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STRUCTURAL ANALYSIS AS AN EVALUATION TOOL FOR ADAPTIVE CAPACITY IN THE ODESSA COASTAL AREA

A study into the potential of structural analysis framework for identifying adaptive capacity in a system is given a review in the paper. Systems thinking approach is made use of in the research which is based on the case study of the Black Sea coastal area within the Odessa agglomeration. The suggested adaptive management tools and monitoring criteria for the area under study represent the research outcomes.

Key words*: Structural analysis, coastal area, socio-ecological system, stakeholder, influence, participatory causal matrix, causal loop diagram.*

Introduction. Nowadays many countries and regions experience lack of efficient governance approaches to increasingly complex challenges they have faced. From one point, it constitutes a particular challenge for the economies under the transition period, from the other, it has also been a problematic issue for the areas where the two systems – the ecological and the social – significantly interact with one another, like, for instance, the marine coastal areas.

The coastal zones, being rich in natural resources, are at the same time among the most exploited areas in the world economy. The spatial organization of coastal economy is associated with industrial specialization, including transportation and recreation activities. In the author’s opinion, coastal areas should be managed with due regard to meeting social and economic needs as well as contributing to conservation and restoration of natural ecosystems, which calls for finding efficient and sustainable solutions in the field of adaptive governance.

In view of the growing anthropogenic impact, there emerges a pressing problem of natural landscape conservation in the areas of mass tourism and recreation. Tourist activity, as well as other service industries, is resource-demanding and is the source of various types of environmental pollution which endanger existence and health of local ecosystems. Intensive recreational activity induces soil erosion, contamination of the sea water with sewages, decrease in populations and biodiversity of flora and fauna and causes damage to the places of historic interest.

At the same time, ecological values, as is stated in [6], constitute the basis for tourist attractiveness and commercial efficiency of tour operators’ offers. For this reason, the basic principles for ecological management of tourist businesses have as of late assumed ever greater significance - conservation of biological diversity in natural recreation territories, strengthening economic sustainability in a region, participation of the entities involved in touring activities in environmentally responsible tourism, enhancement of their environmental culture and preservation of ethnographic status of recreation territories.

The paper is a result of a seminar and intensive training on ‘Adaptation and Adaptive Governance of Ecosystems’ held by the Central European University in Budapest (Hungary) on 22 June 2011 through 10 July 2011 as an action under the EC TEMPUS IV project 511390-TEMPUS-1-2010-1-SK-TEMPUS-JPCR ‘Environmental Governance for Environmental Curricula’.

The aim of the research is to analyze the potential of participatory structural analysis framework for identifying a system's adaptive capacity, based on the Black Sea coastal area within the Odessa agglomeration, with the adaptation policy aimed at higher degree of sustainability in tourism.

Reinvention of the complexity of systems based on interdependence, partnerships, flexibility, and diversity in almost every aspect of life [1] is reshaping the modern view of scientific inquiry which stays in need for new and more appropriate investigation approaches. In line with that, coastal territories are considered social-ecological systems for the research purposes (Fig. 1).

An adaptive governance framework requires both interdisciplinary and broad participatory approaches while pursuing a policy oriented research.

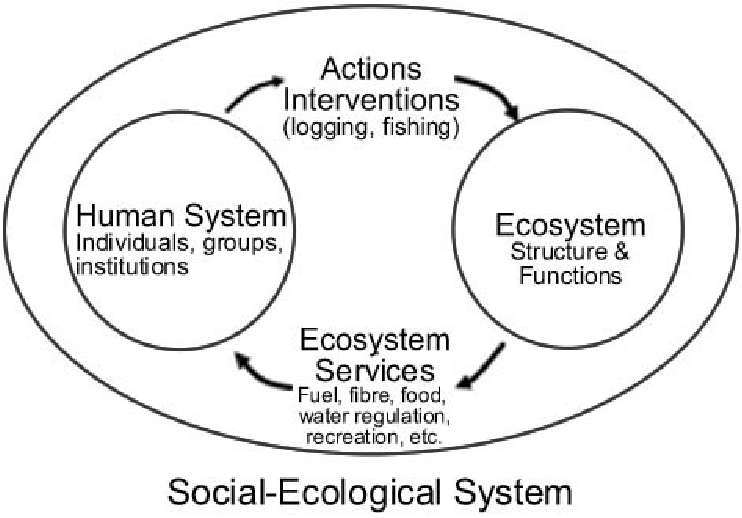

Fig. 1 - Visual representation of a Social-Ecological System

Methodology. Structural analysis was chosen as a methodology tool to reach the first objective as it affords ground for holistic thinking and improvement to system learning and offers not only making identification of a system's components and their role in the system as a whole, but also tracing interactions among the system's components [3]. Such an analysis is conducted as a three-stage process, given below.

