CHAPTER 8 CONCLUSIONS

8.1 Summary of Findings

The topic in this research is mainly to develop a mathematical model on the bases of some assumptions integrated with the ecosystem and economic structure based on available data to find out current environmental and economic state and future changes, which are very important to be able to formulate and introduce an optimal policy to achieve an improvement on water quality with considerable economic growth. Considering whole Turkish Black Sea Basin the summary of result, we figure out as follows:

8.1.1 Comparison of Result with Previous Studies

The results we found out show the similar outcome as BOD and COD concentrations with the empirical studies carried out by two universities in Turkey mentioned in Chapter 1 (Bakan and Buyukgungor 2000; Tuncer et. al 1998). These two studies carried out based on analysis of river pollution along the Black Sea coast covering almost all the rivers flowing into the Black Sea. However, total TN and TP loads are somehow smaller than our results. In addition, these two studies results have also some differences in terms of pollutant loads. Another work, “the monitoring of pollutants” in almost all rivers carried out by SHW belong to Ministry of Energy and Natural Resources in Turkey shown in Table 2-7 in Chapter 2, the results are also similar which are the most reliable official data that the mean concentration of pollutants are estimated as a total annual load in the zones and in the basin mentioned in detail in Chapter 2.
8.1.2 Basic Case (current state)

1- According to simulation result from 1998, total pollution in terms of pollution parameters, BOD by about 23%, COD by 22%, TSS by 21%, TN by 4%, and TP by 7% decrease at the end of 2009. It is clear that reduction of pollutants is quite different particularly TN and TP because existing treatment systems do not include nutrient removal systems.

2- Domestic sources of pollution is the main factor in the zones and in the basin although it is reduced by 37% for BOD, COD, TSS and about 13% TN and TP. Furthermore, it contributes about 50% BOD, COD, around 55% of TP and 40% of TN at the end of the simulation period. In case of the zones, reduction of pollutants are not the same i.e., in zone1 BOD and COD reduction is about 60%, TN and TP about 5%. In addition, the number of treated population is not the same in the zones. For example, zone1, which is the richest and developed zone in the basin therefore all municipalities (city, town) receive biological treatment at the end of 2010. However, in the other zones considerable numbers of people have even no sewerage systems within the simulation period. This is because of treatment systems, investment for treatment, and distribution of population in each category that are different in the zones. Furthermore, existing treatment plants are not adequate regarding TN and TP treatment.

There is no investment for village population category (28% of total population in the basin) because there is no option for treatment. Therefore, according to increase or decrease of population by the year the pollution increases or decreases. Village settlements contribute about 25% of total household pollution at the initial year of simulation period (1998) in the basin.

3- Land use activities are the second biggest contributors in the basin and in the zones except TN that more than 50% of TN comes from land use categories as a whole.
Therefore, in terms of TN land use is the main factor in the basin. In addition, land use itself also contributes around 25% of BOD, COD, and TP in the basin. Agricultural activities are the dominant factor in the land use categories. The land used for crop production contributes itself more than 55% of all pollutants and it reaches 60% of BOD, COD, 70% of TN and 80% of TP together with vegetable-vineyard-orchard category. These two categories are together determined as agricultural activities. The others contribute like pasture-meadow 15% of BOD, COD, about 10% of TN and 5% of TP, city unused land about 10% of BOD, COD, TN and about 12% of TP, and forest areas contribute 10% of BOD, COD, and about 8% of TN, 4% of TP as total land use pollutants in the basin. Zone3 is the biggest contributor in terms of all pollutants next zone1, 4, 2, 5, and zone6 respectively. This is because of the land use pattern that distributed quite different in the zones. Moreover, the change of land use area is negligible for each category. Therefore, total pollutants are constant by the simulation period. However, contribution ratio is quite different (toward to increase) at the end of the simulation period because of the reduction of household pollutants by the time due to treatment.

