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RESEARCH ARTICLE

Implementation of integrated scenario analysis and modelling for the sustainable development of a coastal area in Eastern Mediterranean

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Abstract

1 - The gulf of Gera is a semi-enclosed water body located on the island of Lesvos, Greece in Eastern Mediterranean. The main economic activities in the surrounding watershed are related to the primary, secondary and tertiary sectors, among which the former and the latter have increased during the last decade. The primary sector activities include agriculture (mainly oliveculture), fisheries, livestock breeding and aquaculture. The most important industrial activity in the Gera watershed is the elaboration of oil crops, whereas tertiary sector is focused on tourism and services.

2 - Three scenarios of environmental and socio-economic change have been applied in the area: the baseline or reference scenario (Business As Usual, BAU), the policy targeted scenario (Policy Targeted, PT) and the 'deep green' scenario (Deep Green, DG). Two versions of each scenario were evaluated, one that considers low and practically non-influential climate change (BAU1, PT1 and DG1) and one that assumes an important influence of climate change (BAU2, PT2 and DG2). A quantitative description of each scenario was developed and simulation was applied for evaluation. Increased nutrient loading was predicted by the model from November to May, especially in winter, during the period of flow of the ephemeral rivers.

3 - The main effect of climatic change in nutrient loading is observed in winter, due to rainfalls of high intensity. The effects of future climatic changes are important since a fourfold increase in surface runoff is predicted by the model. This will increase substantially the frequency of flood events in the watershed, have an important effect on the amount and pattern of the nutrient loads into the gulf and cause problems of erosion. The overall phosphorus loading predicted by the model is higher in the BAU and lower in the DG scenarios, whereas nitrogen loading is almost equal under the BAU and PT scenarios and halved under the DG scenarios.

Keywords: Scenarios, Coastal Zone Management, Simulation Modelling, Eastern Mediterranean

Introduction

Coastal areas represent a policy issue of ever increasing importance: As meeting points of land, water and air, coasts have served to provide food and security, industrial and commercial development and, lately, leisure and conservation. As the process of industrialization and economic expansion has accelerated, coastal zones have come under heavy pressure from human activities. The ensuing problems include physical modifications and habitat loss through coastal erosion, contamination, coastal pollution and depletion of fisheries. As a consequence, approx. 85% of the European coast is at high or moderate risk from development-related pressures (Karageorgis *et al.*, 2005).

The problem is illustrated by the fate of coastal

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wetlands in the Mediterranean, a valuable source of natural capital that has been destroyed and degraded to a great extent. Their loss and/or degradation in this century amounts to 73% of the marshes in Greece, 86% of the most important wetlands in France, 60% of wetlands in Spain and 15% of lakes and marshes in Tunisia (MedWet, 1996). The situation is, as expected, crucial for island states and/or nations with a long shoreline. In Greece, a handful of indicators aptly demonstrate the importance of the coast and its vulnerability to human pressures: Coastal areas represent 72% of total territory, 86% of population, 88% of employment in manufacture, 90% of tourist activities and 90% of energy consumption (OECD, 2000).

The present paper addresses the issues of analysis and assessment of integrated scenarios of environmental change in the Gera catchment/coastal zone continuum. It reports on the design and application of integrated analysis of environmental change scenarios and their evaluation using simulation modelling. The problem setting is described within the wider context of Eastern Mediterranean basin and its global change implications. The coastal area of Gera was chosen as typical for the Aegean and Eastern Mediterranean. It is of high ecological value and it is included in several networks of protected areas. The environment is characterised by good quality and health, however the environmental and socioeconomic pressures exerted during the last decade due to agriculture, urbanization and tourism impose the need for the application of integrated management approaches. Control and adaptation options are selected from a list of feasible policies for the region and tested in focus groups and meetings of the main stakeholders. The final output is by no means exhaustive; it represents work in progress, focusing on the major analytical questions of Gera management options with a primarily socio-economic orientation. It combines descriptive, analytical and evaluative dimensions.

The primary emphasis is on those policy issues, which are vested with a high degree of uncertainty and thus deserve special attention. These are the problems in which the question of societal responses and adaptations to water quality deterioration is posed more starkly, given the complicated synergies of ecosystem, economic and cultural impacts of socio-economic activities on the regional scale.

In what follows, the test site, the gulf of Gera, Greece, is presented. A revision of the general socioeconomic setting in the region (‘storylines’) is then discussed, which helps to explore further the integration of responses within the national and international institutional context. Following this, the structure of the Gera scenarios are presented, their testing, as well as the outcome of the simulations. The final section offers a discussion of the insights gained and reflects on the future perspectives of integrated river basin management in the region.