1) Identification of system components via creation of their inventory based on the author's reflections for each of the subsystems in the coastal system (see Fig. 2).

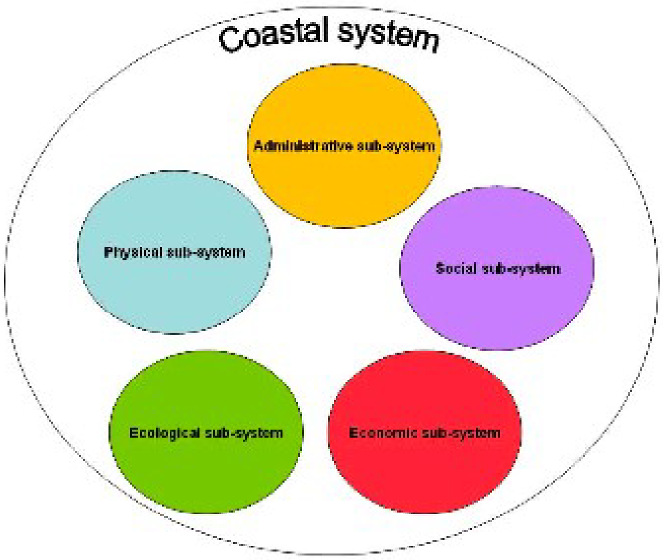

Fig. 2 - The coastal system and its sub-systems

2) Description of relations among the components via assembling double-entry matrices for the research case and the corresponding problem.

Each matrix relates the various elements found therein by asking the following question of ‘Has variable V_i a causal relation with variable V_j?’ for each variable in the first column (see Table 1.) while moving from left to the right. The answer to this question provides information on the existence of a hypothetically causal relationship [4].

To identify polarity (positive or negative effect of one variable on the other) for this causal relationship, the question of ‘Does increase in V_i lead to increase or decrease in V_j?’ is asked, and, depending on the answer, '+' or '-' marks are attributed to the corresponding cell.

Table 1 - An example of filled Participatory Matrix

	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}
V_1		-					-					
V_2									+			
V_3						+						
V_4												
V_5												
V_6			-									
V_7												
V_8			-									
V_9						+						
V_{10}												
V_{11}			-									+
V_{12}												

3) Identification of key components via comparing the ranking of the variables from the direct classification which lets identify the influential or dependent nature of each variable.

The research area is located in the north-western part of the Black Sea (46°N 30°E), which is an inland water body, connected to the Atlantic Ocean via the Mediterranean and the Aegean Seas and various straits. Although the sea lies between Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine, the research area is limited only by the territory of Ukraine. The well-known health resort of Odessa city is situated here. Nevertheless, this region is exposed to considerable anthropogenic load, for instance, salt waters of the Odessa port are considered the most contaminated in the Black Sea. So the main problem in this area is how to maintain sustainable tourist activity under depletion and pollution of water resources.

The following main stakeholders have been identified for this area: health resort institutions, environmental agencies and NGOs, port management and research institutions.

Research Results. The conducted research, according to the method described above, was divided into three phases: 1) identification of system components; 2) description of the relations among the components; 3) identification of key components.

Phase one has resulted in the following table 2. It shows 5 subsystems of the social-ecological system of the Black Sea coastal zone: physical, ecological, social, economic and legal administrative. Each of the subsystems corresponds to a group of influences, identified by the author totalling 20. In the last column, the influences are given symbolic notations as variables (V_1, V_2, … , V_{20}).

