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Adverse Effects on Alfeios River Basin and an Integrated Management Framework Based on Sustainability

IOANNIS D. MANARIOTIS
PANAYOTIS C. YANNOPOULOS*
Environmental Engineering Laboratory
Department of Civil Engineering, University of Patras
GR 265 00
Patras, Greece

ABSTRACT / The Alfeios River, the longest and highest flow-rate river in Peloponnisos, constitutes an important water resource and ecosystem in Greece. In the present study, human activities in the Alfeios River Basin are described, and their impacts on water quality and the ecosystem are analyzed; effects resulting from interventions on river geomorphology between Flokas Dam and the river delta are determined. These actions have caused significant adverse impacts on the infrastructure (the dam, railroad, and road bridges), the level of aquifer water table and area water uses, and the aquatic and riparian ecosystem. A general integrated management strategy is formulated and a master management plan is proposed for resolving management problems in river basins. The plan considers local conditions and national requirements and complies with the European Communities legislation; it would help prevent further basin deterioration, improve water quality, and protect water resources and ecosystems in the area in accordance to sustainable development. The Alfeios River Basin serves as a case study in the development of the plan.

River basins are complex systems and consist of a number of subcatchment areas incorporating tributaries, streams and/or lakes, and the development of each basin is affected by local structural and quantitative properties and climatic conditions. The extended uncontrolled use of water resources and all other goods and services provided by river basins have imposed severe alterations and deterioration on their geomorphology, water quality, and ecosystem. Infrastructure works (dams, flood protection works, embankments for river straightening, gravel extraction) constructed in the basins frequently cause geomorphologic impacts that alter river velocities and discharge, with subsequent differentiation in the sedimentation process and the levels of surface water and the groundwater table (Morris and Fan 1997). These alterations usually adversely affect the quality of the water and ecosystem and impair the supply of drinking water and use for fishing and recreation (Lorenz and others 2001; Thorne and others 1997). River basins in Greece have been used more intensively in the last decades, with man-imposed pressures often exceeding the sustainable resource limits; in addition, changes in the natural river boundaries can occur. To prevent or repair these problems, an integrated approach to river basin management is needed, and related efforts have recently received much attention (Burton 1995; Howard and others 1995; Shin 1999; Lorenz and others 2001; Bernauer 2002; Mance and others 2002).

The Alfeios River Basin in Peloponnisos, Greece (Alfeios basin) has experienced all the aforementioned problems and more (MDDWRR 1996; HMEP-PPW 1997). The aim of the present article is, therefore, to establish the need for integrated Alfeios basin management based on the sustainable use of water resources and to provide key elements for the development of a suitable master plan that would facilitate this task. The characteristics of the basin and the structures and activities related to it are described, and a framework is presented for an integrated management strategy that would enable the establishment of government regulations and measures for the sustainable development of the area. The objective evaluation of the proposed management plan should be based on indicators formed by expert opinions, public issues, and legislation, in conjunction with available data on the Alfeios River water quality and ecosystem deterioration; to this end, the most relevant existing information is summarized, reviewed, and coevaluated.

KEY WORDS: River basin management; Environmental impacts; Bank erosion; Water resource degradation; Ecosystem deterioration; Sustainable strategy

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*Author to whom correspondence should be addressed, *email:* p.c.yannopoulos@upatras.gr

