Environmental Impact Assessment of Development in the Southern Coast of the Caspian Sea (Northern Iran)

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Abstract

One of the critical aspects which has been emphasized at UNCED conference is utilization of coastal areas and its issues. Considering the afore-mentioned critical problems, the coasts of the Caspian Sea are of particular importance. The Caspian Sea is located between five countries: Iran, Turkmenistan, Azerbaijan, Russia and Kazakhstan. The area, with high and specific ecological capabilities, is very suitable to urban development. There is no doubt that development and industrialization might provide socio-economic welfare to the area-dependent inhabitants, but socio-environmental issues could be generated by improper application of technology and industry. As hurried development, without carrying-out environmental impact assessment in watersheds of the Caspian Sea, might impose adverse effects on the environmental quality of the water body, the present study intends to execute Land Degradation Model (LDM) and determination of ecological susceptibility of terrestrial ecosystems using the Object-Oriented Method in sub-watersheds of the water body.

Since long-term environmental issues could not immediately be solved by technological approaches, understanding the relationship between development and environmental protection and consideration of environmental impact assessment (EIA) as an important planning tool in planning process, are being focused in order to achieve sustainable development.

Keywords: Caspian Sea, Iran, development, Land Degradation Model (LDM), technology

Introduction

The Caspian Sea, the biggest lake in the world, is about 400,000 km^2 in area and at the present time is shared by Iran, Russia, Turkmenistan, Azerbaijan and Kazakhstan. Russia and Kazakhstan have the shortest (695 km) and the longest coasts (2700 km), respectively. Turkmenistan has 1200 km, Iran 900 km, and Azerbaijan 850 km [1].

Pollution of the water body, reduction of biodiversity and also the water body-dependent natural resources have caused concerns for people who live on the coast of the Caspian Sea. As land-originated pollution has created a major contribution to pollution of the water body, belief in the commitment of the above-mentioned countries to the environmentally-sound management of the coast of the Caspian Sea might improve the environmental quality of the water body. The present study has been carried out to determine the extent of the environmental quality in the southern coasts of the water body (Map1).

It should be remembered that environmental impact assessment is necessary for assisting ecological capabilities, and preventing the performance of environmentally destructive projects, as a tool to obtain sustainable development [2].

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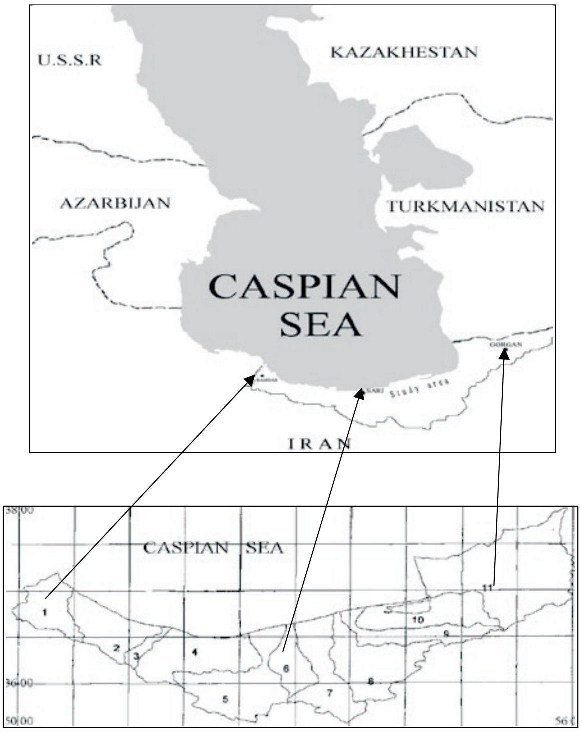

Map 1. The geographical position of the study area.

Habita [3] has also mentioned that the mere technological assessment transformation from the northern countries to the southern countries cannot meet the environmental requirements. So, the localization of the assessment technologies and planning, like LDM, used in this research [4], can be an approach in environmental impact assessment methods (EIA). In fact, LDM is one of the environmental impact assessment methods (EIA) that analyzes the impact of human activities in a quantitative manner in a regional or watershed scale. Concerning LDM, a literature survey shows that the model was first developed by Makhdoum [5] and executed in Azerbaijan Province. Jabbarian [6], Azari [7], Nouri [8], Mimarian [9] and Jafari [10] have run it in different watersheds of Iran.

