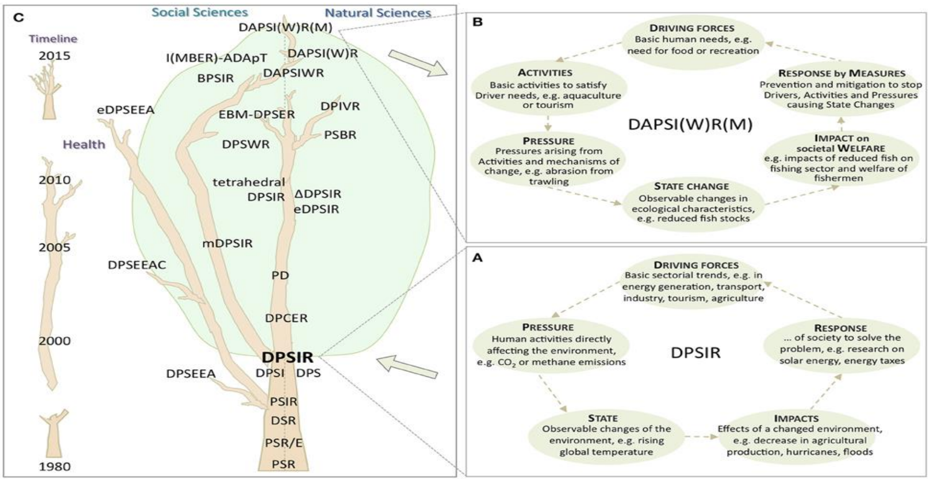

Fig. 1. Author compilation (DPSIR and derivatives development; (A) DPSIR first elaboration, redrawn from the original EU framework (EC, 1999), (B) DAPSI(W)R(M), top of the tree evolution of DPSIR (as defined in Scharin et al., 2016), (C) timeline and development/relationship of DPSIR and derivatives).

DPSIR model is a tool for analysing the environmental issues in relation to sustainable development (Borja et al., 2006) [6]. The basic aims of its approach are: (i) to provide relevant information on the various components of the DPSIR sequence, (ii) to clarify the ways in which they are connected and related to each other and (iii) to assess the effectiveness of responses.

