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Diagnostic analysis of the Lake Uluabat in Turkey

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Abstract: *Diagnostic analysis of wetlands is an ordered/structured method of examining wetland systems to identify their values and constraints for the solution of the environmental problems. This study focuses on the diagnostic analysis of Lake Uluabat on the feasibility of "Objective Oriented Project Planning (OOPP)" approach, created by the United States Agency for International Development (USAID) and further improved by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). Negative changes both in water quality and quantity were determined as the core problems. The main results were summarized as the water pollution and fluctuation in the water level caused by the urban and agricultural waste disposals, sedimentation, and overfishing. These negative effects cause loss of biodiversity and damage to crops. Disposal control, training, adequate regulations, and a centralized control and monitoring authority have been proposed to cope with the determined problems.*

Key words: *Diagnostic analysis, Problem analysis, Objective analysis, Environmental management, Lake Uluabat.*

Introduction

Water resources management is a dynamic and continuously changing subject. Many studies have been carried out to use water resources efficiently in favour of human and environment in the new millennium. In order to achieve this goal and to meet the increasing populations' demands, achievement of sustainability and efficiency in water resources management is very important. Unfortunately, ecosystems of rivers, lakes, and seas are under threat due to inappropriate water resources projects designed on watersheds as well as the externalities created by other human activities. Nevertheless, wetland functions have been threatened in the world as a result of human activities such as swamp reclamation, disposal of municipal and industrial wastewater, agricultural use of fertilizers and pesticides, tourism and urbanization, illegal and over fishing, and overgrazing and uncontrolled marsh removal.

Wetlands are one of the most productive water resources in maintaining rural development projects and play an important role in the freshwater system. They positively contribute to the quality of both surface and groundwater supplies (Miller, 1990). They are generally considered to have functions on hydrologic flux and storage, biological productivity, biogeochemical cycling and storage, decomposition, and community/wildlife habitat (Richardson, 1994). Two of the main functions of wetlands are to provide water regime balance and serve as a host of rich and characteristic aquatic flora and fauna.

Turkey is one of the richest countries in terms of wetland resources in Europe and in the Middle East. Wetlands in Turkey are globally important because, they are located on the route of migratory waterfowl among Asia, Europe, and Africa. The wildlife protection has become one of the main issues in United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992 and the 18,000 participants from 166 countries has come into agreement on wetland protection. Although Turkey is a party of International agreements on wildlife protection and management, care and legislation are inadequate on the subject. Despite their valuable functions in providing ecological balance and sustaining biodiversity, wetlands are under risk in Turkey and its problems were not determined well enough.

The diagnosis of a system can be viewed as the process for solving problems by identifying the reasons of them, qualifying and quantifying of their effects, examining the methods of ordering, and presenting and using information (Bruscoli and Preti, 1998). Therefore, the aim of this study is to make a diagnostic analysis of Lake Uluabat, focusing on the feasibility of "Objective Oriented Project Planning (OOPP)" approach. The OOPP approach was created by the United States Agency for International Development (USAID) and improved by the Deutsche Gesellschaft für Technische Zusammenarbeit GTZ (Anonymous, 1988).

Materials and Methods

Study area: Lake Uluabat is located on the south of Marmara Sea, in Karacabey and Mustafakemalpasa districts of Bursa Province in Turkey (Fig. 1). It covers an area of between 135 and 160 km^2 depending on the lake level. The mean and maximum depths are 2.5 and 10 m, respectively. The sea level of the lake is 9 m. The area of the lake has been determined as 120 km^2 by a remote sensing study. The watershed has an area of 10,555 km^2, covering three provinces. There are eight islands of different sizes on the lake. A large and expanding delta has been formed by silt deposition around the Mustafakemalpasa river mouth in the southwest section (Aksoy *et al.,* 1997).