Methods

The study site

The gulf of Gera is a semi-enclosed water body located on the island of Lesvos, Greece, in the Aegean archipelago (Fig. 1). The surface area of the gulf is approximately 43 Km^2, and the mean depth of about 10 m. The gulf is connected to the open sea through a channel, having a width of 200-800 m, length of 6.5 Km and depth ranging from 10 to 30 m. The waters of the gulf have been characterised in previous studies as mesotrophic with eutrophic episodes observed mainly during winter (Arhonditsis *et al.*, 2002a; 2002b). The surrounding area of approximately 200 Km^2, can be divided into two parts with differences in geomorphology and land use. The western part of 170 Km^2, is characterised by a rather smooth terrain cultivated mainly with olive trees, the location of five villages with a total population of 7000 people and a rich hydrographical network of small rivers flowing mainly during winter. The eastern part of the watershed, of approximately 30 Km^2, is covered with olive trees growing on rather steep terraced slopes (Arhonditsis *et al.*, 2000). The main economic activities in the area are related to the primary (agriculture, fisheries, livestock breeding, aquaculture), secondary (oil

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production) and tertiary sectors, including tourism. Olive cultivation was a traditional monoculture that sustained the local economy to a large extent. However, during the recent decades, the proliferation of competitive substitute products for olive oil, i.e. seed-oils, resulted in an economic decline followed by a mass emigration of the inhabitants to continental Greece and abroad (Arhonditsis *et al*., 2002a). The size of an average farm is approximately 2.3 ha, with 2 ha being olive groves. The cost of agricultural products is high and the prospects for mechanization are limited due to the mountainous terrain and the small size of the farms. Furthermore, the implementation of modern techniques, as irrigation, pruning, optimal application of fertilizers and hand or chemical thinning of olive groves are the exception rather than the rule in this area (Arhonditsis *et al*., 2002b). This fact is attributed mainly to the lack of knowledge by the local farmers, to limited advice by the authorities and to the low price of olive oil, making increased production unprofitable (Arhonditsis *et al*., 2002a). The Gross Margin per holding-the Gross Value Product minus the Variable Expenses-is estimated at 2200 $US according to the average annual production during 1984-1994.

In most cases the gross margin covers 25% of the average annual household expenditure, estimated at 9000 $U.S., whereas in special occasions of high annual yield, this proportion doubles (Arhonditsis *et al*., 2002a). Consequently, serious underemployment characterises the agricultural sector, that cannot ensure an income sufficient to cover the needs of a family. Tourism is less developed in the area, despite its positive economic impacts, compared with other areas of the island. ? small increase in tourism occurred after the late 1980's. Thus, the local farmers supplement their income mostly as construction workers and as livestock breeders. The livestock of the area numbers about 5500 sheep and goats. Aquaculture is not developed in the area; only one aquaculture plant exists in the gulf of Gera, producing 150 tons/year of sea bass and sea bream.

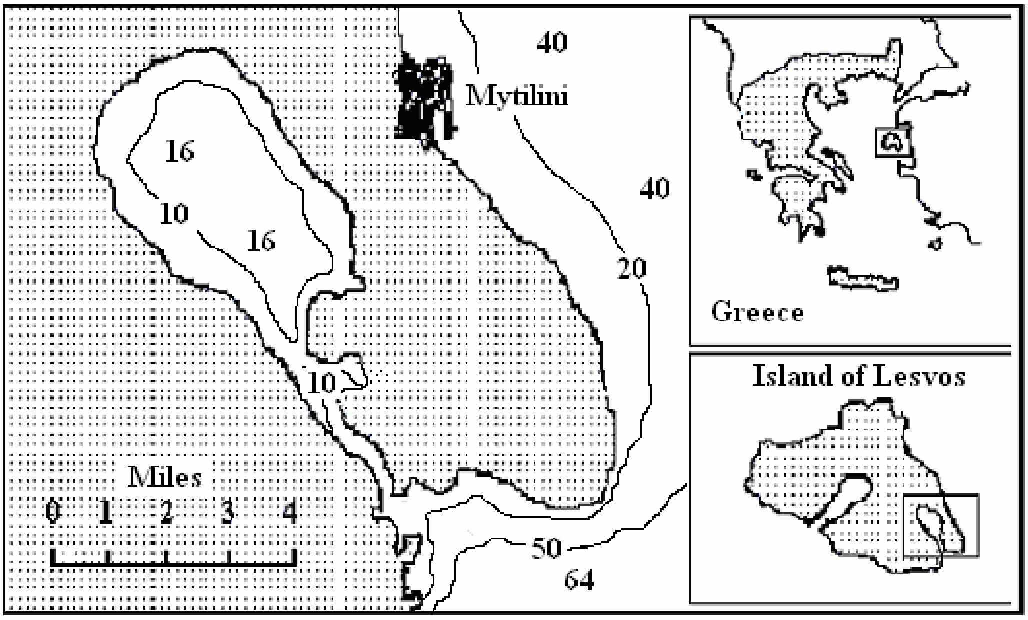

Figure 1. The gulf of Gera on the Island of Lesvos, Greece.