4- Livestock in the basin contribute about 10% of BOD, COD and TP, 5% of TN and about 30% of TSS. TSS seems high. In fact, because of land use activities that may also contribute considerable amount of TSS, but in this model land use activities is not included for TSS. Livestock is determined as number of cattle and poultry. As a result, cattle husbandry contributes pollutants more than poultry category. Contribution of pollution from cattle is about 83% of BOD, 78% of COD, 52% of TN and 60% of TP of total livestock pollution in the basin and the rest comes from poultry category. Zone3 again main contributor in terms of all pollutants next zone2, 4, 1, 5 and zone6.

5- Industrial sector, particularly manufacturing is the source of pollution.
Contribution from manufacturing is about 14% of BOD, 18% of COD, 10% of TSS and about 5% of TN and TP at the end of the simulation period in the basin. In addition, all pollutants increase by the time such as BOD by 27%, COD 25%, TSS 52%, TN 17%, and TP by 18% from 1998 to 2009. In case of the zones behaviors of pollutants are relatively different i.e., in zone1 BOD, COD approximately 47%, and TN, TP 33% increase by the time. However, in the other zones increasing of pollutants are not as high as in zone1. For instance, BOD in zone3 17%, zone4 7%, zone5 23% and zone6 11% increase within the simulation period. We can conduct that pollutants come from particularly some industries that do not have treatment plants or treatments are not efficient. Manufacturing of food and beverage is the biggest contributor in terms of COD next paper, textile, chemical, and wood industries respectively. In case of TN, chemical industry is the dominant factor next food, leather, and metal-machinery category. In addition, chemical and food industry contribute more than 80% of TN in the basin. Moreover, the same industries are also main contributors for TP. Furthermore, sectors distributions and treatments are different in each zone. Therefore, sources of pollutants and their contributions are also relatively different i.e., zone1 is the biggest producer among the others contributes more than 40% of COD at the beginning of simulation period and reaches approximately 50% at the end of the period in the basin as a whole. Another example, zone2, and zone5 contribute about 20% within the simulation period, next zone3, 4 and zone6 totally contribute around 20%. As a result, we could emphasize that food, textile, paper, chemical, wood, plastic, and metal industries are the main sources of industrial pollution and TN, TP pollution are almost zero except particularly chemical, food, leather, and metal-machinery respectively.

Pollution from freshwater fish farming in terms of BOD-COD is not large amount. However, TN and TP contribution is highly considerable. Total pollutants increase around 10% within the simulation period. Zone2 is the main contributor (more than 40%) next is
zone 3, 1, 5, 6, and zone 4 respectively. Besides, there are no abatement facilities and options to mitigate nutrients from fish farming in the basin.

6- According to simulation result, GRP increase in each zone by the time. Zone 1 has the biggest amount of GRP, contributes 45% of total GRP in the basin and it increases by 77% at the end of the 2009 comparing the initial year 1998. Zone 3 is the second biggest zone contributes about 27% of total GRP in the basin and it increases by 64%. Zone 1 and zone 3 together contribute about 70% of total GRP in the basin indicate that main economic activities carried out in that zones. Zone 2 and zone 5 are the third and fourth biggest zones and GRP increase about 60% by the time, their contributions are also similar around 10%. Zone 4 and zone 6 GRP increase 70% and 54% respectively and contribute together about 10%. Zone 6 is the poorest and undeveloped zone comparing the others.