The lake is largely fed by Mustafakemalpasa Stream located on the southeast of the Susurluk basin, and has been

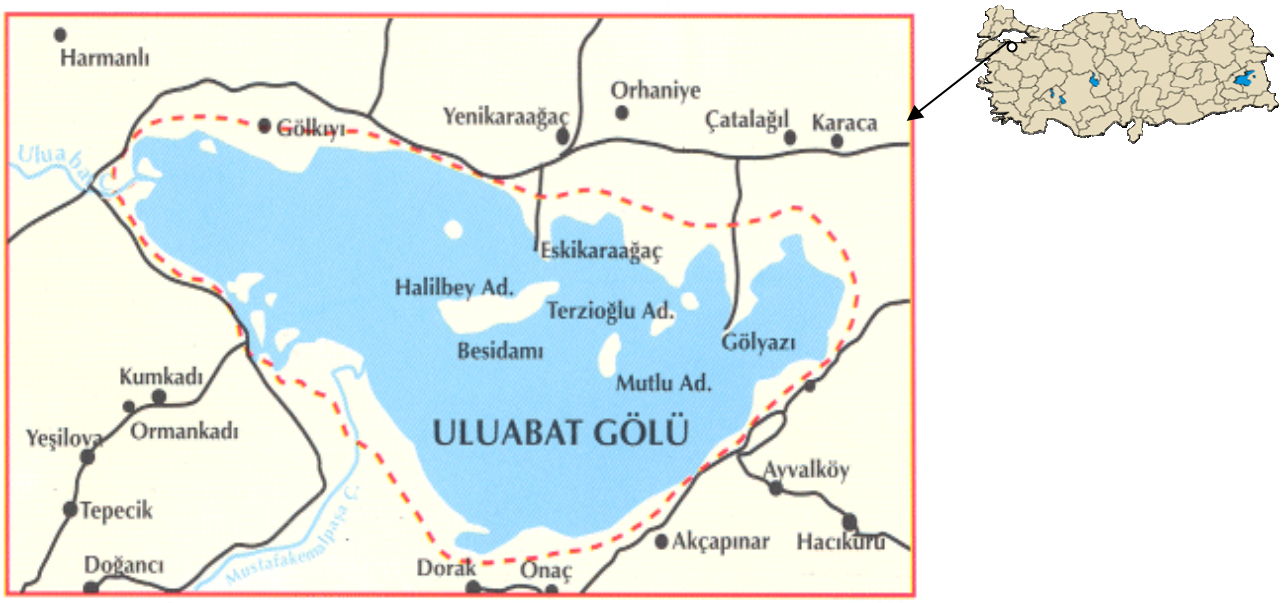

Fig. 1: The map of Turkey (right) and Lake Uluabat (left).

formed by Emet and Orhaneli streams further upstream. The water leaves the lake via Uluabat Stream (the main outflow) from the west shore of the lake, and via Susurluk stream reaches to Marmara Sea. Lake water quality is threatened by discharges of polluted water into the rivers which recharge to the lake as well as by discharges of polluted water directly into the lake itself. The main sources of the pollutants entering into the rivers (Emet, Orhaneli, and Mustafakemalpasa) are the waste from mining activities, industrial and sewage effluents, and agricultural use of fertilizers, herbicides and pesticides. The main sources of the pollutants entering into the lake directly are irrigation drainage water, industrial discharges, and sewage effluent. Water quality parameters reported by Schot *et al.*, (1999) of the lake were given in Table 1 by the stations. The sediments in the river water settle out on the lake bottom near the point of inflow into the lake, forming the Mustafakemalpasa river delta. The amount of suspended matter in the lake directly affects the depth of light penetration, affecting the growth of aquatic plants, and fish species composition (Aksoy *et al.*, 1997). The lake is one of the nine RAMSAR (Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1994) sites in Turkey due to its rich biodiversity and valuable freshwater sources. Almost all shores of the lake are covered with submerged plants. Dominant macrophytes in the lake are *Scirpus*, *Typha, Butomus umbellatus* and *Nympha alba* (Welch and Welch, 1998).

The lake is located on the migratory bird route and is very close (35km) to another RAMSAR Site, the Manyas Lake. The lake has become one of the most important wetlands in not only Turkey but also the Middle East and Europe due to the degradation of natural characteristics of Manyas Lake as a result of human activities. It supports significant bird populations in winter (429,423 in 1996, the highest wintering waterfowl count at any Turkish site since 1970). The latest DHKD (Society for the Protection of Nature Turkey) survey (Welch and Welch, 1998) found 823 pairs of Pygmy Cormorants, 105 pairs of Night Heron, 109 pairs of Squacco Heron, 48 pairs of Spoonbill, 150 Little Bittern, and 30 Ferruginous Duck breeding on the lake.