Table 2 - Social-ecological system of the Black Sea coastal zone: identification of influences

Name of a subsystem	Name of an influence	Notation
physical - 3	Climate water resources soil condition	V_1 V_2 V_3
ecological - 3	biological resources biodiversity and natural ecosystem (habitats) health pollution of natural environment components	V_4 V_5 V_6
social - 5	comfortable living conditions demographic situation education and research cultural heritage national minority issues	V_7 V_8 V_9 V_{10} V_{11}
economic - 6	ICT navigation and fish industry recreational attractiveness economic diversity and employment supporting infrastructure land-use regime	V_{12} V_{13} V_{14} V_{15} V_{16} V_{17}
legal administrative - 3	political stability regulations and standards policy support mechanisms	V_{18} V_{19} V_{20}

Phase two results are represented by the table 3 and 4, and by the fig. 3.

Table 3 shows a participatory causal matrix (PCM) filled by stakeholder 1 (health resort institution). There the interrelationship of selected influences marked with '+' can be seen. Similar PCMs have also been filled by 3 other stakeholders (research institution, environmental NGO, port administration), but for the sake of convenience and brevity they are not included into this paper. Nevertheless, all the four filled out PCMs were taken account of in the next steps.

In the fig. 3 a causal loop diagram based on the PCM filled by stakeholder 1 is presented. The identified relations between the factors are indicated by unidirectional arrows.

The shared participatory causal matrix based on the causal matrices filled by each of the four stakeholders is shown in the table 4. Grouping the contribution of all stakeholders (by summing up the number of causal relationships) also gives information on the significance of each factor V_i in terms of significance in rows S_x and significance in columns S_y. The total significance S_i is given by the sum of a number of relations established with factor V_i. Here, the total of S_x, as well as S_y, equals 402.

Phase three results are reported in the table 5. The figures in the second and the third columns are obtained from the previous table, and in the fifth column – from the causal loop diagram based on the shared PCM (not shown in the paper due to its complexity and largeness). Here, S_{ix} and S_{iy} are the sums of the significance given to each factor by stakeholders in the causal matrix, and the number of outgoing arrows N_{iout} means the number of factors affected by changes in V_i. The values of the sixth column are calculated by means of multiplication of the total significance S_i by the number of outgoing arrows N_{iout}.

Table 3 - Participatory causal matrix (PCM) filled by stakeholder 1 (health resort institution)

	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}
V_1		+	+	+	+		+							+						
V_2				+			+						+	+						
V_3																	+			
V_4					+								+							
V_5							+	+						+						
V_6		+		+	+		+							+						
V_7								+			+			+						
V_8									+		+				+					
V_9						+		+				+							+	
V_{10}												+	+	+	+					
V_{11}							+	+										+		
V_{12}							+		+					+		+				+
V_{13}		+		+		+								+	+					
V_{14}							+								+	+	+			
V_{15}							+	+				+						+		
V_{16}						+	+					+		+	+					
V_{17}			+			+								+		+				
V_{18}							+							+	+					
V_{19}						+	+													
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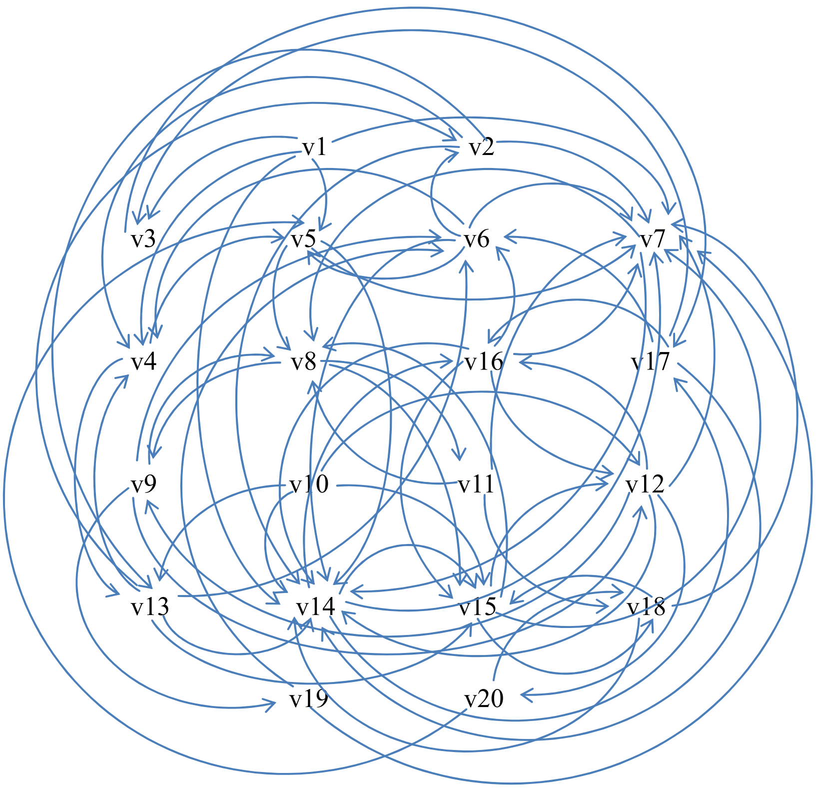

