THE ROLE OF DPSIR DIAGRAM IN THE ANALYSIS OF ECOLOGICAL AND SOCIAL CONDITIONS OF THE ARAL SEA SHRINKING PROBLEM IN UZBEKISTAN

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The paper deals with application of the DPSIR diagram approach to the Aral Sea ecosystem problem. The DPSIR diagram, a causal framework for environment-society interaction, represents complex connections between the shrinking of the Aral Sea and various social and ecological problems in the region. Examining the components of this interdisciplinary approach – economic forces, pressures, states, impacts and responses could lead to a common response to the environmental, social and economic challenges in the Aral Sea region.

Keywords: Aral Sea, DPSIR diagram, driving force, pressure, state, impact, response, ecological, social conditions

"Today it is quite obvious that the complex of ecological, climatic, social and demographic problems came about in the Aral Sea adjacent area, which are of a global, I would say, planetary scale" stated the first President of Uzbekistan Islam Karimov at the Meeting of Heads of States-Founders of the IFSA on April 28, 2009.

The Aral Sea was an endorheic lake lying between Kazakhstan in the north and Uzbekistan (Karakalpakstan) in the south. Over the past four decades, it has dried, due to both natural and human forces. As a result of the shrinking, the diversity of social and environmental problems in Uzbekistan has increased. A large debate between international policies, focusing on different methods and ways of solving the problem, is still ongoing.

The Aral Sea which stands in the 4th place according to size is drying up before the eyes of one generation. The problem of the Aral Sea is not only a local but also a global catastrophic problem in the world over the last two decades due to the reduction of the Aral Sea. The variety of problems in the region is increasing in the socio-economic and natural environment. Normally developed conceptual frameworks, such as the DPSIR (Drivers, Pressures, State, Impact, Response Model Intervention), could adapt to this issue, so that they are familiar with and able to address a huge environmental catastrophic problem of the DPSIR diagram (Carr et al., 2007).

In order to give a structure of the complex problem and to present all indicators with their links, it is helpful to use the DPSIR framework. The DPSIR framework is a tool consisting of five main parts: Driving force, Pressure, State, Impact and Response (Kristensen, 2004). The driving forces are the socio-economic and socio-cultural forces of human activities. Pressure covers the tensions that human actions place on the environment and societal invention that leads to a change in the "State". State is the condition and quality of the Environment. Impact covers only negative consequences, whereas positive effects of environmental problems and societal impact of a change should be a part of the "State". Response denotes to the possible solution by society to the environmental situation and it is this societal response that feeds back on the Driving force, Pressure, State and Impact again. The DSPIR tool can give feedback on the complex problems to the policy makers and cannot hereby help in decision-making (Digout, 2005).

The proposition is that the interdisciplinary framework like the DPSIR tool can analyze the social and environmental problems of the Aral Sea region in order to give a clear overview of the problem for the decision-makers. It can be argued without the complex analysis that the DPSIR diagram can present, the links of the problem can be missed, what will further influence the wrong decision making.

The paper consists of the short overview of the Aral Sea disaster and its negative consequences to the region, further, the problem will be analyzed from the interdisciplinary approach using the DPSIR diagram of the case.
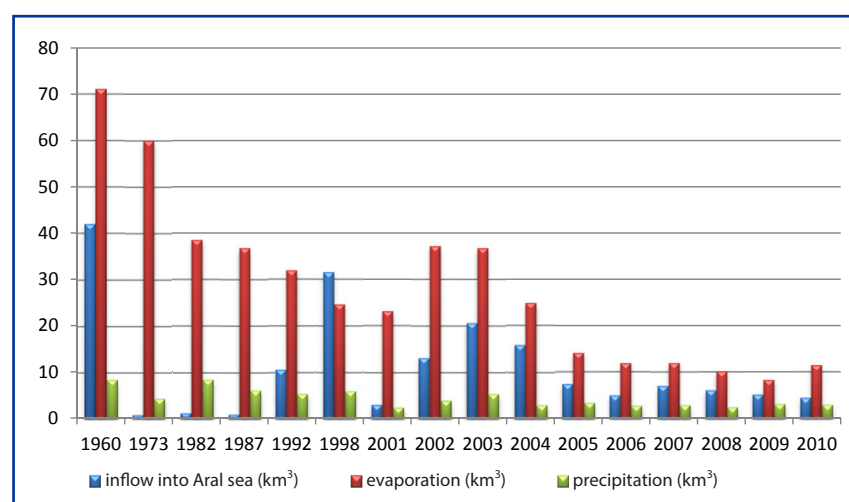
The Desiccation of the Aral Sea and its negative Consequences