Fishing is one of the main human activity at the site. Fish fauna of the lake consists of *Scardinus erythrophthalmus, Rutilus rutilus, Blicca björkna, Alosa maeotica, Vimba vimba, Alburnus alburnus, Esox lucius, Chalcalburnus chalcoides, Carassius carassius, Cyprinus carpio, Silurus glanis, Mugil cephalus, Barbus plebejus,* and *Tinca tinca* (DHKD, 2001). *S. glanis, M. cephalus, B. plebejus* and *T. tinca* were represented by a small portion in the fish fauna. Crayfish (*Astacus leptodactylus*) is also an important element of the lake but its stock decreased after a fungal disease in 1986.

Diagnostic analysis: In this study, the diagnostic analysis of the Lake Uluabat was carried out in three different phases, focusing on the feasibility of the OOPP approach. Initially the preliminary objectives were defined and the survey phase followed. Later the data were collected about the environmental conditions of the lake with the participation of different factors using a participation analysis methodology. Finally problem analysis was developed by the OOPP methodology by structuring the problem tree. The main steps of the OOPP analysis are participation analysis, problem analysis and objective analysis. To increase the acceptance of project planning and to ensure including the hypothetical needs and interests of the system users in the planning, the OOPP uses a participatory approach for the analysis through so-called the OOPP session or meeting (Anonymous, 1987 and Anonymous,

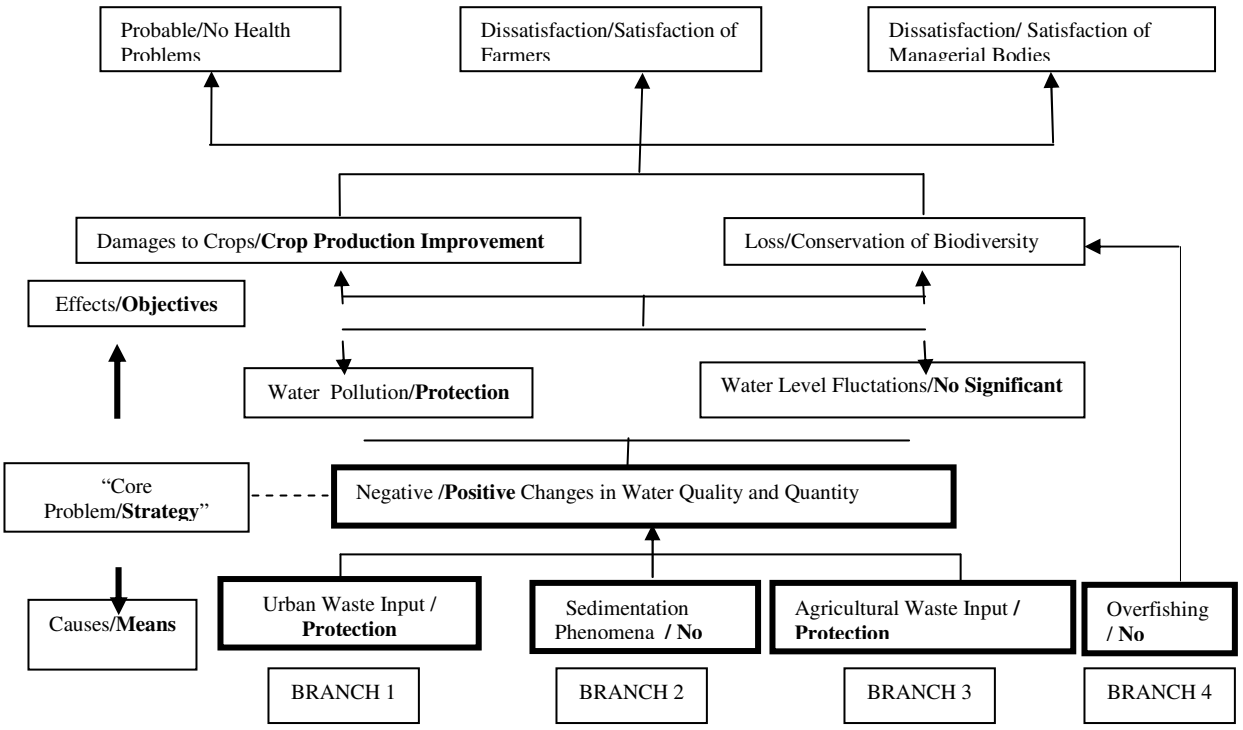

Fig. 2: Problem and objective tree of the Lake Uluabat in OOPP analysis.