The general setting of the scenarios

Regional environmental scenarios are embedded in wider scenarios of socio-economic and cultural/institutional change. These so-called ‘generic scenarios’ provide the general context, according to which the specific characteristics of regional developments unfold. In the case of the coastal area of Gera, downscaling from the generic trends to regional ones means adapting to the realities of Mediterranean island economies and Northern Aegean in particular. The basic narrative behind the Gera scenarios revolves around broad issues of the New Development Strategy of the region, which represent the major socio-economic drivers that will affect the catchment area of Gera. They can be summarized as follows (Konsolas *et al*., 2002): (a) Inversing the trend of population decline, (b) Securing equal opportunities and access to health, education and cultural services, (c) Diversifying the local economies by investing in product quality and (d) Overcoming isolation.

The achievement of these goals should take into consideration the following regional characteristics: An agricultural region with below national average population density, growing urbanization and expansion of built environment, loose implementation of existing legal framework ('symbolic politics'), evolving interest by NGOs and citizen's groups, a heritage of diffuse agricultural pollution, a heritage of intensive water use for irrigation, importance of tourism, raising interest of public authorities in environmental incentive schemes, importance of underground water reserves for water supply in neighbouring areas, accelerated integration of economic activities in the market and duality of social values: Intensified consumerism versus stable traditional family and culture values.

The Gera scenarios were defined and calibrated by local stakeholders in order to gain insights into questions of vulnerability of sectors/groups along with perceptions of risk and the importance of socio-cultural capital in the region.

The scenarios in detail

The Gera scenarios deployed here are prospective scenarios of a mixed qualitative/quantitative nature and a time horizon that extends to 2015. The scenarios represent, on the one hand, a baseline projection of the prevailing trends and, on the other hand, divergent paths approaching gradually a maximum target of water quality. The environmental and socioeconomic scenarios used, were the baseline or reference scenario (BAU), the policy targeted scenario (PT) and the 'deep green' scenario (DG), according to the EUROCAT formulation (Ledoux *et al*., 2005). In the presence of enormous uncertainty referring to the regional impacts of climate change and the ensuing complications for the scenario building, two versions of each scenario were examined, one that assumes low and practically non-influential climate change (BAU1, PT1 and DG1) and one that assumes an important influence of climate change (BAU2, PT2 and DG2). In the versions of the scenarios with climate change, rainfall patterns are expected to change during the next decades. An overall decrease of rainfall in autumn and an increased frequency of episodic rainfall events, especially in winter, are expected.

Each scenario is characterized by four endogenous variables: (a) Population change, (b) Tourism activity, (c) Agriculture intensification and (d) Aquaculture intensification and an exogenous one, that is Rainfall change (as proxy for climatic conditions). A detailed description of the three scenarios is given below:

Business as Usual Scenarios. Business as Usual (BAU) represents a future in which prevailing trends are allowed to continue without major interventions, 'symbolic' implementation of European and national legislation in the region, without (BAU1) or with (BAU2) the influence of climate change. The current trend in the area is characterised by a year by year growth in the tourist activities, overexploitation of fisheries, application of farming practices not necessarily friendly to the environment and changes in the land use by the construction of houses or small industrial settlements, especially inside the important biotope on the north of the gulf, acting as a buffer zone between the land and the sea. There is no water management scheme and most of the water for drinking and irrigation comes from drilling. There is a small growth in the permanent population of the area, especially on the western side of the watershed, whereas the seasonal increase is much more important.

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Under these assumptions, the (implicit) policy target in both BAU1 and BAU2 referring to coastal water quality in Gera can be summed up as: tolerate eutrophication.

Policy Targeted Scenarios. The initial conditions of the policy targeted scenario are characterised by a future in which environmental protection becomes active (partial implementation of European and national regulation), without (PT1) or with (PT2) the influence of climate change. In this respect, a partial implementation of European and national environmental regulation is witnessed in the region. In addition, policies for economic growth are encouraged by the decision makers, focusing on tourism and agriculture growth.