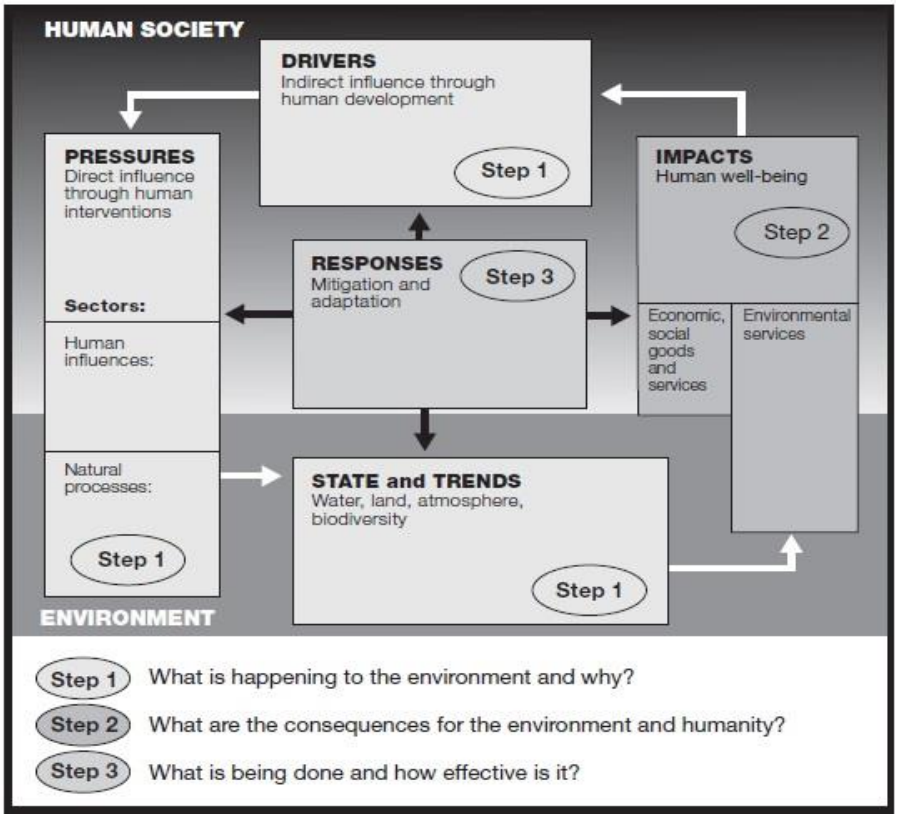

Fig. 2: DPSIR framework for GEO-4
Source: [8].

The DPSIR model provides useful information about the relationship between the origins and the consequences of environmental problems and, at the same time, it helps understanding their dynamics by addressing the links between the DPSIR elements. This integrative approach implies a significant understanding of the fundamental causal relationships between human activities and the resulting impact on the ecosystems, coastal economies and on communities and human response mechanisms. However, the integrated nature of the model leads to a wide use of it, in particular by the European Environment Agency, in selecting the indicators for evaluating the implementation of environmental policies in the EU. Also, UNEP has adopted a version of the model to help in the preparation of the *Reports on global environmental perspectives* [7] (Fig. 2).

The DPSIR model has the ability to integrate knowledge from different disciplines, creating alternatives at different levels of decision and decreasing the gap between different sciences and disciplines) [8]. In a first phase, the DPSIR model was developed and used to assess the impacts of various activities on the environment. Subsequently, the model underwent several modifications and adaptations. In the year 1999, EEA picks it up in order to carry out a conceptual, general and comprehensive framework for analysis. The framework for analysing the environmental problems and its elements, proposed by the European Environment Agency, has the following components:

1. Driving Forces (for example, economic and social development) (D - driving forces);
2. Pressures/modifying forces (they put pressure on the system) (P - pressures);
3. The result is given by the State of a specific environment (S - state);
4. Impact (for example, climate changes have an impact on ecosystems, on people's health, etc.) (I – impact);
5. As a result of these effects, the society responds to driving forces or pressures, through preventive, adaptive or curative solutions (R - responses).

Application of the DPSIR model involves a relatively large data base and information, through which indicators are supported/promoted (specific or common indicators); the common indicators for the driving forces include economic, social aspects and demographic changes in society; the status indicators describe some quantitative and qualitative changes of the physical environment, the biological components of the environment; the impact indicators presents the effects on social and economic functions of the environment.

The response indicators refers to the responses of the different groups as well as government initiatives for prevention, improvement or adjustment and they can take the form of legislative, political measures, etc. The answers vary depending on the actual situation (in the field). Initial responses are generally directed towards impact, because the consequences are perceived in time. The various reactions have also different temporal implications, irrespective of whether they can achieve the long-term objectives or short-term benefits. The costs of implementation also vary and the prioritization of the replies depends on the ability of Governments and society to solve these problems [9].

Some analyses have appealed to the DPSIR model to assess the impact of various phenomena on environment and water [10], to understand the linkages and economic and social interrelationships in the coastal areas [11], in order to monitor and assess the actions based on agricultural policy and water management in rural areas [12], etc. The DPSIR model is viewed as a framework for the analysis of economic and social phenomena, with the help of indicators able to provide useful information to decision-makers from different sectors, but particularly to those in the field of environmental protection (Fig. 3).