Fig. 3 - Causal loop diagram based on the PCM filled by stakeholder 1

Table 4 - Shared participatory causal matrix based on the causal matrices filled by each of the four stakeholders

Has a direct relation with / is the cause of	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	Significance S_x
V_1		+++	++	++++	+++		+++	+					+	++++			+				22
V_2	+		+	++++			++++						++++	++++			++				20
V_3				+	+												++++				6
V_4			+		++		++	++					++++	+	+++						15
V_5				+++			+	+					++	++++							11
V_6	+	++++	+++	++++	++++		++++	+++					++	++++							29
V_7								+++			++++		+	++++	+	+		++		+	17
V_8		+	+	+++	++	++			+		+++	+	+		+++			+++			21
V_9					+	++	+	++		+		++++			++	+++	++	+	++++	+++	26
V_{10}					+	++		+++	+++		++	+	+++	++++	++++	++	+			+++	29
V_{11}							+	+++		+					++			++++			11
V_{12}							++++	++	++++	+			++	++	+++	++++		+	+	+++	27
V_{13}		+++		++++	++	++++	++	+						++++	++++	++					26
V_{14}						+++	+++	++			++		++		++++	+++	+++				22
V_{15}						++	++++	++++	+		++	++++				+++		++++			24
V_{16}						+++	++++	++	++			+	++	++++	++++		+				23
V_{17}		+	+++	++	+++	++++								++	+	++					18
V_{18}							++++	++	++		+++		+	++++	++	++	+			+	22
V_{19}	+	+	+		++	++++	+++						+++	++		+	+				19
V_{20}					++	++	+	+			++						+	++++	+		14
Significance S_y	3	13	12	25	23	28	41	32	13	3	18	11	28	43	33	23	17	19	6	11	402

Table 5 - Ranking of factors for the Black Sea coastal area within the Odessa agglomeration

	Significance S_x	Significance S_y	Total significance $S = (S_x+S_y)$	Number of outgoing arrows N_{out}	Ranking $R=S*N_{out}$	Group
V_8	21	32	53	11	583	1
V_{14}	22	43	65	8	520	
V_6	29	28	57	9	513	
V_{13}	26	28	54	9	486	
V_9	26	13	39	12	468	
V_7	17	41	58	8	464	2
V_{12}	27	11	38	11	418	
V_{16}	23	23	46	9	414	
V_{18}	22	19	41	10	410	
V_{10}	29	3	32	12	384	
V_{15}	24	33	57	5	285	3
V_4	15	25	40	7	280	
V_{17}	18	17	35	8	280	
V_{19}	19	6	25	10	250	
V_2	20	13	33	7	231	
V_1	22	3	25	9	225	4
V_{20}	14	11	25	7	175	
V_5	11	23	34	5	170	
V_{11}	11	18	29	5	145	
V_3	6	12	18	3	54	
Total	402	402	804			

The figures from the last column make it possible to rank all the factors in accordance with their significance and degree of influence. This ranking resulted in the identification of 4 groups of 5 factors, ranged in terms of significance and causality, assigned by the stakeholders.

Now it is possible to select a group representing the most important factors as a preliminary set of indicators from the table above. Since group #1 includes such factors as: demographic situation, recreational attractiveness, pollution of natural environment components, navigation and fish industry, education and research, these will be considered the most important drivers for the given coastal system.