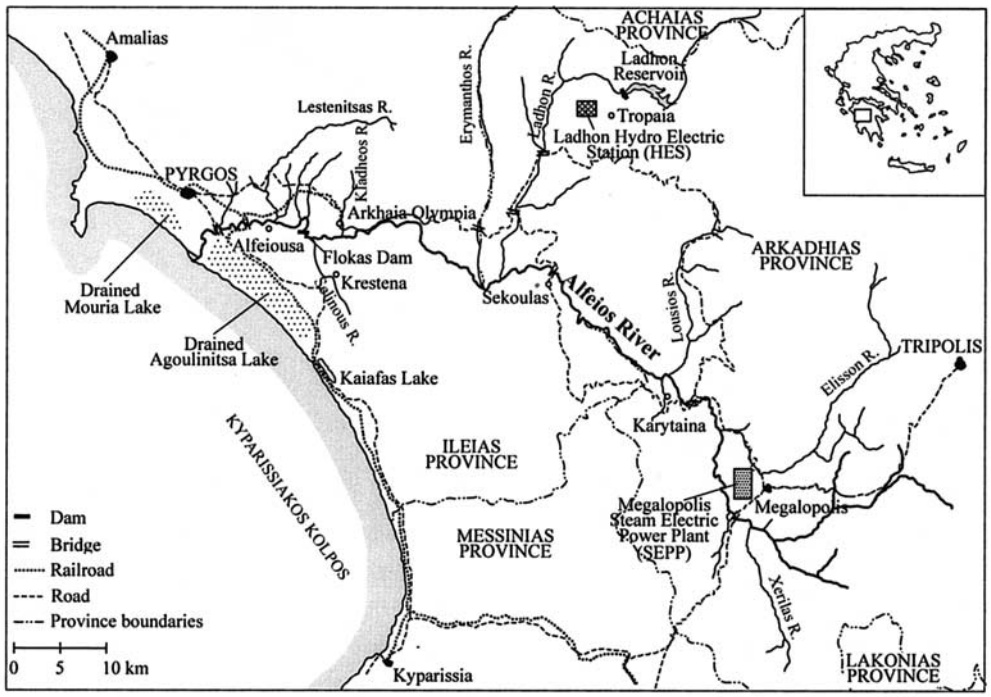

Figure 1. Alfeios River Basin.

Overview of Prevailing Conditions

The Alfeios River is the longest (112 km) and highest flow-rate (absolute maximum and minimum values recorded 2380 and 13 m^3/s) watercourse in the Peloponnisos region of Greece (Argiropoulos 1960), with a drainage area of 3658 km^2 and an annual water yield of 2100×10^6 m^3 (MDDWPR 1996). The Alfeios basin extends to western Peloponnisos and is distributed in the provinces of Arkadhias (60%), Ileias (30%), and Achaias (10%). The basin constitutes a significant ecosystem and natural resource (including water, alluvial gravel, and lignite) for these provinces, and the Alfeios River Delta (Alfeios delta) is an important part of the wetland chain of western Greece. Following the main flow direction, the river could be divided into three parts: (1) the upper Alfeios (250-km^2 draining area), with most significant tributaries being the Xerilas, Elisson, and Lousios; (2) the middle Alfeios (3048-km^2 area), with primary tributaries being the Ladhon, Erymanthos, Kladheos, and Selinous; and (3) the lower Alfeios (362-km^2 area), with the main tributary being the Lestenitsas. Important locations in the Alfeios basin are shown in Figure 1.

The soil of the Alfeios River catchment area consists of alluvial and sandstone deposits, as well as Neogene deposits characterized by discontinuity and heterogeneity. Basin hydrogeology is based on Karstic systems and clastic formations, and in some regions, an increased ferrous and manganese content makes groundwater unsuitable for potable use. Geologically, the Alfeios catchment area consists of Alpine deposits belonging to the Ionian, Pilos-Gavrovo, and Olonos-Pindos Zones, which have been overthrusted to the Tripolis and the central Peloponnisos Zones (MDDWPR 1996).

The prevailing climate in the coastal and flat areas is the marine Mediterranean climate, whereas in the interior, it changes to continental and mountainous types. Precipitation averages 1100 mm annually, ranging from 800 to 1600 mm, and occurs for 80–120 days; the annual basin mean air temperature is 19°C, with a range of variation usually less than 16°C (MDDWPR 1996).

The total population of the catchment area is estimated (according to the 2001 census) to be about 135,000 inhabitants (inh) (Table 1), which includes permanent residents and transient summertime tourists; the mean population density varies and is about 101, 23, and 18 inh/km^2 in the low-altitude, semihigh-altitude, and mountainous areas, respectively. Approximately 24% of the total basin area is used primarily for agriculture, including cultivation, crops production, and animal farming; the irrigated land is estimated to be 230 km^2. Industries are scattered in the Alfeios basin

Table 1. Residential, agro-industrial, and tourist activities using the Alfeios River for wastewater disposal

Alfeios River subareas	Population (inhabitants)	Agro-industrial units	Cow and pig farms	Hotels and camping units	Electric power plants	Municipal wastewater treatment		
							Design	
						Plant Units	Population (inh)	Flow (m^3/day)
Lower	55,000	26	90	7		3	50,200	22,630
Middle	70,000	27	51	24		0	—	—
Upper	10,000	20	1	14	2	2	9,000	2,000

Source: Greek National Tourism Organization (http://www.eot.gr); General Secretariat of National Statistical Service of Greece (http://www.statistics.gr); Ileias and Arkadhias prefectures; Bakalis and others (1995).

and are summarized in Table 1; the most significant units are concentrated near the Alfeios delta, partly on the drained Agoulinitsa Lake, and in the Megalopolis area, where lignite mines and a steam electric power plant (SEPP) are operating (Figure 1).