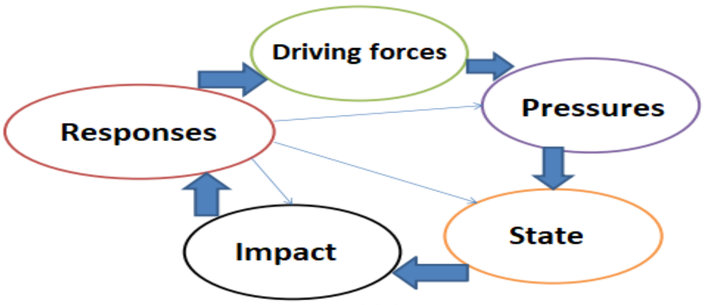

Fig. 3: DPSIR Model
Source: [13]

The DPSIR model has been modified by different researchers, its variants including MDPSIR (Modified DPSIR), DPSWR (Drivers-Pressures-State-Welfare-Responses), DPCER (C and E indicate the chemical and ecological state) and DPSER (Impact is replaced by Ecosystem services containing both negative and positive impacts on ecosystem). The model contributes to the identification of a causal chain relations, between the specific elements outlined above, which finally can lead to actions and policies aimed at reducing the existing problems. Also, it is useful in describing and explaining the relationships between the causes and consequences of environmental problems, but in order to understand the dynamics of the relationship is needed a detailed analysis of the links between all the elements of the model.

3. ADVANTAGES AND DISADVANTAGES OF USING THE DPSIR MODEL

DPSIR represents a holistic model, a tool that is widely applied to all kinds of environmental issues. By identifying the progressive chain of events that lead to a change, to impact and response, the DPSIR model is useful to be applied to all categories of environmental issues. For example, Fock [14] et al. (2011) used the PSR (the first form of the model) to link marine ports with environmental objectives in Germany, in the EEZ (Exclusive Economic Zone). Langmead and colleagues [15] used the DPSIR model to manage changes related to habitats, eutrophication, chemical pollution and invasive species from the European seas. The model was used in the selection and development of indicators for environmental analysis [16] and for the management decisions [17].

As pointed out earlier, the DPSIR model is widely used in management and troubleshooting. The power of the DPSIR model is presenting, in a simple manner, the important connections between society/human actions and the state of the natural environment. Correlating problems between them, it leads to a better communication between different disciplines, between researchers, policy makers and stakeholders.

Among the weaknesses of the model, we can remember that sometimes it is very difficult to bridge the gap between the quantitative and qualitative information.

4. APPLYING THE DPSIR MODEL

The DPSIR model presented above might be applied both at country level, and at regional or sub-regional level.

The current situation of the region, from the demographic, economic, and social viewpoint is presented in the table hereunder (Tab. 1). Thus, the region has a population of 3.1 million inhabitants (2017), representing 14% from total population, and comprises seven counties (Argeș, Prahova, Dâmbovița, Călărași, Ialomița, Giurgiu, Teleorman), and is the largest region from the number of counties viewpoint (7 counties). The region is predominantly rural, about 60.6% of the inhabitants living in the villages of the region. However, the density is less than at national level (87.5% as compared with 93.9%) and an employment rate below 2.8% of the national average. GDP represents 12.2% out of the national total.

Indicators	**Total population (mill. inhab.)**	**Urban (mill. loc.)**	**Rural (mil. loc.)**	**Urban (%)**	**Rural (%)**	**Inhab./ sqKm.**	**Active population**	**Employed population**	**Employment rate**	**GDP (bill. Lei)**
South-Muntenia Region	3.1	1.19	1,8	39.4	60.6	87.5	1370	1247	59.9	86,7
Romania	22.2	12.51	9.69	53.7	46.3	93.1	8940 **46.3**	8449	61,6	712.7
South-Muntenia vs. Romania	13.96% of total	9.51 % of total 0.10	18.5 % of total	- 26.63 0.19	+30.9	-6.02 -26.63	15.26 % 30.89	14.76 %	-2.8 93.98	12.2 %

15.26 14.76 -99.0

Tab. 1: The main statistical indicators of South-Muntenia Region, 2016 (for population 2017 year, June), Source: Romanian Statistical Yearbook, 2017

In order to add to the model DPSIR, the theoretic components of the model were taken into account, starting from a series of indicators delivered by the national statistics. The components of the model and the specific indicators are as follows:

1. **Driving forces**: population (especially from the rural area), transportation, industries (extractive industry, oil processing, chemistry, and petro-chemistry, machine building, construction materials, metal processing), agriculture, services etc.