The unique features of the LDM are its dependence on expert judgment and extensive fieldwork. These characteristics might mislead low experience environmental assessors during application of the model. Since they should assess the degree of ecological susceptibility and also the extent of environmental degradation, on the basis of his own ecological knowledge and expert judgment.

Jabbarian [6] has taken some steps to develop and introduce an object-oriented method to determine the ecological susceptibility of terrestrial ecosystems. Nevertheless, determination of the extent of degrading factors are based on expert judgment. Meanwhile he has proposed the following formula for objective determination of the extent of the degrading factors:

$$I_i = \sum_{i=n}^{i} \left(\frac{AI_i}{AS_i} \text{ x } D_i \right) \qquad (1)$$

where:

I_i - extent (intensity) of the degrading activities in sub-watershed i

AI_i - area occupied by the degrading activities in sub-watershed i

AS_i - area of sub-watershed i

D_i - importance value of the degrading activities in sub-watershed i

The present paper intends to determine the environmental quality degradation extent in sub-watershed scale through the application of LDM.

Study Area

The study area is located in the southern coast of the Caspian Sea between 35° 47' 00'' to 36° 35' 00'' north and 50° 36' 00'' to 54° 10' 00'' east. It has 23756.6 km^2 area (1.46% of the area of the country, Data Book of Mazandaran Province, 1998). This macro-watershed has 11 sub-watersheds of different areas (Table 1). Alborz Mountain Range plays a key role in establishing a unique ecological feature (dense forests, good ranges and fertile lands) through trapping the evaporated water of the Caspian Sea. The study area includes 20 counties and about 2,673,852 inhabitants with a density of about 112.5 persons/km^2 [1].

Method

For carrying out the present study, LDM was applied. The model is one of the modeling methods and might be classified as a system analysis approach [5].

In the model framework, linear equations are being applied to express the degree of environmental degradation in sub-watershed scale. For expressing the extent (intensity) of the degrading factors, different human activi-

Table 1. General features of the sub-watersheds in the study area.

No.of subwatershed	No.of networks	Area km^2	Percent
1	285	1781	3.4
2	482	3012	7.2
3	77	481	1.16
4	672	3919	9.42
5	881	5506	13.22
6	241	1506	3.62
7	456	2850	6.84
8	733	4581	11
9	448	2800	6.72
10	561	3506	8.42
11	1872	11700	28.1

Table 2. Classification of intensity of environmental quality degradation.

Class	Quality of environmental degradation
1	Minor
2	Moderate
3	Severe
4	Very Severe

Table 3. Classification of Ecological Susceptibility of Terrestrial Ecosystems.

Class	Quality of ecological susceptibility
1	Very resistant
2	Resistant
3	Moderate
4	Susceptible
5	Very Susceptible

ties might be listed in all the sub-watersheds as an impact unit. Intensity of the degrading factors and determination of ecological susceptibility of terrestrial ecosystems have been classified on the basis of Table 2 and 3. In each impact unit the degrading factors and its intensity might be determined. In order to realize the impact of human population on sub-watersheds, physiological density [11] has been included in the model [5].

For expression of the extent of environmental degradation and in order to compare sub watersheds, the following formula is presented [4]:

$$LDM = \sum_{i=n}^{1} (A_i \times I_i) + \left(\frac{D_i}{S_i}\right) \quad (2)$$

where:
LDM - Land Degradation Model
A_i - the degrading factor I in sub-watershed
I_i - intensity of environmental degradation in sub-watershed
D_i - physiological density in sub-watershed
S_i - ecological susceptibility in sub-watershed

Results and Discussion

For determination of the intensity of human activities, through using topographic map, 11 sub-watersheds have been delineated, human activities have been listed and its intensity has been subjectively specified. Table 4 shows physiologic density in sub-watersheds.

On the basis of the object-oriented method for determination of ecological susceptibility of terrestrial ecosystems [6] and through using maps of physical re-

Table 4. Physiologic density in sub-watersheds of the study area.

No. of sun-watershed	Physiologic density (person/ km^2)
1	610
2	2929
3	402
4	812
5	845
6	12428
7	2644
8	327
9	21961
10	316
11	34

Table 5. Mean of ecological susceptibility of sub-watersheds and their classification in the study area.

No. of sub-watersheds	Ecological susceptibility	Class
1	82.3	5
2	69.7	4
3	80.8	5
4	74	4
5	61.5	3
6	64.7	3
7	59.7	2
8	59.3	2
9	81.7	5
10	44.9	1
11	54	2

sources (slope, face, elevation, geology and climate) and maps of land resources (soil, vegetation) ecological susceptibility of sub-watersheds have been determined [12]. Table 5 reveals the mean of ecological susceptibility of terrestrial ecosystems (sub-watersheds) and their classification.