The Olympia site, which reflects the area of Arkhaia Olympia in ancient times, is included in "The Greek 'Habitat' Project Natura 2000" (GR2330004), and the Alfeios delta (GR2330001) is a candidate for this project (Dafis and others 1996). The types of vegetation recorded in the Alfeios basin include sand dune, halophytic, humid grasslands, reed-beds, shrubs with tamarisk, salix, alnus and platanus species; phrygana vegetation and Aleppo pine stands are limited, while there are some Stone pine representatives (Dafis and others 1996). In the aquatic ecosystem of the Alfeios River, increased habitation levels of cephalos, tsironi, and cheli, moderate levels of cyprinos, tsima, thalassopestrofa, chamosouris, and freshwater cephalos, and relatively low levels of zournas and potamosaliara are recorded (HMEPPPW 1997). Downstream of the Flokas Dam (Figure 1), frisa and mediterranean shad and several other species found in semisaline waters and seawaters are also recorded.

Water Quality and Discharge Rate Monitoring

Limited short-term characterization work has been carried out to assess the Alfeios River water quality. Dalezios and others (1977) provided the first estimate of the river water quality and impact on its ecosystem by the Megalopolis SEPP; this study was based on a 2-day (March 5–6, 1977) sampling and analysis in terms of total solids, visibility and sulfates at 14 locations along the entire river span and reflected local public opinion. The Hellenic Ministry of Agriculture beginning in 1983 has undertaken water-quality monitoring in order to satisfy irrigation criteria; samples are collected irregularly (at 1- or 2-month, or longer intervals) from the Flokas Dam and three other locations in the Megalopolis Basin (HMA 1997). The Environmental Engineering Laboratory of the Civil Engineering Department, University of Patras, has conducted four 1-day (August 20, 1991, December 13, 1992, May 1, 1993, October 18, 1993) field and laboratory measurements of physicochemical water characteristics (Yannopoulos and Tsivoglou 1992; Vossos and others 1993); sampling was undertaken at 10 different locations in order to enable the assessment of environmental impact on the Alfeios River water quality and ecosystem. Finally, Bakalis and others (1995) have reported water-quality measurements conducted during a 2-day period (January 11–12, 1995) in the upper Alfeios area.

The Public Power Corporation has undertaken discharge measurements for long periods at several river locations (primarily railroad and road bridges) and has installed and operates 18 meteorological stations and 5 hydrometric stations in the Alfeios basin. Also, the Directorate of Water and Physical Resources of the Ministry of Development since 1987 has been publishing registries of area meteorological and hydrometric station data.

Basin Works and Activities

Several activities have been developed along Alfeios River and its tributaries (Table 1) and have caused adverse effects from residences, tourism, agriculture, industry, and instream gravel mining, water pollution due to municipal and industrial wastewater disposal, and contamination by fly ash and fertilizers through runoff (the annual fertilizer use in the part of Alfeios basin located in the Ileias Province approached 30×10^6 kg in 1993). Water is pumped from the river for water supply, irrigation, or animal consumption, and the basin has long served as the main gravel reservoir for the nearby area; up to the mid-1990s, gravel was primarily extracted in the lower Alfeios basin (downstream of the Flokas Dam); however, the need to protect the archaeological site of Arkhaia Olympia has moved this oper-

Table 2. Activities causing negative impacts to Alfeios River Basin

Land cultivation, fertilization, and grazing	Continuous urbanization at delta site
Forest burning and exploitation without replanting	Discontinuous urbanization, dispersed habitation
Hunting, trampling, and overuse	Agro-industrial facilities, meat farming
Sand and gravel extraction, erosion	Tourist facilities
Polderization and land reclaimation	Open cast lignite mining in Megalopolis terrain
Drainage of areas surrounding the river delta	Steam electric power plant in Megalopolis
Embankments, hydrographic functioning changes	Hydroelectric power station in Ladhon River
Canalization and river-modifying structures	Industrial development near the delta site
Water-level management at dam locations	Water pollution and eutrophication
Other man-induced changes in hydraulic conditions	Soil pollution by agro-industrial activities
Dumping and disposal of dredged materials	Landfilling and disposal of inert materials
Construction and operation of transportation works	Air pollution by power generation

Source: Bakalis and others (1995); Dafis and others (1996).

ation to upstream river reaches and areas far from the riverbank.

The larger municipalities and villages in the Alfeios basin have simple sewerage systems and use the Alfeios River for wastewater discharge. Although the city of Pyrgos is at the boundaries of the Alfeios basin (Figure 1), its wastewater is disposed upstream of the Alfeios delta, 2.4 km from the seashore and the municipal treatment facility began operation in 2003; the delta land is used mainly for agricultural activities. The Megalopolis SEPP and the municipalities of Krestena, Arkhaia Olympia, and Megalopolis also have domestic wastewater treatment facilities (Table 1); however, the SEPP industrial wastes are only partially treated.