The decline in groundwater levels in the Amudarya and Syrdarya areas has contributed to the accumulation of salt on the surface. This increase in salt content was later accompanied by a change in vegetation coverage, as the plants began to die due to the increased salinity of the sea. As a result, vegetation in the region has decreased by at least 40%. A side effect of the decrease in the protective vegetation cover was intensified winds, which led to more dust storms in the area. Six million hectares of agricultural land were destroyed as a result of salinization and desertification (Bosch, 2007).

Table 1　　Hydrological observation and morphologic change of water index of the Aral Sea

Years	Inflow into Aral Sea in km^3			Evaporation in km^3	Water volume in km^3			Precipitation in km^3	Salinity in g.L^{-1}
	Amudarya	**Syrdarya**	**total**		**small sea**	**large sea**	**total**		
1960	20.7	21.3	42.0	71.1	–	–	1093	8.5	10
1973	0.6	0.3	0.9	60.0	–	–	824.2	4.4	13.4
1982	0.0	1.3	1.3	38.5	–	–	579.8	8.5	18.8
1987	0.0	1.0	1.0	36.8	22.4	323.2	345.6	6.2	25.0
1992	7.4	3.2	10.6	31.9	20.3	240.2	260.5	5.4	35.0
1998	23.9	7.6	31.5	24.6	27.0	168.4	195.4	6.0	42.0
2001	0.4	2.7	3.1	23.1	17.9	131.2	149.1	2.5	58.6
2002	6.7	6.4	13.1	37.1	18.4	110.8	129.2	4.0	82.0
2003	11.4	9.2	20.6	36.7	19.8	97.2	117.0	5.4	86.0
2004	5.9	9.9	15.8	24.8	22.4	93.5	115.9	3.0	91.0
2005	3.0	4.4	7.4	14.0	22.5	89.8	112.3	3.5	98.0
2006	1.5	3.5	5.0	11.8	24.0	81.3	105.3	2.8	109.0
2007	2.5	4.5	7.0	11.9	23.2	81.1	104.3	3.0	112.0
2008	2.0	4.1	6.1	10.1	23.0	80.1	103.1	2.5	117.0
2009	2.1	3.1	5.2	8.3	22.8	79.2	102.0	3.2	120.0
2010	2.0	2.5	4.5	11.4	22.6	75.5	98.1	3.0	130.0

Source: Gaybullaev et al. (2012)

Figure 1 Water inflow, Evaporation and Precipitation indexes at the Aral Sea (Based on the tab.1)

like Tuberculosis, Anemia, Breathing and Nerves system diseases are often met among the people. During years of water shortage, the mineralization degree of ground water was increased from 10 g.L^{-1} to 40 g.L^{-1}. Due to this situation, 77% of the urban population of Karakalpakstan and villages are supplied with fresh water by water-pipe (Cawater-info portal data).

Shrinking of the Aral Sea is the main reason for the decreasing conditions of social life and causes the increasing of the desertification process. Moreover, there are changes in the ecosystems, a sharp decrease of the fertility of the soil harvest and an extinction of the animals and fish species in the region.

Since the case of the Aral Sea is related to all kind of problems, varying from social to ecological issues, it makes sense to discuss the case using an interdisciplinary approach, thereby covering all sorts of related problems.