2. **Pressures:** use of resources, polluting emissions (direct and indirect in the air, water and soil, waste generation, noise pollution, natural hazards;

3. **State:** air quality (regional, local, urban), water quality (lakes, rivers, underground waters, etc.), soil quality (local, natural areas, agricultural areas), ecosystems (biodiversity, vegetation, soil, microorganisms, invasive species), health, and quality of life.

4. **Impact**: changes in the biological, physical, chemical state of the environment determine over the quality of the ecosystems and influence the welfare of individuals. Otherwise said, these changes might have an economic or environmental impact on the operation of ecosystems, on life supporting possibilities, and on the performance and quality of the human society as a whole.

5. **Responses:** One "response" of the society or of the political decision factors is in fact the outcome of an unintended effect, and it may affect any part of the relationship between the driving forces and impact.

As result of analysing the regional indicators, the following findings can be mentioned:

1. Based on the analysis of the indicator *population* is found that the demographic trends are negative at regional level, and on areas. Thus, both total population and the urban and rural one recorded decreasing tendencies. The total population decreased in the period 2017-2007, by about -4% (from 1.24 mill. inhab. to 1,18 mill. inhab.), while urban population decreased by -4.48%, and the rural one by –3.5% (Fig. 4). At the level of the South Muntenia Region there is only one Territorial Administrative Unit of the 1st[1] rank in the Prahova county; 14 localities of the 2nd rank, the most numerous being in Arges, Ialomita and Teleorman. Next, there are 33 localities of the 3rd rank from which most in Prahova and Dambovita, followed by 519 localities of the 4th rank in the counties Arges and Teleorman. The depopulation phenomenon of the region continues (Appendix 1).

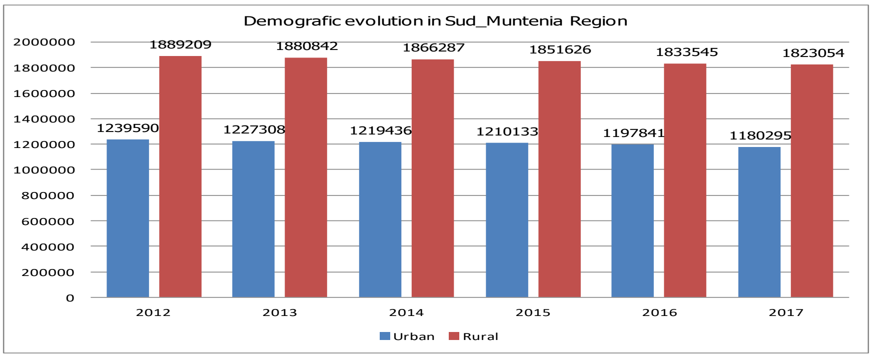

Fig. 4: Demographic evolutions' tendency, in the region South – Muntenia
Source: own computations on NIS data, http://www.insse.ro/cms/

[1] In the Romanian's National Spatial Plan, there is Section IV - The Network of Localities (the Plan was approved by Law no.351 of 6 July 2001). According to the law, the national network of localities is made up of urban and rural localities ranked by ranks (according to annexes no. II-IV). The hierarchy of settlements by rank is the following:
a) rank 0 - the capital of Romania, a city of European importance;
b) rank I - municipalities of national importance, with potential influence at European level;
c) rank II - municipalities of inter-county, county or balance importance in the network of localities;
d) rank III - cities;
e) rank IV - villages with common residence and f) rank V - village components of communes and villages belonging to municipalities and towns.
The passing of the localities from one rank to another is done by law, at the proposal of the local councils, with consultation of the population through the referendum and the institutions involved.