Adverse Environmental Impacts

Riverine activities, which are summarized in Table 2, directly or indirectly affect the water quality and general conditions of the ecosystem. The construction and operation of infrastructure works, in conjunction with continued gravel extraction, are linked to geomorphologic alterations, which cause adverse environmental impacts and affect water resources, thereby causing ecosystem deterioration (Dafis and others 1996; HMEP-PPW 1997). The geomorphological input to river management is potentially considerable and contributes to prevailing arguments about habitat structure and dynamics in freshwater ecology (Newson and Newson 2000).

Field observations, correlated with area contour and photo maps taken in 1965 and 1996, respectively, have enabled the authors to estimate that erosion in the lower Alfeios basin totaled about 11.5×10^6 m^3; however, 17.6×10^6 m^3 or more of gravel were cumulatively extracted from the basin between 1967 and 1995 (Nicholas and others 1999). Consequently, it can be concluded that river conveyance of sediments during the past 30 years was roughly equal to the volume eroded, and assuming complete cessation of gravel extraction, restoration of the basin might be anticipated in a span of 30 years.

The aquifer water-table drop taking place in the lower Alfeios basin during summertime has influenced significantly the flora (Dafis and others 1996; Manariotis and Yannopoulos 2001) and, in sequence, the fauna. The previously mentioned vegetation (sand dune, halophytic, etc.), which is limited to the delta area and stretches toward the dam, is seriously degraded in other areas, and it is significant to note that the edges of the delta and vegetation-covered areas are under constant pressure from low levels of sedimentation; as a result, the site as a whole is under a state of continuous degradation due to human activities (Dafis and others 1996).

The trampling and unregulated building near the Alfeios delta, especially in sand dune areas, result in river basin alteration and subsequent deterioration, and have considerably increased during the past years, causing flora degradation and low soil backup. The agro-industrial enterprises in the area are of small to medium size and are distributed in the basin (Table 1); these activities together with habitation contribute to water pollution, mainly through direct wastewater disposal. Agricultural cultivation activities (fertilizing, spraying) constitute a nonpoint source of river pollution and cause enrichment of the water with nitrates, nitrites, and phosphates, potentially contributing to eutrophication; in addition, use of pesticides might cause toxicity problems on the ecosystem and the area population.

Summarizing, the integrity of a river basin might be damaged by the activities and related impacts reported in Table 2; some of these apply specifically to the Alfeios basin and are listed in project Natura 2000 for the site of the Alfeios delta (Dafis and others 1996).

Taking into consideration information on geomorphological concepts and tools recently reported by Newson (2002), these observations could assist in forming a robust management plan for the Alfeios basin.

Protection of Water Resources and Ecosystems

The primary use of groundwater in the Alfeios basin is for water supply, whereas river surface water is directly utilized for fishing, irrigation, and animal consumption. In the past 10 years, the city of Pyrgos stopped using wells (located about 500 m from the riverbank) because ammonia and ferrous and manganese oxides were found in excess of allowable limits, and the presence of other pollutants was suspected due to the uncontrolled wastewater discharge. Wastewater disposal directly to the river or to its basin, therefore, requires particular attention, and according to the rules for the disposal of municipal and industrial wastewaters, the approval of the principal use of the receiving water and the applicable environmental terms should precede any wastewater discharge. These conditions for the Alfeios River, and its tributaries have been established primarily by prefecture decisions (Manariotis and Yannopoulos 2001), whereas a Joint Ministerial Decision (22485/96) summarizes approved environmental terms for the construction and operation of works for the relocation of the upper reach (7 km in length) of Alfeios. These works are in progress and must be completed by June 30, 2006.

Two tables summarizing the Greek National and European Community legislation enacted for the protection of water resources and ecosystems can be found on the website for *Environmental Management*. This information would apply to the Alfeios basin and might prove useful to authorities, stakeholders, resource users, and consultants for the assessment of environmental impacts in other regions and basins, or for the management, usage, and design of basin activities and resources.

Responsibility for Environmental Impacts

Public opinion considers the Megalopolis SEPP to be responsible for observed pollution episodes leading to crops damage, unsuitable drinking water quality, and a great ecological deterioration in riverine areas (Dalezios and others 1977; Manariotis and Yannopoulos 2001).