Analyzing the Aral Sea problem using the DPSIR diagram

In the following figure 1, the DPSIR diagram is presented. If before it was considered that the shrinking of the Aral Sea is the main reason for all social and ecological problems in the region,
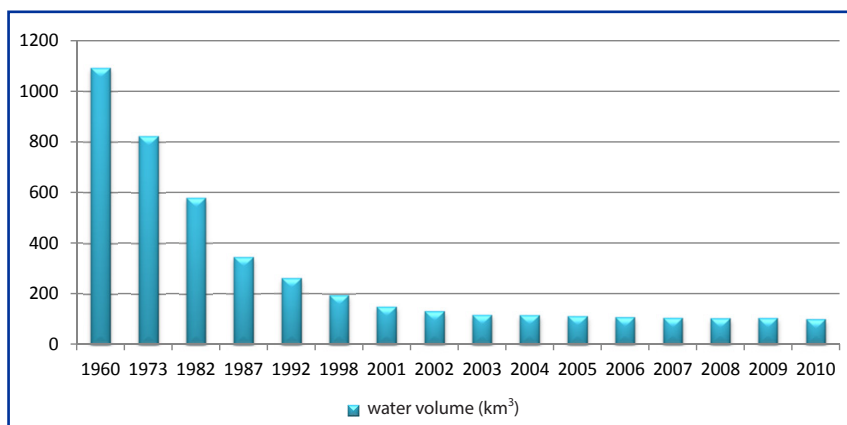
A sharp increase in salinization of lands is one of the most negative consequences of the Aral Sea crisis. Groundwater level decline also caused salt accumulation in the subsoils. This led to the increase in salt deposition in the soil profiles and reeds were replaced by grass saltworts as a result, which prevented anything from growing there. Salinization of soils accelerated the desertification process as it accompanied the sharp decline in groundwater level and the drying of subsoils. This eventually led to soil erosion, one of the primary reasons for extensive fertilizer use. In turn, these abusive fertilizing practices further deteriorated soils and created pollution that went both into the Aral Sea through groundwater circulation and into the air through dust storms.

As a result of the shrinking Aral Sea, the death rate of children, bacteriological and infectious diseases

Figure 2 Water volume index at the Aral Sea (Based on the tab.1)
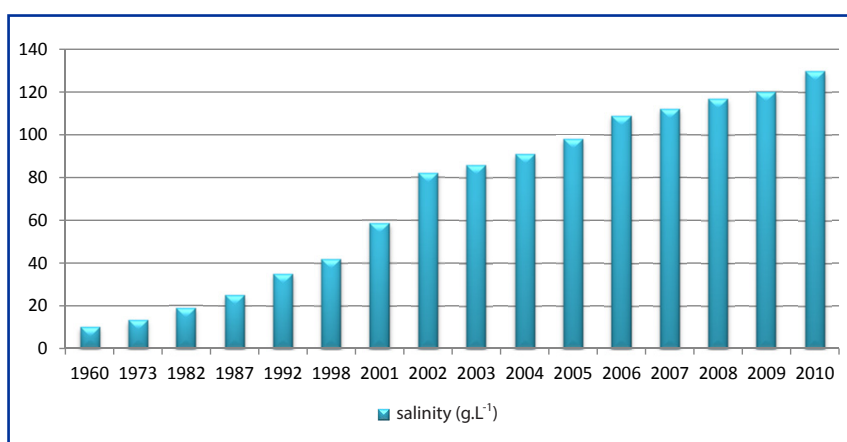

Figure 3 Salinity index at the Aral Sea (Based on the tab.1)

now the DPSIR diagram will show the real source of the problems. Increased irrigated area under the cotton growth because of the Soviet Union policy is presented as the driving force in this case and it has influence to water balance in rivers and in the lake, which has sharply decreased. According to these changes, the state of the area, presented in natural conditions as the quality of air, water and soil, loss of biodiversity and of course the regional climate has changed.