As another economic indicator, total production and distribution by the zone also give similar result as GRP. Zone 1 and zone 3, again are the biggest zones, the next is zone 2, 5, 4 and zone 6. In addition, total investment also gives similar result as production. However, investment for industrial and household treatments have different trends comparing the GRP, total production and investment in the basin and in the zones i.e., total investment for household treatment increases dramatically till the end of 2008 and next year becomes almost zero because all population are treated at that time in zone 1. In case of industrial investment for treatment, the result shows that the amount of investments are almost the same in zone 1, 2 and zone 3 though their GRP, production and investment are totally different indicate that the relation between pollution, production and investments for treatment are not the same in the basin and in the zones.
8.1.3 Simulation Cases

We have introduced some simulation cases regarding to reduce of BOD (same as COD and TSS), TN, and TP that how much pollutants can be reduced introducing optimal investments without changing the current socio-economic and environmental state in a period of time. It is assumed that reduction of BOD gives similar result for COD and TSS reduction since treatments systems are the same as exist in the basin. Total reduction of pollutants and interrelated to investment, production and GRP are summarized in the following;

8.1.3.1 Reduction of BOD

Reducing of total BOD by 2.5% shows that at the end of the simulation period there are still more than 4 million people have no treatment plant and around 100,000 people have just received sewerage systems. However, in case of 5% reduction in 2008 all population receives biological treatment. With 2.5% reduction rate, total BOD decreases almost the same amount such as the basic case mentioned above. However, with 5% reduction, total BOD reduces by 40%, 32%, 43%, 45%, 55% and 31% in zone1, 2, 3, 4, 5 and zone6 respectively, and it also reduces approximately 43% in the basin that is about two times bigger than the basic case simulation. Furthermore, household pollution itself reduces significantly by the simulation period. Except village population, all the other categories have treatment facilities, which reduce BOD around 90%.

In case of industrial sector, reducing of BOD by 2.5% as an example, in zone1, 2 and zone3 total pollution increase by 25%, 15% and 5% respectively in the simulation period from 1998 to 2007. It also means that total BOD reduces about 22%, 1%, and 12% in the same zones comparing basic case simulation. Furthermore, in zone4, 5, and zone6, total pollution reduce by 21%, 60%, and 7%. In the basin, as a whole, total BOD
increases just 1% by the simulation period. In case of 5% reduction target, total pollution increase by 7%, 6%, and 4% in zone1, 2, and zone3 respectively. However, in zone4, 5, and zone6, total BOD decrease about 40%, 72%, and 9%. Moreover, in the basin, total reduction is about 10% at the end of simulation period. It also means, comparing basic case, total reduction increases 37% in ten years from 1998.

GRP reduction is about 407 million US$ in total ($1=260,000 TL in 1998 price) in case of increasing the reduction of BOD from 2.5% to 5% in ten years. Moreover, as an average for each year’s reduction of GRP in zones vary between 0.03% and 0.14%. In case of the basin, average reduction of GRP is about 0.06%. This money is small amount comparing the total GRP in the basin. However, it might influence on manufacturing sectors productions and government expenditures if the investments are just presented by manufacturing sectors, and by government for wastewater treatments. In addition, total investments reduce about 585 million $ because of expenditure for treatments i.e., according to result of simulation, around additional 430 million $ is necessary to construct and maintenance the treatment plants that all population will be treated at end of simulation period. Total output from manufacturing sectors reduce 115 million $ almost one fifth of the total reduction of output in the basin. Industrial investments for treatment of BOD are quite various by sectors. Investments are doubled in almost all manufacturing sectors in case of increasing reduction of BOD by 5%. Some sectors, in terms of basic case simulation, have no treatment during the simulation period because there is no option for investments by those sectors. However, with the case 2.5% and 5% many sectors receive treatment plants because the investment is endogenous variable optimized by computer programming according to model constraints to reach the reduction rates of pollution.
8.1.3.2 Reduction of TN

Reduction is applied by 0.5% and 0.8% of TN in each year of simulation. In accordance with simulation result, by 0.5% reduction, total pollution in terms of TN reduces approximately 2%, 3%, 8%, 13%, 15% and 3% in zone 1, 2, 3, 4, 5, and zone 6. In the basin as a whole, TN reduces by 8.2%, which is two times bigger than the basic case simulation. In zones, reductions of TN are different comparing by 0.5% and 0.8% reduction ratio. However, in case of the basin, reductions of TN are similar for both cases.