The guiding principles of PT refer to the general policies, institutions and values characterizing the driving forces of this scenario, that is:

- A top-down approach of a centralized state authority, coupled with partially devolution of authority and financial means to local communities. Within this frame, elements of consultation with citizens and NGOs foster enforcement and effectiveness. Still, water basin management in Gera remains essentially an uncoordinated domain.
- Policies are designed to promote sustainable regional economic growth, which allows a partial compliance with environmental and natural resources legislation. The basic legal frames, which are going to play a crucial role in the region, are, on the one hand, the Water Directive 2000/60 (EC, 2000) and the Habitats Directive 92/43 (EC, 1992). The latter has prompted Law 2742/99 on Urban Planning and Sustainable Development, which in turn institutionalises the Governing Boards of Natura 2000 protected areas in Greece.
- A partial implementation of Water Framework Directive 2000/60 in Greece is again a phenomenon of 'institutional capture' where local and state administration is watering down the effectiveness of water management measures through loose controls and excessive use of article 4 referring to allowable exceptions from the accepted quality standards due to meeting specific goals of public interest.
- Openness of Gera to markets brings along a considerable pressure for technological and infrastructure modernization. Modernization of lifestyle goes hand in hand with consumerism and individualism though a 'green' shift in preferences and values, especially of the urban population in the catchment, is felt. Social networks and NGOs become visible and officially recognized as active players in the policy arena. Under these assumptions, the target in PT referring to coastal water quality in the Gulf of Gera can be summed up as: reduce the probability of occurrence of algal blooms.

Deep Green Scenarios. The initial conditions of DG are characterised by a future in which environmental protection becomes prominent (full compliance with European and national regulation). In DG, the opening of the region towards international markets and institutions goes hand in hand with a strengthening of environmental protection in the region. Side-obligations accompanying state investments in infrastructure as well as the strengthening of local networks and environmental NGOs in the catchment support further measures complementary to the ones in PT. Under these circumstances, decision makers in the municipalities can be described as focused on long term planning and actively pursuing proactive and precautionary measures in their environmental concerns.

The guiding principles of DG refer to the general policies, institutions and values characterizing the driving forces of this scenario, that is:

- A participatory approach to environmental management is coupled with a substantial devolution of authority and financial means to local municipalities in the region. In this direction, elements of consultation with citizens and NGOs foster enforcement and effectiveness. Water basin management in Gera becomes essentially coordinated by the Regional Committee on Water Resources as well as by effective bilateral cooperation with academics and other experts.
- Policies in the catchment are designed to promote sustainable development of the

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region, which allows a full compliance with environmental and natural resources legislation as well as with the obligations of present to future generations. GDP growth becomes less important, since food and 'quality of life' issues are strongly brought to bear on the quality of natural environment. The Water Directive 2000/60 and the Habitats Directive 92/43 are overcomplied with, serving as inspiring and guiding strategies.

• Openness of Gera to world markets brings along a considerable pressure for technological and infrastructure modernization but, contrary to PT, this is accompanied with the adoption of strict environmental standards. Modernization of lifestyle in DG does not imply uncritically endorsing consumerism and individualism. A strengthening of 'green' preferences and values, in both the rural and the urban population in the catchment, is felt. Social networks and NGOs gain a decisive stance and are officially recognized as active players in the policy arena. Under these assumptions, the target in DG referring to coastal water quality in Gera can be summed up as: Reduce the probability of occurrence of algal blooms to the lowest possible level.

The above storylines and rationales, and the main scenario assumptions were discussed and approved in stakeholder meetings (Kontogianni *et al*., 2006). Furthermore, a quantitative expression of each scenario was developed for applying models for scenario evaluation. As it was mentioned above, each scenario can be expressed through four endogenous variables (population change, tourism activity, agriculture intensification, aquaculture intensification) and an exogenous one (rainfall change) as proxy for climatic change. The sets of values of the variables for each one of the scenarios to be tested is shown in Table 1. Metric information, as well as ordinal scaling, was used.

Table 1. Quantitative information for the five scenario variables used in simulation modelling.

Scenario	Population change	Tourism Activity	Agriculture Intensification	Aquaculture Intensification	Rainfall Change
BAU1	10	30	1	30	0
BAU2	10	30	1	30	1
PT1	10	60	2	30	0
PT2	10	60	2	30	1
DG1	20	30	2	30	0
DG2	20	30	2	30	1

BAU scenarios express the current trends in the area. A population increase is observed during the last decade which is expressed as a 10% increase in the next decade, to 2015. Tourism activities are also increasing in the area (a 30% increase is assumed), whereas aquaculture is also an important developing economic sector (a 30% increase is also assumed). The agriculture intensification is expressed in an ordinal scale. Since the model to be used for scenario testing, calculates loading from non-point sources taking into account the various land uses, the numbers used express changes in land use. Agriculture intensification 1 expresses oliveculture intensification, a trend observed during the last decade. Abandoned olive groves are cultivated and fertilizers are applied. There is limited concern for environmental protection expressed as a 10% compliance to environmental legislation.

PT scenarios express policies to be applied in the area focusing on environmental conservation and economic growth. A partial compliance with environmental and natural resources legislation is assumed (30%), related to the application of good agricultural practices and measures for environmental conservation. The main economic activities to be improved are tourism and agriculture. A 60% increase in tourism is assumed, whereas agriculture intensification 2 refers to oliveculture intensification especially in terraced steep slopes and horticulture in plain areas. Aquaculture is also an important sector of economic activity and a 30% increase in production is assumed.