The social condition presented as the quality of life standard and health, economic activities and current condition of ecosystem services in the area also changed. The impact from the changed states of natural conditions are as follows: air pollution, lack of water resources and a simultaneously increasing concentration of salt in water, increasing salinity of the soil and a decreasing harvest year by year, disappearing fauna and flora and an increase of the regional temperature, while the social conditions impacts presented in economic activity decrease in the Aral Sea region, tuberculosis,

DRIVING FORCE:	
Increased irrigated area under the cotton growth because of the SU policy	
PRESSURE:	
Extraction of water:	
– lower water balance in the rivers	
– lower water balance in the lake (shrinking)	
State (Natural):	**State (Social):**
– Quality of air	– Quality of health
– Quality of water	– Economic activities
– Quality of soil	– Condition of Ecosystem services (Cultural services)
– Loss of biodiversity	
– Regional climate change	
Impact (Natural):	**Impact (Social):**
– Air pollution (Increasing of the dust in the air)	– Economic activities decrease in the Aral Sea region
– Lack of water resources and simultaneously increasing the concentration of the salt in water	– Tuberculosis, Asthma and Anemia disease increase among the population
– Increasing salinity of the soil and decreasing harvest year by year	– Lack of clean drinking water
– Fauna and flora disappearance	– Agricultural activities decrease year by year
– Regional temperature increase	– Cultural services, (tourism and recreation services almost dying)
RESPONSE:	
– Improving public awareness about the negative impacts of the shrinking the Sea	
– Organizing and creation the complex (landscape) reserve and state Biosphere reserves, in order to be familiar and safe the current condition of the Aral Sea and biodiversity	
– Launching pilot projects which will be based on new desert plants (in order to keep the dust) in the dried part of the Aral Sea	
– Some legislation to protect the Aral Sea	
– Education on effects of the Aral Sea shrinking problem	

Figure 4 DPSIR diagram of the Aral Sea problem

asthma and anemia disease increase among the population, lack of clean drinking water, agricultural activities decrease year by year and cultural services.

Furthermore, both conditions refer to the ways of solutions for the Aral Sea problem as Improving public awareness about the negative impacts of the shrinking, organizing/creation of the complex (landscape) reserve and state Biosphere reserves, in order to be familiar and safe with the current condition of the Aral Sea and biodiversity, launching pilot projects which will be based on new desert plants (in order to keep the dust) in the dried parts of the Aral Sea, some legislation to protect the Aral Sea, and of course creating some education on effects of the Aral Sea shrinking problem in the region.

It is important to mention that interdisciplinary approach and the DPSIR tool play a big role in analyzing the problem. It can be seen from next example. Let's pretend that the decision maker is not going to use the DPSIR diagram structure that was shown above and he or she will be motivated only by one part of the problem, for instance, increasing of tuberculosis and asthma diseases in the region (only social aspects). His or her main focus will be directed to decrease the disease in the region, but not the cause of the disease. The problem of the region will still exist and people will continue to suffer from the other influences of the Aral Sea disaster, because the natural problems were not taken into account during the decision making.

This example shows how important it is to use interdisciplinary approach and to think wider while analyzing the problem and taking into account possible links from different perspectives.

Conclusion and Discussion

In conclusion it can be said that the interdisciplinary framework and the DPSIR tool is very helpful to make an overall overview of the problem without missing the links of causality of the problem. Based on the assessment of the Aral Sea's hydrological balance and other inputs on society and nature, DPSIR provides a methodical approach for comprehensive environmental assessment. The study also presents how the diagram can influence the decision making. Nevertheless, among all benefits of the DPSIR tool

and interdisciplinary framework there could be some lacking points. As it was mentioned that the diagram represents fully all the problem, for decision makers it could be sometimes very difficult to cover all the aspects that the frame gives and the preference will be directed to one small part of the problem. It is usually done in a case of investment. However, it can be said that using interdisciplinary framework like the DPSIR diagram takes much more time compared to other disciplinary approaches in order to determine every detailed data about the specific area and in this case the efficiency and complexity of the problem has high results.

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