TN from household reduces by 5%, 29%, 29%, 32%, 29%, and 14% in zone 1, 2, 3, 4, 5, and zone 6 respectively. In the basin, TN from household reduces by 22% that is again almost two times bigger than the basic case.

TN from manufacturing industry increases by the time since reduction of TN from household seems more appropriate than industrial TN for optimizing of investments to reach the target reduction in the model. With two cases by 0.5% and 0.8% reduction rate, total pollution still increases by 9%, 12%, 4%, 11% and 16% in zone 2, 3, 4, 5, and zone 6 that there is just only 1-2% difference between two cases in the zones and in the basin. However, in zone 1, TN increase by 26% by 0.5% reduction ratio but only 20% increase by 0.8% reduction.

8.1.3.3 Reduction of TP

The simulation target is reduction of TP by 1% and 1.4%. We have found out that simulation gives similar result as TN in terms of GRP, investments for productions, and treatments. However, reduction rate is a little bigger comparing TN reduction described as follows;

As a total reduction of TP for both cases (1% and 1.4%) reduce around 3.5%, 14%, 16%, 20%, 22%, and 12% in zone 1 to zone 6 respectively. In case of the basin, total
reduction is 14%, which is two times bigger than the basic case simulation in ten years period. TP from household reduces by 23% in the basin, which is again about two times bigger than basic case. Besides, in the zones, TP reduce by 6%, 31%, 33%, 31%, and 26% in zone1, 3, 4, 5, and zone6 respectively. Only in zone2, reduction increases from 25% to 29% in case of changing reduction rate from 1% to 1.4%.

TP from industrial sectors increase by 4.5% in the basin, which is almost three times smaller than basic case, and by 24%, 8%, 17%, 5%, and 10% increase in zone1, 2, 3, 4, and zone5 respectively except zone6 in which the reduction is about 10% by the time.

8.1.3.4 An Alternative Option for Nutrient Reduction

In the basin, GRP, investments, and productions are not effected considerable amount since household treatment option is only biological treatment that does not include nutrients removal systems and nutrients are just removed around 40% by biological treatment. Second, TN contribution by household and industrial wastewater is about 45% as a whole in the basin. It means 55% comes from the other sectors like land use and livestock activities.

As a current state, case1, case2, and case3 simulation, pollution from agriculture and livestock do not change by the time because pollutants linked to the type of land use area. Therefore, total pollution cannot be reduced as stated above if those activities are not taken into consideration. As a result, nutrients generated from agriculture and livestock are linked to production with the cost of abatement in the model. In addition, nutrient removal system is also inserted with biological treatment in order to reduce TN and TP effectively from household wastewater.

The model is run in ten years introducing the new scenario mentioned above by 5%, 7%, and 9% reduction of TN, by 5% and 6.5% of TP in a year within the simulation.
period. The results indicate that TN might be reduced by about 41%, 45%, and 53% by ordering 5%, 7% and 9% reduction rate respectively in the basin.

TN from household, the reduction reaches almost 60% by the end of the year 2007 in the basin. Agricultural TN increases by the time because of increasing production at the same time without any abatement. However, reduction of TN reaches by 53%, 57%, and 75% with targeting 5%, 7%, and 9% reduction rate. Livestock is the third biggest contributor as mentioned previous section. TN discharges from livestock activities also increases considerable amount because of the same reason as increasing of production and it increases again by 16% by introducing 5% reduction rate. However, it reduces 26% and 55% by the reduction of 7% and 9% respectively within the period in the basin. Industrial origin of TN still increases even with reduction scenario. This is mainly because of the abatement by household, agriculture, and livestock sectors that reduction of TN from those sectors is more cost-efficient for optimizing investment. In fact, TN from industrial activities is very less amount comparing other sectors. Therefore, it might not be regarded as an important source except BOD, COD, and TSS.