In a final step, LDM has, through the acquired data and information, been formulated for sub-watersheds of the study area as follows:

$$\begin{aligned} S_1 = & XF_3 + XT_3 + FU_4 + X_4 + ZF_3 + HA_3 + H_4 + XU_3 + \\ & + XR_3 + RI_2 + RT_2 + Z_2 + IL_3 + PS_3 + OG_3 + W_2 + YA_2 + \\ & + YN_2 + YS_2 + WU_2 + WA_2 + FI_3 + GW_2 + EX_2 + TO_3 + \\ & + DI_2 + IM_2 + R_3 + 610/5 = 196 \end{aligned} \quad (3)$$

$$\begin{aligned} S_2 = {} & XF_3 + XT_3 + FU_4 + X_3 + ZF_3 + HA_4 + H_3 + XU_4 + \\ & + XR_3 + RI_3 + RT_4 + Z_2 + IL_3 + PS_3 + UG_4 + W_2 + YA_3 + \\ & + YN_3 + YS_3 + WU_2 + WA_3 + FI_4 + GW_3 + EX_2 + TO_4 + \\ & + DI_3 + IM_3 + R_4 + 2929/4 = 820 \end{aligned} \quad (4)$$

$$\begin{aligned} S_3 = {} & XF_2 + XT_3 + FU_4 + X_3 + ZF_3 + HA_4 + H_3 + XU_3 + \\ & + XR_3 + RI_3 + RT_4 + Z_3 + IL_3 + PS_3 + OG_4 + W_2 + YA_4 + \\ & + YN_3 + YS_3 + WU_2 + WA_2 + FI_4 + GW_3 + EX_2 + TO_4 + \\ & + DI_2 + IM_3 + R_4 + 402/5 = 165 \end{aligned} \quad (5)$$

$$\begin{aligned} S_4 = {} & XF_3 + XT_3 + FU_3 + X_4 + ZF_4 + HA_3 + H_3 + XU_3 + \\ & + XR_1 + RI_4 + RT_3 + Z_2 + IL_4 + PS_3 + OG_3 + W_4 + YA_2 + \\ & + YN_3 + YS_3 + WU_4 + WA_4 + FI_2 + GW_3 + EX_3 + TO_3 + \\ & + DI_3 + IM_1 + R_4 + 812/4 = 288 \end{aligned} \quad (6)$$

$$\begin{aligned} S_5 = {} & XF_3 + XT_2 + FU_3 + X_3 + ZF_3 + HA_3 + H_3 + XU_4 + \\ & + XR_3 + RI_4 + RT_4 + Z_2 + IL_4 + PS_3 + OG_3 + W_4 + YA_4 + \\ & + YN_4 + YS_4 + WU_4 + WA_4 + FI_4 + GW_5 + EX_4 + TO_4 + \\ & + DI_4 + IM_4 + R_4 + 845/3 = 375 \end{aligned} \quad (7)$$

$$\begin{aligned} S_6 = {} & XF_2 + XT_3 + FU_3 + X_3 + ZF_3 + HA_4 + H_3 + XU_2 + \\ & + XR_2 + RI_4 + RT_3 + Z_2 + IL_3 + PS_4 + OG_4 + W_3 + YA_2 + \\ & + YN_4 + YS_4 + WU_3 + WA_3 + FI_3 + GW_3 + EX_2 + TO_3 + \\ & + DI_3 + IM_2 + R_3 + 12428/3 = 3892 \end{aligned} \quad (8)$$

$$\begin{aligned} S_7 = {} & XF_3 + XT_2 + FU_3 + X_3 + ZF_3 + HA_4 + H_4 + XU_3 + \\ & + XR_4 + RI_2 + RT_3 + Z_3 + IL_3 + PS_4 + OG_4 + W_4 + YA_3 + \\ & + YN_4 + YS_4 + WU_4 + WA_3 + FI_4 + GW_3 + EX_3 + TO + \\ & + DI_3 + IM_3 + R_3 + 2644/2 = 1412 \end{aligned} \quad (9)$$

$$\begin{aligned} S_8 = {} & XF_3 + XT_2 + FU_4 + X_3 + ZF_3 + HA_3 + H_3 + XU_3 + \\ & + XR_2 + RI_3 + RT_2 + Z_2 + IL_2 + PS_4 + OG_3 + W_3 + YA_3 + \\ & + YN_3 + YS_3 + WU_4 + WA_3 + FI_2 + GW_2 + EX_2 + TO_2 + \\ & + DI_3 + IM_2 + R_3 + 327/2 = 240 \end{aligned} \quad (10)$$