DG scenarios stress on economic growth activities friendly to the environment (biological agriculture, alternative forms of tourism) and full compliance with environmental legislation. There is no change in economic activities in relation to the PT scenarios but the compliance to environmental legislation is assumed to be 90%. A population growth of 20% is also assumed, considering the importance of the attractiveness of the area for the residents.

All the three scenarios will be evaluated with the current climatic conditions as BAU1, PT1 and DG1. The climatic conditions are expressed through the exogenous variable Rainfall change which has the value 0 for the present conditions of rainfall intensity and frequency. The value 1 expresses the climate change, as rainfall patterns are expected to change during the next decades. An overall decrease of rainfall in autumn and an increased frequency of episodic rainfall events, especially in winter, are expected. This would cause an increase in the frequency of flood events in the watershed and hence it would have an important effect on the amount and pattern of the nutrient loads into the gulf. The scenarios BAU2, PT2 and DG2 are considering the effects of the climatic change.

The watershed models

Two mathematical models, already calibrated with field data, were applied in order to calculate the nutrient and organic matter input to the sea from the watershed, taking into account both non-point and other sources (Tamvaki and Tsirtsis, 2005, Arhonditsis *et al.*, 2002a).

Surface runoff was estimated according to the Curve Number Equation (CNE) (Haith and Tubbs, 1981) based on the land uses. The three parts of the Gera watershed (eastern, western and northern) were further divided into 234 fundamental cells (Hatzopoulos *et al.*, 1992), each one of them considered homogenous according to its main characteristics (slope, land use, hydrological conditions, agricultural practices). The amounts of nutrients and organic matter transported to the gulf due to surface runoff were determined using a special function, belonging to the category of 'loading functions'. These functions are models in which the calculated surface runoff is multiplied by the transferred concentrations of nutrients or pollutants in dissolved phase. The concentrations of nutrients required to apply the loading functions were determined by field experiments. Applying the loading functions approach, the concentrations of nutrients and organic matter that flow into the gulf of Gera after a precipitation, can be estimated. In the current application the concentrations of nitrate, ammonium and phosphate, were estimated.

The loading from other sources was also estimated. The sources taken into account were sewerage, by-products of livestock breeding, industrial activities (olive-oil refineries) and aquaculture. Transfer coefficients from the literature were used to estimate loading from each source and a retention factor was also applied in order to consider physical processes occurring along the route connecting each source with the sea. These retention factors were estimated using field data. Each set of scenario variables could be easily incorporated into the models and the resulting nutrient loading was estimated.

Results

The rainfall height on a daily basis during 1996, a typical year concerning the annual height, frequency and intensity of rainfall events for the last decades (available data from the Hellenic National Meteorological Society), is shown in Fig. 2. Precipitation is high during winter (November, December, January and February), whereas the driest months of the year are May, June, July and August.

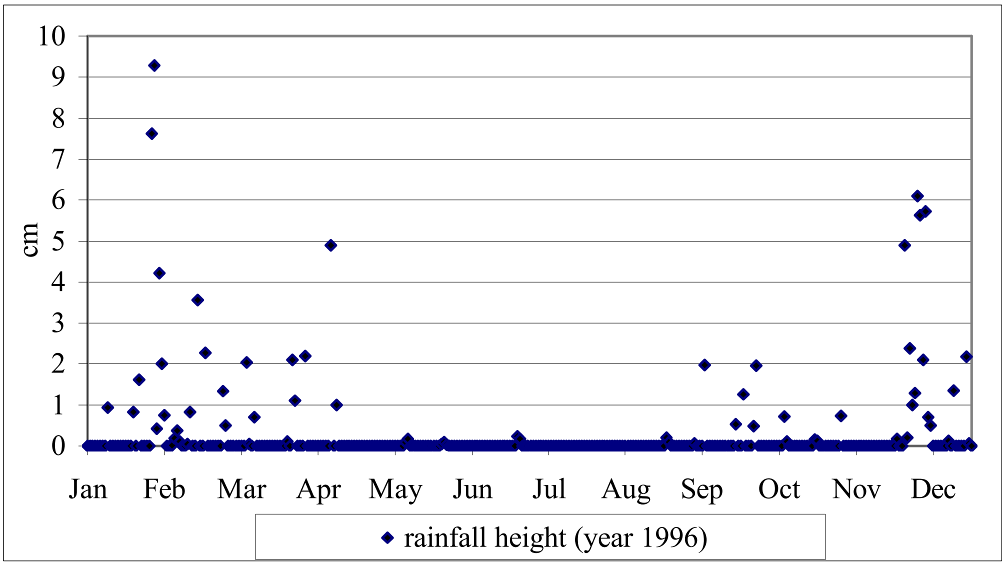

Figure 2. Rainfall height on a daily basis in the watershed of the gulf of Gera during 1996.