2. The region has an agricultural character, over 70% of the total surface being agricultural. The region has the widest cultivated surface compared with all regions of development of the country and is positioned from this viewpoint in the top of the NUTS2 regions at European level. The employed population in agriculture represents about one third of total employed population of the region (over 300 thousand persons) and this is one of the highest values at the level of the NUTS2 regions within the EU, as well. It is, also, the region with the highest number of employees in the food industry from Romania (about 23 thousand persons in 2016).
3. Agriculture represents the essential economic sector for the counties from the southern part of the region – Calarasi, Ialomita, Teleorman, and Giurgiu. At regional level, there are about 2800 active local units (SMEs) in agriculture, hunting and ancillary services (about 20% of the national total), and about 1100 active units within the food industry (2015). In the region are found companies included in the national Top 10 in the following sectors: agricultural producers, meat industry, condiment producers, vegetal oils producers, dairy producers, alcoholic beverages producers, wine industry producers, beer producers, and companies in the tobacco/cigarettes industry.
4. The agro-food field at regional level is faced with a series of structural deficiencies: in many of the rural areas of the region the subsistence agriculture is practiced, lands are fragmented, and the number of small farms that produce for self-consumption is high, while there is structural imbalance between small farms and very large farms, etc. About 5% from the total agricultural surface at regional level is not put to good use (degraded land, resting land) etc.
5. At regional level, there is poor endowment regarding drinkable water installations (out of the 567 human settlements, only 64.93% have such installations). Public sewerage systems cover only 16.93% of the localities. The most important polluting factor for waters is ammonium, especially due to the existence of oil areas. At the same time, some industries have a high degree of pollution potential, for instance the chemical industry, the extractive and food industry; animal husbandry, oil industry, machine building, construction materials, metallurgy in the northern area of the region, and agriculture in the uppermost area of the region. Houses have a low level of interconnectedness to the wastewater treatment systems (27.29%)[2]. The air quality is relatively good even if there are high quantities of particulate matter due to traffic and to the use of wood fuels. The quality of water is affected also by organic load, chlorates, nitrates, but also because of the industries in the region; the quality of the soil presents pressures determined by the use of chemical fertilisers, plant protection products, animal husbandry residuals, polluting activities of the industrial sector, accidental pollution), along with the presence with polluting sites (361 potentially polluting sites).
6. Biodiversity: the region shows high biodiversity, but there are good chances that it will be affected as result of land conversion, transportation

[2] http://www.fonduri-structurale.ro/Document_Files/Stiri/00013480/hj6kd_pdr20142020regiuneasudmunteniadraft31iulie.pdf

infrastructure development, development of human settlement, hydro-technic works, invasive species, climate changes, and pollution, over-exploitation of natural resources, etc. The presence of natural risks: floods, arsons, landslides, soil erosion, draught, earthquakes, and avalanches that can affect the biodiversity.

7. Technological risks caused by deficiencies and errors in the design and building of industrial installations with a high degree of physical and moral degradation. Here might be added the erroneous exploitation, human errors, improper management of economic operators in transportation of dangerous substances and waste, breakdown of dams, or explosions of some installations both because of natural causes, and of anthropic ones triggering thus a succession of extremely complex events under the form of chain reactions.

Taking into account the above analysis, a possible DPSIR model for the South Muntenia region is summarized in the figure below (Fig 5).