1988).

Results and Discussion

The problem tree with four branches is presented in Fig. 2. The core problem related to the investigated wetland was identified as negative changes in water quality and quantity because of urban and agricultural waste inputs and sedimentation, causing water pollution and water level fluctuations. These effects, water level fluctuations and pollution, caused damages in crops and loss of biodiversity of a globally important wetland, ultimately causing dissatisfaction of users and managerial bodies and slowing down the rural development. Over fishing is also an important cause of the loss of biodiversity.

The detailed explanation of each of four branches in problem tree is shown in Fig. 3. Urban waste input was the result of inadequate protection structures and urbanization, disposal of municipal and industrial wastewaters, and bad people habits (Branch 1 in Fig. 3). The reasons of the sedimentation phenomena were threefold: uncontrolled forest removal, irrigation development, and wastes from mining activities (Branch 2 in Fig. 3). Agricultural wastes were produced by the uncontrolled application of agricultural chemicals such as fertilizers and pesticides, irrigation development activities, and lack of farmer training and monitoring facilities (Branch 3 in Fig. 3). Finally, overfishing was due to the lack of education of people, legislation, and control measures and monitoring systems (Branch 4 in Fig. 3).

The effects were determined as water pollution and water level fluctuation. Annual nutrition loading to the lake varied from 1 to 8 g P m^{-2} However, this value should not be more than 1 g P m^{-2} in this like shallow lakes. Suspended solid matter in the lake water was more than 200 mg l^{-1} in 2000. Total dissolved inorganic nitrogen concentration varied from 0.2 to 0.4 mg l^{-1} between 1986 and 1992. But this increased to 0.6 mg l^{-1} in 1998 and then 0.8 mg l^{-1} in 1999 (DHKD, 2001). So eutruphication of the lake has increased due to this high nutrition loading. The water quality of Mustafakemalpasa River just before it entered the lake was: 0.770 mg l^{-1} boron, 0.059 mg l^{-1} arsenic, 2.100 mg l^{-1} Biological Oxygen Demand (BOD), 0.210 mg l^{-1} ammonium, 0.023 mg l^{-1} chromium, and 97 mg l^{-1} suspended solid materials. The water quality of Emet river just before its entered the lake was: 1.07 mg L^{-1} boron, 2.0 mg l^{-1} BOD, and 109 mg l^{-1} suspended solid materials. The water quality of Orhaneli river just before entered it the lake was: 0.72 mg l^{-1} boron, 0.025 mg l^{-1} chromium, 2.0 mg l^{-1} BOD and 0.059 mg l^{-1} arsenic. Waste disposal from Vatan Canned-Food Anonymous, Sıla Oil, Nestle Türk, 52 leather-Lezzo Food, and Merko Food companies into the lake were 270,000 m^3 /year, 288, 100, 8,500, 960 m^3/day, respectively (Aksoy *et al*., 1997). The effects of water level fluctuation can be summarised as hydrological regime changes, water turbidity, and loss of biodiversity. The area of the lake decreased from 133.1 km^2 in 1984 to 120 km^2 in 1993 due to the accumulation of the sediment at the lake bottom (Aksoy *et al*., 1997). Because of the illegal and overfishing, economical fish stocks, *S. glanis*