In case of TP, by the reduction cases of 5% and 6.5% in a year it reduces about 33% and 36% respectively in the basin. TP from household reduces about 16% in the simulation period. However, from agriculture and livestock TP reduces significantly (more than 70%) though their contribution is almost half of the household contribution itself.

Investment for household treatment, as a current state simulation result is approximately 300 million $ and more than this amount is necessary for reduction of BOD, COD given by simulation cases mentioned in Section 8.1.3. 5% reduction case in a year, in other words reduction of TN by 41% in the basin, costs about an additional 190 million $ for household TN abatement facilities. In addition, it is also 92 and 23 million
$ necessary for agriculture and livestock abatement facilities to reach the 41% TN reduction in the basin. If the TN reduction reaches 45%, (7% reduction ratio) the cost increases three times more than 5% reduction case scenario. Besides, when the TN reduction reaches 53% (9% reduction ratio), both household and livestock investment for treatment increases about 50% comparing with 7% reduction rate. However, agriculture investment increases just about 20%.

Investments mostly go to household wastewater treatment for TP reduction because it contributes significant amount that huge amount of capital (more than 600 billion$) uses for optimal investment to reach the 36% of TP reduction in the basin. Second, household wastewater treatment cost is about two third of the total cost and the rest shared by agriculture, industries and livestock respectively. Treatment cost for agriculture and livestock are not very high that it is reasonable to implement one of the cost-effective abatement methods mentioned above.

8.2 Conclusions

Finally, conclusions with policy suggestions are introduced to make it possible to contribute as an appropriate action expressed briefly in the following.

8.2.1 The Modeling Approach to Address the Problem

According to the results, it can be concluded that the integrated approach, is an effective method in providing valuable information that are linked to the sources of pollution, to their contributions and relation with economic indicators in the watershed basin systems like Turkish Black Sea Basin and by the purpose of introducing policy instruments to address the water pollution problems. In addition, this study indicates that any approach to dealing the water quality problem cannot succeed if socio-economic and
environmental status and their interrelation is not taken in consideration in each sub-basin in the entire Black Sea Basin. This is because each sub-basin has different socioeconomic and environmental characteristics and priorities.

8.2.2 The Sources of Pollution and Future Changes

This study has found the sources of water pollution, the contributions by sectors and the impact of future socio-economic changes on the environment in the Turkish Black Sea Basin. The main sources of pollutants are domestic wastewater, land use particularly agriculture, industry mainly manufacturing, and livestock activities.

As a result, we would emphasize that the current socio-economic policy is not sufficient in reducing the pollutants in the future because;

(i) The existing treatment system is not adequate to reduce TN and TP for household treatment.

(ii) Although there are some investments for treatment the trend of industrial pollution will continue to increase.

(iii) Since there is no considerable control measures on agriculture and livestock production activities, and their pollution is directly related to the amount of production, then agricultural activities could be the most important source of the water pollution in the future.

8.2.3 Cost-effective Options for Abatement of Pollutants

According to the results, it is essential in determining a cost-effective method, to address water pollution issues in the basin that would be feasible as an appropriate action expressed in the following;

1- The simulation indicates that reduction of pollution from household wastewater
is very important since it contributes significant amount of nutrients in the basin. The results also show that towns and cities in the basin need sewage systems and treatment plants. It is known that construction of sewage systems is more expensive than treatment plants. However, first it is essential to establish a sewage network in order to construct treatment plants. Construction of a biological treatment system is a cost-effective treatment option that might apply in cities and towns, particularly with a population less than 100,000. For higher populated cities (>100,000), biological treatment with nutrient removal systems are required to mitigate TN and TP. However, in zone 2 and zone 5, the most populated cities and towns are located on the coastline of the Black Sea and their wastewater is discharged directly to the sea. Therefore, mechanical treatment with deep-sea outfall systems is appropriate. For the village settlements, household disposal systems such as septic tanks may be used. In addition, wetland establishment is possible if the settlements (villages) have appropriate place to construct wetland, which is a cost-effective solution already implemented in some villages in Turkey.