The monthly variability of inorganic phosphorus loading according to the BAU scenarios is shown in Fig. 3. The loading is transported mainly by the rivers, which are ephemeral and flow from November to May. Therefore, increased loading is observed during these months, especially in winter, whereas during the summer period the only exogenous source of nutrients is aquaculture. The main effect of climatic change in nutrient loading is observed from January to May, the period of rainfalls with high intensity.

Surface runoff from the Gera watershed estimated according to the six scenarios is presented in Fig. 4. A slight increase in surface runoff is observed when the scenarios PT and DG are applied, due to the resulting changes in land use. Considering the effects of future climatic changes, a fourfold increase in surface runoff is predicted by the model.

The annual loading of inorganic phosphorus from non-point and other sources predicted by the model for the six scenarios is shown in Fig. 5. Other sources including sewerage, industrial activity, aquaculture and livestock breeding by-products seem to be the dominant sources for inorganic phosphorus.

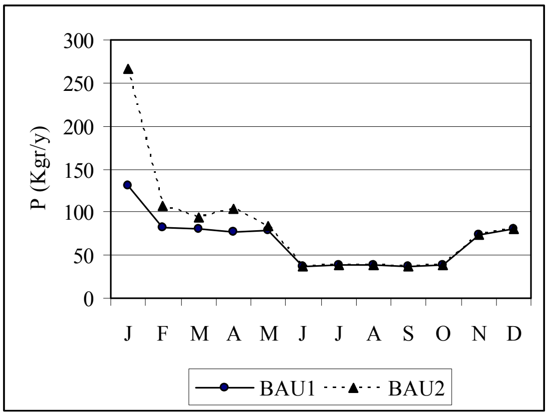

Figure 3. Monthly variability of inorganic phosphorus loading according to the BAU scenarios.

These sources are not affected by climatic change, whereas considerable increase in phosphorus loading is observed for the non-point sources (agricultural runoff) due to the climatic change. The overall phosphorus loading is higher at the BAU and lower at the DG scenarios. The annual loading of inorganic nitrogen from non-point is lower than the loading from other sources (Fig. 6) in the scenarios describing the current climatic conditions. This trend is reversed, if the climatic changes occur. The overall nitrogen loading is almost equal under the BAU and PT scenarios and halved under the DG scenarios.

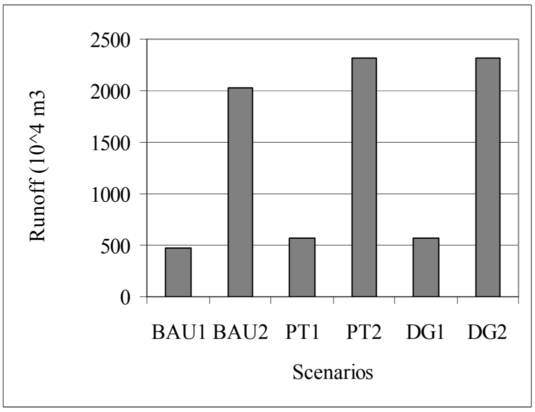

Figure 4. Annual surface runoff (in 10^4 m^3) from the Gera watershed according to the six scenarios.

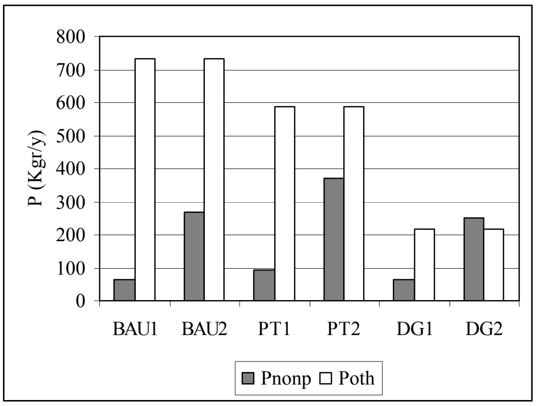

Figure 5. Annual loading of inorganic phosphorus from non-point and other sources predicted by the model for the six scenarios.

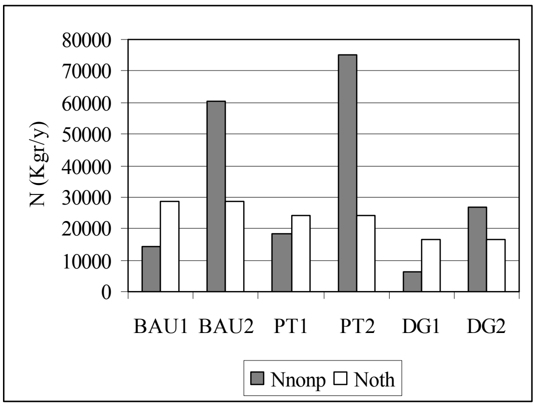

Figure 6. Annual loading of inorganic nitrogen from non-point and other sources predicted by the model for the six scenarios.