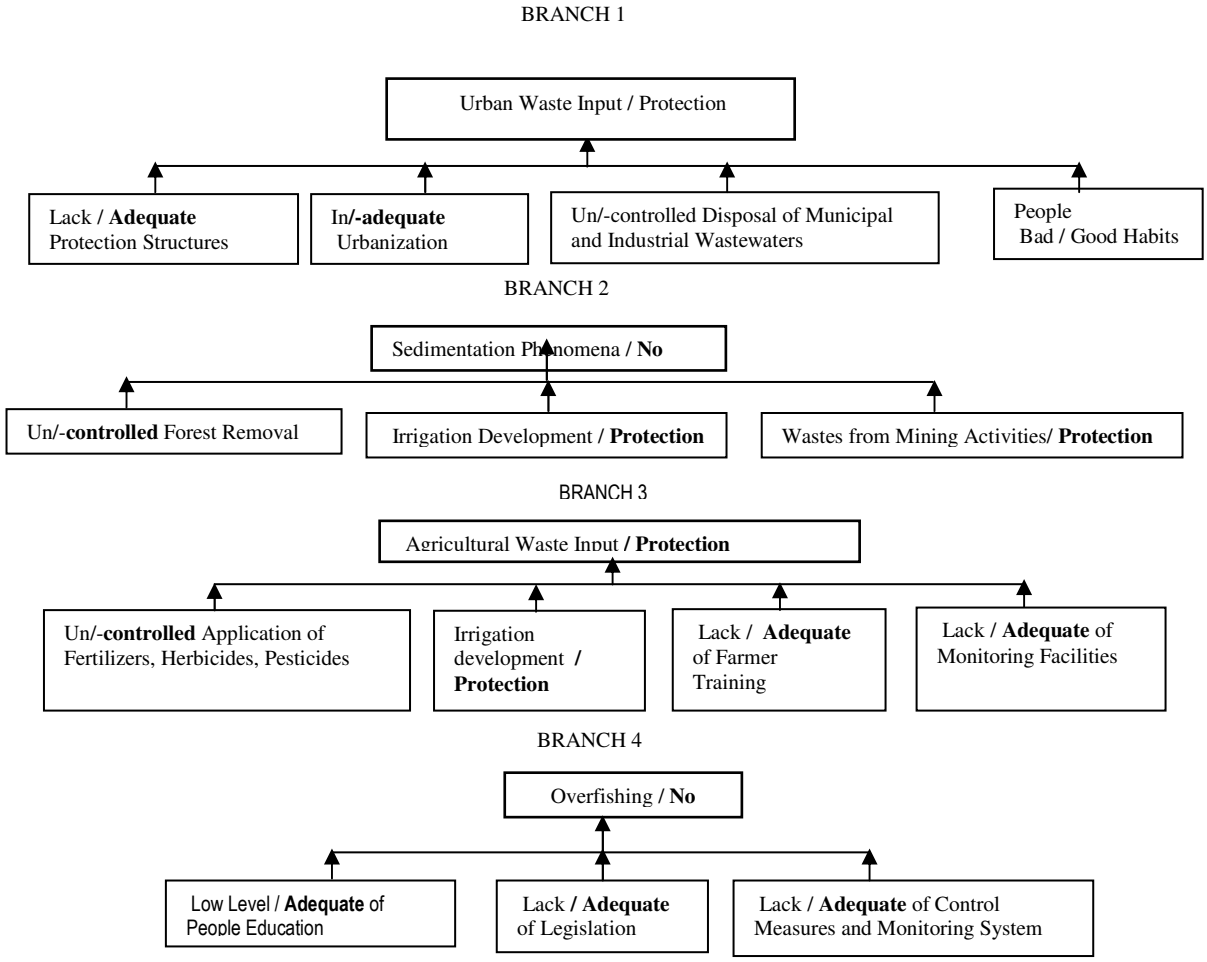

Fig. 3: The branches 1, 2, 3, and 4 in the problem and objective tree of the Lake Uluabat.

and *M. cephalus*, collapsed and fish fauna and biodiversity of the lake was changed.

The problem tree was then transformed into an objective tree with four branches (Fig. 2) in which the effects became objectives and the causes became means. The ecologic and hydrologic conditions of the lake can be improved by preventing waste inputs from the urban and agricultural lands and sedimentation, resulting better quality and stable level of water, and ultimately satisfaction of users and managerial bodies and improving the rural development.

The waste input from the urban can be prevented by means of adequate protection structures and urbanization, controlled disposal of municipal and industrial wastewaters, and improving the people's habit (Branch 1 in Fig. 3). Contolled forest removal, irrigation development, and mining activities prevent the wetland from the sedimentation (Branch 2 in Fig. 3). Agricultural waste input can be detained by the controlled application of the agricultural chemicals such as fertilizers and pesticides and irrigation development and adequate farmer training and monitoring facilities (Branch 3 in Fig. 3). Finally, overfishing problems can be solved by means of an adequate education of people, legislation, and control measures and monitoring systems (Branch 4 in Fig. 3).

When reviewing the available studies related to the lake by now, it was found that there was no monitoring and evaluation information system for the determination of the factors affecting the lake. In order to have outputs of factors affecting the lake for short-term in the Figs. 1 and 2, a monitoring and evaluation system must be established in which all interest groups are involved in the framework of the watershed management. On one hand, monitoring and evaluation information system should serve to diagnose and solve the problems for short-term in the lake. On the other hand, it should allow making long-term plans and projects.