Conclusions and suggestions. As a result of the structural analysis, assumptions about the role of the studied coastal system's components in the overall system's adaptive capacity can be identified which, in its turn, can be further used fat development of adaptive management tools and monitoring criteria for the studied area.

Thus, a conclusion can be made that the issues related to population dynamics, public health, recreational development, environmental pollution, sea water exploitation, environmental awareness etc. should become a matter of general concern. Therefore, the adaptation strategy for the area under research should be defined in accordance with these issues. In particular, it should include such measures as: improvement of the health care system, social welfare services; development of environmentally sound recreation and entertainment facilities; control and support for local health resort institutions; regulation of atmospheric emissions, discharge of sewage and solid wastes; limitation of fishing and navigation within the recreation zone; streamlining environmental education and promotion of environmental values.

Concerning the relation between environmental pollution and public health, Dasgupta and Mäler [2] assumed that major violations of ambient air-quality standards due to rapid growth of urban areas are responsible for significant degradation of human health. They suggested introduction such measures as economic incentive policies, particularly modest emission fees, for controlling industrial sources, and transportation controls, whether mandated or based on congestion fees, for controlling future mobile-source emissions, but noted the necessity for infusion of funds (perhaps through fare increases and/or privatization or through foreign donors) to maintain, upgrade, inspect, and convert urban diesel-bus fleets.

Baldzhi and Kharichkov [5] demonstrate sufficient reasons for highlighting socio-ecological-economic systems which consist of three substructures: the social, the ecological and the economic, composed, in turn, of such constituents as population settlement, natural-resource and production components, infrastructure etc. With all this taken into account, a substantial result for an improvement in the use of natural-resource potential and socio-economic development can be obtained due to an increase in efficiency of the natural resource management, its thrifty application and introduction of advanced low-waste and zero-waste technologies. This, in accordance with [5], will prove possible under building up the national policy based on the principles of sustainable society development.

List of References

1. *Capra F.* The Hidden Connections: A Science for Sustainable Living. - Flamingo, 2003. – 320 p.

2. *Dasgupta P., Mäler K.* The Environment and Emerging Development Issues. - Oxford University Press, 2000. – 593 p.

3. *Godet M., Durance P.* Strategic Foresight for Corporate and Regional Development. - Dunod, Unesco, 2011. – 173 p.

4. *Sanò M.* A Systems Approach to Identify Indicators for Integrated Coastal Zone Management / PhD Dissertation, Universidad de Cantabria, Santander, Spain, 2009. – 195 p.

5. *Балджи М.Д., Харічков С.К.* Метрологія соціо-еколого-економічних систем // ІПРЕЕД НАН України. – Одеса, ІПРЕЕД, 2010. – 342 с.

6. *Семенов В.Ф., Балджи М.Д., Мозгальова В.М.* Регіональний вимір рекреаційно-туристичної діяльності: Монографія. – Одеса: Вид-во «Optimum», 2008. – 201 с.

Структурний аналіз як інструмент оцінки адаптивної здатності прибережної зони Одеси.
Гусєва К.Д.
В роботі проводиться аналіз потенціалу методу структурного аналізу для визначення адаптивної здатності системи. У дослідженні застосовується системний підхід, і, як приклад, за основу береться прибережна зона Чорного моря в межах Одеської агломерації. В результаті дослідження були запропоновані інструменти адаптивного управління та критерії моніторингу досліджуваного району.
Ключові слова: *структурний аналіз, прибережна зона, соціально-екологічна система, зацікавлена особа, фактор впливу, каузальна матриця участі, каузальна петльова діаграма.*

Структурный анализ как инструмент оценки адаптивной способности прибрежной зоны Одессы.
Гусева Е.Д.
В работе проводится анализ потенциала метода структурного анализа для определения адаптивной способности системы. В исследовании применяется системный подход, и в, качестве примера, за основу берется прибрежная зона Черного моря в пределах Одесской агломерации. В результате исследования были предложены инструменты адаптивного управления и критерии мониторинга исследуемого района.
Ключевые слова: *структурный анализ, прибрежная зона, социально-экологическая система, заинтересованное лицо, фактор влияния, каузальная матрица участия, каузальная петлевая диаграмма.*