The contribution of other sources of nutrients under the assumptions of the six scenarios, is shown in Fig. 7 to 9. Aquaculture seems to be the main source of phosphorus, whereas livestock breeding is the main source of nitrogen according to the BAU and PT scenarios (Fig. 7 and 8). A different trend is observed for the DG scenarios where livestock breeding is the main source of both phosphorus and nitrogen (Fig. 9). Sewerage is also considered as an important source for all scenarios, whereas the contribution of the by-products of olive oil refineries is important only for nitrogen.

Discussion

Regional environmental scenarios are embedded in wider scenarios of socio-economic and cultural/institutional change. These so-called ‘generic scenarios’ provide the general context, according to which the specific characteristics of regional developments unfold. The consideration of local, national, regional and international parameters in the design of scenarios is desirable. Today more than ever, the world and the European perspective are indispensable in order to identify the global driving forces affecting the future of the planet and consequently the specificities of the geopolitical regions (WBCSD, 1997, UNEP, 2000). Meanwhile, fundamental changes have occurred in our understanding of the functions and values of catchments (Skourtos *et al.*, 2004), and these have prompted many recent international efforts to protect and achieve the substantial use of them. Today, these efforts have been coordinated through a number of international protocols and agreements, the implementation of which requires concerted action, joint fund raising and mutual cooperation in catchment management and policy. In this line, adopting the “wise use” imperative of the European Union is a prerequisite, but also taking explicitly into account a number of factors considered to affect specifically the management of Mediterranean catchments, namely, poverty and economic inequality, pressure from population growth, immigration and mass tourism and social and cultural conflicts.

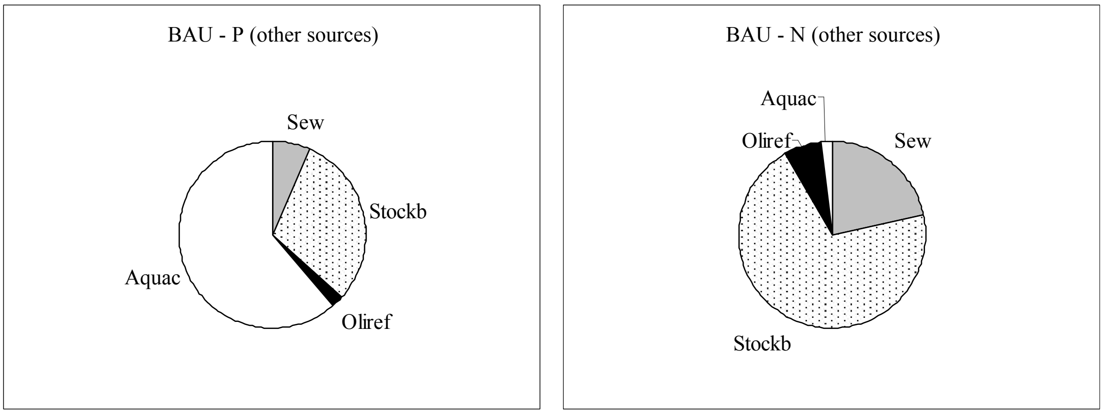

Figure 7. Contribution of other sources of inorganic phosphorus and nitrogen to the loading of the gulf of Gera under the BAU scenario.

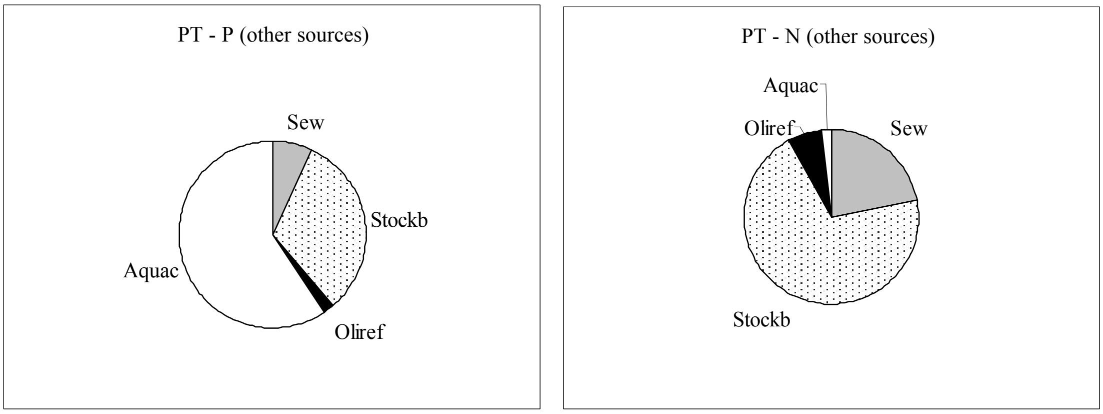

Figure 8. Contribution of other sources of inorganic phosphorus and nitrogen to the loading of the gulf of Gera under the PT scenario.