On the problem tree it can be realized that various number of stakeholders affected the lake in the various forms. The main stakeholders were industry enterprises, domestic wastewater producers, mining facilities, agricultural water users, fishermen, farmers, public institutions, and local people.

Application of the problem and objective analysis approach in the area in which different stakeholders involved allowed making diagnosis and finding solution to the problem.

Table – 1: Water quality of Lake Uluabat (Schot *et al*., 1999).

Station	pH	HCO_3 (mg/l)	Al (mg/l)	Cl (mg/l)	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Fe (mg/l)	Mn (mg/l)	Na (mg/l)	PO_4 (mg/l)	NH_4 (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)	Si (mg/l)
1	8.36	268	0.19	24.25	24.34	50.00	3.00	0.33	0.02	23.96	0.27	0.42	0.34	55.70	5.35
2	8.09	580	<dl	132.30	56.60	81.80	8.14	0.16	0.07	129.60	1.77	3.96	1.20	84.00	14.68
3	7.92	622	<dl	86.90	79.90	105.00	5.98	0.03	0.04	69.30	1.24	2.09	0.24	79.40	16.92
4	8.33	390	0.18	11.22	64.20	56.00	2.48	0.40	0.03	15.06	0.22	<dl	3.77	91.40	9.54
5	8.74	293	0.18	17.46	36.12	51.70	3.65	0.48	0.02	18.60	0.37	0.85	<dl	67.00	1.35
6	8.75	268	0.17	13.41	31.05	49.61	2.07	0.43	0.02	15.53	0.11	<dl	0.23	61.60	2.56
7	8.81	275	<dl	13.31	29.80	50.10	1.90	0.04	<dl	15.50	0.11	<dl	<dl	61.30	0.97
8	9.15	275	<dl	13.91	28.46	48.89	2.03	0.04	<dl	15.90	<dl	<dl	<dl	58.10	1.11
9	9.42	226	<dl	19.29	19.55	46.10	1.81	<dl	<dl	18.47	<dl	<dl	<dl	44.79	0.27
10	8.96	171	2.17	8.35	37.24	24.30	3.09	2.80	0.16	9.01	0.34	<dl	4.93	40.37	8.99
11	8.65	250	1.00	6.19	41.40	43.94	1.35	2.13	0.08	7.24	0.15	<dl	4.88	50.80	12.76
12	8.58	226	2.26	6.64	38.25	34.40	2.08	3.45	0.18	6.91	0.32	<dl	4.46	42.59	12.38

Stations: 1. out from lake, 2. input of drainage water (a), 3. input of drainage water (b), 4. input of Mustafakemalpaşa Stream, 5. middle of the lake (a), 6. middle of the lake (b), 7. middle of the lake (c), 8. middle of the lake (d), 9. north coastal of the lake, 10. Emet Stream, 11. Orhaneli Stream, 12. Mustafakemalpasa Stream.
<dl: down the detection limit.

However, the diagnostic analysis is only successful with the existence of the efficient and continuous monitoring and evaluation information system. Therefore, it is needed to establish an institution which had sufficient infrastructure, adequate financial resources and authority to achieve this goal. This institution must have effect on interest groups and warn them when it is necessary. It must have a structured watershed management principles and its supervision. Control must be carried out according to scientific basis. In addition, institution must create common platforms for all interest groups involved.

The diagnostic analysis of Lake Uluabat was made using the Objective Oriented Project Planning (OOPP) approach. The main results were summarized as the water pollution and fluctuation in the water level caused by the urban and agricultural waste disposals, sedimentation, and over-fishing. The problems defined in the problem tree were verified some measured data. Therefore, the diagnostic analysis based on the OOPP approach can be very beneficial in diagnosing and solving the problems in areas in which many factors are playing. In order to make a good management for Lake Uluabat, overall objectives mentioned in Fig. 2 should be applied by the lake managers and stakeholders. So nutritional (P and N) and sedimentation loading should be decreased, illegal and overfishing should be prevented by creating new alternative incomes such as ecotourism for local people and biodiversity of the lake should be conserved.

The diagnostic analysis is successful with the existence of the efficient and continuous monitoring and evaluation information system. Therefore, it is needed to establish an institution which had sufficient infrastructure, adequate financial resources and authority to achieve this goal. Control must be carried out according to scientific basis. In addition, institution must create common platforms for all interest groups involved.

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