$$\begin{aligned} S_9 = {} & XF_4 + XT_2 + FU_4 + X_3 + ZF_3 + HA_3 + H_3 + XU_3 + \\ & + XR_3 + RI_3 + RT_2 + Z_3 + IL_4 + PS_3 + OG_3 + W_0 + YA_2 + \\ & + YN_2 + YS_2 + WU_3 + WA_2 + FI_2 + GW_1 + EX_1 + TO_1 + \\ & + DI_2 + IM_4 + R_2 + 21961/5 = 4463 \end{aligned} \quad (11)$$

$$\begin{aligned} S_{10} = {} & XF_2 + XT_1 + FU_3 + X_2 + ZF_2 + HA_3 + H_4 + XU_2 + \\ & + XR_2 + RI_2 + RT_2 + Z_3 + IL_4 + PS_4 + OG_4 + W_2 + YA_2 + \\ & + YN_3 + YS_3 + WU_3 + WA_2 + FI_1 + GW_2 + EX_1 + TO_2 + \\ & + DI_3 + IM_1 + R_2 + 316/1 = 383 \end{aligned} \quad (12)$$

$$\begin{aligned} S_{11} = {} & XF_2 + XT_1 + FU_4 + X_3 + ZF_2 + HA_3 + H_4 + XU_3 + \\ & + XR_3 + RI_3 + RT_2 + Z_2 + IL_4 + PS_4 + OG_4 + W_1 + YA_2 + \\ & + YN_3 + YS_4 + WU_2 + WA_3 + FI_2 + GW_2 + EX_1 + TO_1 + \\ & + DI_3 + IM_1 + R_1 + 34/2 = 86 \end{aligned} \quad (13)$$

where:
XF - transformation of forest into range
XT - transformation of forest into orchards and villas
XZ - forest utilization
X - transformation of forest into arable land
ZF - tree cutting for rural fuel
HA - degradation of habitat
H - irrational hunting
XU - change in land use
XR - transformation of range into arable land
RI - transformation of range into industrial land
OG - over-grazing
W - irrational use of wetland
YA - air pollution
YN - water pollution
YS - soil pollution
WU - over-use of water
WA - waste
FI - over-fishing
GW - high groundwater table
EX - invasion of exotic species

In general, the findings of the study would be applied for prioritization of impact units for allocation of the developmental plans in the study area. Table 6 shows prioritization of the sub-watersheds in the study area.

Conclusion

In several past decades, human society has understood that economic development models were not properly selected. Considering this new approach to economic development, the concept of sustainable development has been introduced into human society. At present, decision making between industrialization and protection of environmental options is losing its importance in many countries of the world. Up to now, many countries do endeavor to achieve a kind of economic development to ensure not only improvement in economic welfare but also in environmental quality as the basis of their economic development.

The results of the present research have revealed that the impact of development on the environment of the southern coast of the Caspian Sea is worrisome. Out of the 28 degrading factors being studied in 11 sub-watersheds of the southern coast of the Caspian Sea (Gorgan to Ramsar), especially in sub-watersheds 1, 3, and 9, which have been known as the most susceptible regions due to irrational uses, the following factors are recognized as the most degrading ones: over-utilization and irrational use of forest, transformation of forest and ranges into arable and industrial lands and, in general, the overall change in uses. Besides, the absence of a

Table 6. Prioritization for allocation of developmental plans on the basis of output of LDM in the sub-watersheds in the study area.

No. of sub-watersheds	LDM index	Degree of prioritization
1	196	3
2	820	8
3	165	2
4	288	5
5	375	6
6	3892	10
7	1412	9
8	240	4
9	4463	11
10	383	7
11	86	1

compassionate future foreseeing and scientific management is quite obvious.

Low degree of degradation in some networks like 10 and 11 is due more to low physiological density (human presence) and/or low intensity of human activities or in other words underdevelopment [8] than to the suitable physical and natural conditions for development. Although the degree of the ecological susceptibility in most of the observed networks is low, any kind of development should be based on ecological (physical and biological) conditions which need assessment studies of ecological capabilities on a larger scale [8]. At any rate, based on the definition of the development, no desirable perspective for the future of the Caspian Sea and the people who are dependent on the sea environment is conceived.

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