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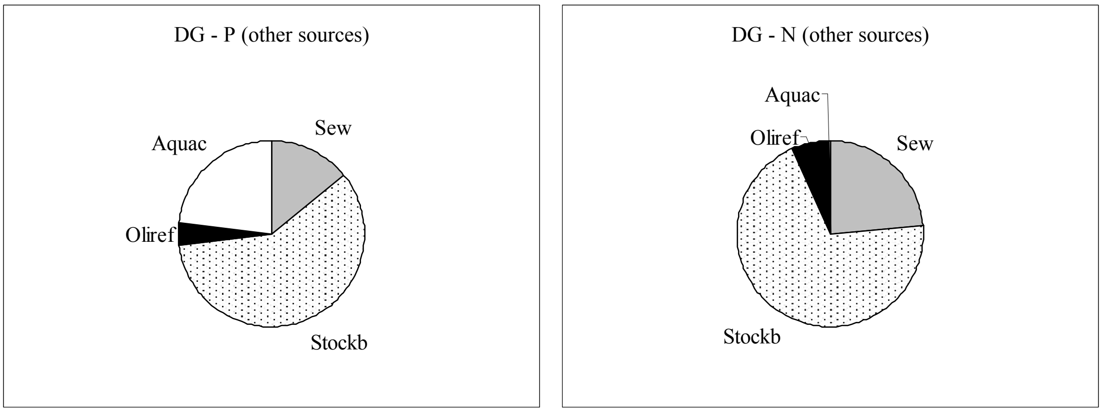

Figure 9. Contribution of other sources of inorganic phosphorus and nitrogen to the loading of the gulf of Gera under the DG scenario.

The initial conditions of BAU scenarios are almost entirely preconditioned by the past trends and the 'history' of the system. Seen from this perspective, the initial conditions for BAU are practically a 'non-response' perspective. Accordingly, the initial conditions in both versions of BAU are characterised by a future in which the development path of the region is not conductive to the strengthening of environmental protection. Past environmental controls are not implemented and new ones are hard to get the attention they deserve. The result is an increased nutrient loading during November to May in the test area, especially in winter, whereas during summer period, due to the ephemeral flow of the rivers the effect is not pronounced. Nutrient loading is higher under the BAU scenario in any case, reflecting the current trend of low environmental protection. This nutrient loading is crucial for the trophic status of the receiving water body, since eutrophic episodes are already observed in the area during winter after heavy rainfall events (Arhonditsis *et al.*, 2002a; 2002b). In PT scenarios, political will brings about the design and implementation of a number of policy measures towards the protection of the environment, a factor that in turn is conductive to the alleviation of pressures on water quality. A crucial factor affecting the effectiveness of environmental protection in the watershed of Gera, and consequently the possibility of a joint effort to manage water quality, relates now to both the side-obligations accompanying state investments in infrastructure as well as the strengthening of local networks and environmental NGOs.

The guiding principles of the DG scenario unfold a development path conditioned on the implementation of several control measures in the areas of industrial activity, agriculture and urbanization, including support for extensive agriculture and agri-environmental measures, urban expansion going hand in hand with an extensive treatment of urban wastewater, extensive agriculture and cattle raising, leading to the reduction in fertilizers, development of alternative forms of tourism, as curative tourism in thermal springs, agrotourism, ecotourism, tourism for sea sports and conferences.

Climate change seems to be an important factor for the future evolution of the coastal areas in Eastern Mediterranean. The annual rainfall height does not seem to change during the last decades, however there is a remarkable increase in the frequency of heavy rainfall events (Arhonditsis *et al.*, 2002b). These episodic events result to high amounts of surface runoff and erosion according to the models and therefore to an increase of the flood events in coastal areas. Moreover, a considerable increase in nutrient loading is also predicted by the models during the rainfall period.

Among the three sets of scenarios, the DG seems to be the most preferable in terms of environmental conservation and economic growth. The increase in economic activities (tourism, agriculture and aquaculture) seems to be sufficient for the development of the area, whereas the compliance with the legislation for environmental protection ensures the conservation of the natural environment. In addition, the application of the DG scenario seems to be the one that is not considerably affected by the climate change, except of the amount of surface runoff which shows a fourfold increase and may result to undesirable phenomena in the coastal area.

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