Government is the main stakeholder in water pollution control in Turkey. In cities, local governments (municipalities) also play a significant role in supplying water, and in constructing, and maintaining the sewerage systems and treatments plants. However, without central government support, municipalities’ efforts do not do enough to overcome the water pollution issues because of budget limitations. Therefore, it is first necessary for the capital to be provided by government as a subsidy since the simulation results indicate that the cost of investments has no significant impact on GRP or production activities. However, the national government cannot recover all costs directly from its budget. Consequently, local government could introduce tax for part of construction and O&M cost of treatment from local residents. In fact, in Turkey and the region most of the municipalities have a tax system called “cleanings tax” collected for solid waste
management. This tax system might be reviewed and extended including wastewater treatment cost that might be introduced such as user charges in each municipality in the basin. The construction of treatments plants should take place from high-populated cities to less populated settlements because of cost-efficiency of treatment.

2- The most difficult issue to deal with is pollutants (nutrients) from agricultural lands since there are many factors have roles on water pollution such as geographical, hydrological, climate, soil structure, production methods, irrigation techniques etc. Overuse of fertilizer for production is the main reason of pollution. According to the simulation result, the cost of abatement is reasonable to mitigate the pollution. In addition, there are many appropriate abatement practices that would be applied like, adequate cultivation, irrigation and fertilization techniques, and application restrictions, crop rotation, land use permits, zoning regulations, watershed level restriction, land retirement, and voluntary BMP. The others, such as fertilizer tax and nutrient emission tax are implemented to discourage overuse of fertilizer application. Therefore, the cost-efficient methods for the abatement of nutrients mentioned above should be selected considering the importance of agricultural production related to socio-economic situation and the impact on the environmental media as a water quality in the basin.

In this study, in order to reduce nutrients in a particular period we have estimated the cost of abatement based on some specific actions that should be undertaken expressed in the following:

Pollution as nutrients from agricultural activities might reduce significantly using abatement methods that are mainly applied by the EU countries. Besides more specified actions are outlined as:

- Develop guidance on fertilizer application rates to individual crops based on soil analysis and requirements of fertilizers for each crop.
- Develop instruction to reduce soil erosion
- Set specific objectives and standards for agricultural practices.
- Undertake pilot project on the adoption of good agricultural practice,

The government here again is the main stakeholder in Turkey. It provides supports to agricultural and livestock producers, such as production procurement, input subsidies, and the exemption of VAT etc. Subsidizing fertilizer is the main part of the government support (20% in 2000), yet it has been declining on a yearly basis. However, in order to reduce nutrients from agricultural activities, government should revise the agricultural policy trying to mimic the approach adopted in the EU Nitrate Directives. In order to implement any remedial action mentioned above at first, land use has to be categorized and designed in each zone in the basin based on water resources quality objectives.

3- In the basin, intensive cattle and poultry farms are the main sources of nutrient discharge. It depends on the amount used per hectare, soil and crop type, harvesting rate, precipitation etc. The estimation of abatement cost is based on manure management (manure storage, application as fertilizers on agricultural land) indicates that nutrient can be removed without significant impact on livestock production. The action that considered, as reduction of nutrient from animal farming should be undertaken, determined briefly as follows:

Nutrient Directive applied by the EU countries should be adopted taking into consideration the factors mentioned above. In order to do so, some specific actions should be carried out. They are expressed as follows: (i) Development of livestock manure management must be area-wide since livestock farms are scattered within the zones. Therefore, there is a need for transportation of excess manure to the areas that are appropriate for agricultural production. (ii) The utilized amount of animal manure should
be identified as the demand for application and timing in zones particularly zone3, zone2 and zone4, then it should be followed by a reduction in the use of chemical fertilizers.