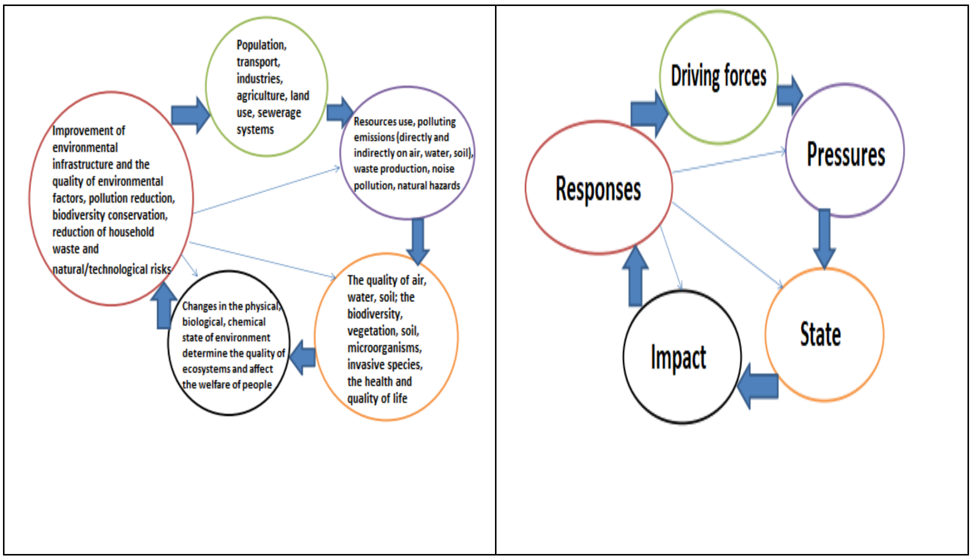

Fig. 5: DPSIR Model adjusted for the Region South Muntenia
Source: own processing

5. CONCLUSIONS

The DPSIR model represents the necessary analytical framework for describing and understanding the links between economic activities and environment, as it provides the opportunity of achieving an integration of the environment in the framework of various economic activities. The conceptual model is intended to capture the key "factors" involved in the relationships between the various sectors, reflecting the complex chain of causes and effects between several factors. The model is at the same time a simplification regarding the reality of the region South Muntenia.

As result of analysing the regional statistical indicators (NIS) a series of necessary information was obtained for adding to the DPSIR model. The values of the indicators were established for the five components of the model.

The hierarchy of concepts in economic, social, health and environmental sciences identified in the generic DPSIR framework is intended to identify potential places for interactions among multiple stakeholder perspectives and across scientific disciplines. The main strength of the DPSIR approach is that it is transparent and simple (with five concepts that are understandable to both scientists and stakeholders), enhances communication by simplifying the complex relations between humans and the environment, fosters a systems approach is human-centric, appealing to the public and decision-makers and implies causal relationships among the factors etc.

For South Muntenia region, DPSIR model can encourages decision-makers and stakeholders to think about specific problems and solutions and their resolves on long term. The model could be considered as a decision - making tool for municipalities that are dealing with the complex issue. The DPSIR framework for South Muntenia region can be a useful tool for taking various responsive steps in the process of diminishing the inequalities. The application of response management can be a key-factor in this process. The DPSIR framework focuses on problems both in economic and environment and how to solve those problems. Therefore, the DPSIR model for South Muntenia region could be useful for all stakeholders that are trying to find a solution for diminishing territorial disparities.

Knowledge:

This article is the paper within the Doctoral training 1st year (stage 1) of the PhD. Student Antonescu Raluca-Mirela. The doctoral training is developed within the University of Bucharest, Faculty of Geography, the Doctoral School "Simion Mehedinti – Nature and Sustainable Development", Scientific Coordinator, Univ. Prof. PhD. Ioan Ianos.

Annex 1: Permanent emigrants and immigrants, 2011-2016 period

		2011	2012	2013	2014	2015	2016
Emigrants	*Romania*	*18307*	*18001*	*19056*	*11251*	*15235*	*22807*
	Region	1107	1414	1646	1214	1590	2393
	Arges	194	214	208	175	250	367
	Calarasi	115	107	152	132	167	199
	Dambovita	173	211	271	211	260	383
	Giurgiu	65	82	122	92	108	143
	Ialomita	72	83	156	92	126	255
	Prahova	297	413	409	283	413	643
	Teleorman	191	304	328	229	266	403
Immigranţs	*Romania*	*15538*	*21684*	*23897*	*36644*	*23093*	*27863*
	Region	499	420	457	426	560	668
	Arges	96	68	84	80	99	123
	Calarasi	14	28	32	37	44	71
	Dambovita	133	65	65	53	74	118
	Giurgiu	21	20	25	43	60	69
	Ialomita	72	42	44	30	69	43
	Prahova	132	175	173	140	145	164
	Teleorman	31	22	34	43	69	80

Source: own computation on NIS data

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