Central and local governments have a major role for investment, research, and technical development on the livestock production and manure management. In order to reach the EU Nutrient Directives, government should revise its policy on livestock production regarding cost-efficient manure management

4- The main polluting industries in the basin and the zones are particularly food-beverage, textile-leather, paper, and chemical industries. There are large numbers of small and medium-scale manufacturing industries distributed around the cities and towns in the zones. Therefore, constructing of treatment plants by those industries is quite difficult and costly. We have estimated the cost of treatment regarding production that has no considerable affect on production activities. However, construction and maintenance cost will be higher than the cost related to production if each industry establishes its own treatment plant. Thus, a number of actions should be undertaken in order to establish cost-efficient treatments. These actions are outlined as follows:

Industries are mainly located in the city areas in zone1 and zone3 that contribute more than 70% of total production in the basin. At first, small and medium-scale industries should move to industrial areas by classification of sectors i.e., food-beverage industrial area. Local government with the support of central government should provide the industrial areas. Then the cost of single treatment plant in that area can be shared by sectors. In this case, their production activities will not be affected considerably. In fact, in some areas in many cities are classified as industrial areas, where industries have been connected to a treatment plant in Turkey. Here, local government has a major role to lead and organize the industries. In case of large-scale industries, the cost of treatment plant construction, operation, and maintenance can be partially born by the government
8.2.4 Policy Proposals for Comprehensive Action

It should be strongly emphasized that the study (GEF 1997) curried out under the GEF, BSEP program to find out total pollutants and contributions by the six Black Sea countries mentioned in Chapter 1 and Chapter 2 does not draw a whole picture in the Black Sea Basin. Besides, total pollution, contribution of pollutants by countries might be different since the contributions of pollutants from Turkish Black Sea Basin are quite different implying that the other Black Sea countries might have similar variations. That is a very important subject which should be taken into consideration in order to build a comprehensive action plan to address the water pollution in the Black Sea bearing in mind the responsibilities of each country on contribution of pollution in the Black Sea. Therefore, the countries in the basin should cooperate considering their socio-economic, political issues, and environmental properties. In addition, modeling of ecosystem integrated with environment is one of the key points to draw the whole picture of the system in a country or its basin that we have considered as a first step of comprehensive action. In order to integrate all the systems, water pollution indicators originated by domestic, industrial and land use activities should be classified, analyzed, and collected as database. Second, main socio economic indicators are also categorized and determined in countries basin to be able to formulate and integrate the systems into a modeling approach.

It is obvious that a uniform policy for pollution reduction targets is neither economically nor environmentally practical for the entire basin, since the basin is very wide and has different natural, environmental, socioeconomic and political systems. Therefore, it is first necessary to determine a clear socioeconomic system and ecosystem interactions in each country to be able to formulate an optimal policy to achieve the
targets in a certain period. Second, it is necessary to integrate policies among countries from the viewpoint of the whole basin of the Black Sea. In order to do so, economic and political contracts between the countries must be discussed. Such negotiation may need a review of possible policy reforms in each country. In this case, a revised policy simulation should be done, based on specific simulation model to reach the targets clarified by the countries.

This study also indicates that, without basin-wide and zone management approach, the water pollution issues cannot be addressed appropriately. In each zone in the basin, local and central government with all private sectors should be organized and represented into an organization including NGOs to establish and implement an action plan considering socio-economic state, sectors demands, and priorities related to the water pollution.

Finally, it worth mentioning that there is no specific basin-wide study in the Black Sea region as introducing the modeling of ecosystem and environmental structure so as to understand and evaluate the nature of the water problems interrelated with socio-economic structure and future changes. These results would be useful in presenting to the researchers, policy makers, and authorities in the Turkish Black Sea Basin and as a reference in the entire Black Sea basin countries to contribute in launching any action plan to reach the water quality objectives in the Black Sea.