Construction and operation of the Flokas Dam caused severe effects on the downstream area due to the limited enrichment of the Alfeios delta with descending debris (Kallinskis 1957), and a shift of the riverine flora has occurred from the delta toward the dam (Dafis and others 1996). The drainage of the Agoulinitsa and Mouria lakes contributed to the destruction of biotopes, which provided considerable fish and eel production, and an eutrophication condition is encountered near the delta, which causes deoxygenation problems (Manariotis and Yannopoulos 2001).

Uncontrolled gravel extraction, practiced until recently, has seriously damaged tufts of riverine forests and riparian vegetation, leading to the degradation of natural vegetation and subsequent poor functioning of the delta, increased river flow velocities, and bank erosion (Manariotis and Yannopoulos 2001). These conditions have contributed to a considerable drop of the basin groundwater table and have damaged the foundations of infrastructure works (the dam, the railroad, and road bridges), requiring large financial resources to preserve the safety of the works (HMEPPPW 1997).

Development of a Management Strategy

The 1992 Rio Summit of the United Nations adopted the significance of "sustainable development" defined primarily by the World Commission on Environment and Development (WCED 1987), and declared that "the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations" (UN 1992). Application of this definition to river basin management implies reducing demands and pressure on freshwater resources by increasing efficiency in use, assuring participation of the stakeholders in the decision-making process, and considering both the ecological and economic values of water. Integrated river basin management requires that informed decision-makers take into account all uses and resources of the basin, following an ecosystem approach to ensure that human collectivities will benefit forever from the basin through the development of harmonious relationships among all users and between man and the river (Burton 1995). Because of the critical direct or indirect conflicts between the uses of water and all other physical resources, a successful sustainable water strategy should also influence the overall river basin management; therefore, sustainable water management encompasses the integrated consideration of all other resources and activities in the river basin.

This concept is supported by the action plan proposed by the Regional Policy of the European Commission (EC 2000), according to which water should be considered in the planning process as another form of a "naturally" given "infrastructure," necessary for the development of the regions. Consequently, the cre-

ation of a culture to be involved in managing water as an irregular and scarce resource, both because of physical reasons and socioeconomic and ecological costs, is a major concern. This is why the European Union (EU) tends to manage water in the Mediterranean Basin as a "common property," suggesting three priority axes: (1) improved knowledge of water resources, ecosystems, and uses, (2) resource demand management, and (3) integrated management of water quantity and quality; these should ensure that decisions related to resource management would be economically efficient, environmentally nondamaging, politically feasible, territorially equitable, and socially acceptable. A sustainable water resources management and planning system should be structured to a general code consisting of six priority actions (EC 2000): (1) assessing the sustainable use of existing available resources, (2) reducing water demand, (3) strengthening efforts for the prevention and reduction of pollution, (4) conserving and restoring aquatic ecosystems and wetlands, (5) developing management tools, and (6) managing crisis; these should be harmonized with the EU Water Framework Directive (WFD) (WFD 2000). All Member States should have formally complied with this directive by December 22, 2003, and as a result, Greece recently (December 1, 2003) adopted Law 3199/03 (Official Gazette 280A/2003) for water protection and management, although required additional legal instruments (decrees, ministerial decisions) are pending.

The main WFD environmental target is the achievement of a good ecological potential and good water quality within 15 years after the deadline for formal compliance; emphasis is placed on the protection, enhancement, and restoration of all water bodies and protected areas in river basin management plans. The directive requires the establishment of classification schemes to reflect the ecological status of surface water bodies, as measured by the condition of specific biological, hydromorphological, and chemical and physicochemical quality elements. The WFD emphasizes the importance of providing proper information to the general public in order to ensure participation on the implementation of the river basin management plan, which would contribute to its overall success. Member States have to make a clear effort to facilitate access to background information and promote active involvement and consultation of all interested parties. Three steps of the planning process are prescribed: (1) early involvement in the identification of the river basin district, which, will raise awareness; (2) involvement in the characterization of the river basin district, which will help collect data and experiences from stakeholders, identify conflicts, and establish common understanding; and (3) consultation after the completion of draft plans and during preparation of documents, which would aim at learning from comments, perceptions, experiences, and ideas of the stakeholders and would ensure that all interests or viewpoints are represented. Background documents should include as a minimum all data summarized in the river basin management plan (WG 2002).

Taking into consideration these priority actions, a general framework for an integrated basinwide management strategy was formed and is shown in Figure 2; the Alfeios basin serves as a case study. In applying this framework, management should consider the ecological, economic, technical, and social status of the catchment area, which needs to be monitored and assessed, considering the principles of sustainability and assuring that water resources will be available with acceptable quality forever and that aquatic ecosystems and wetlands will be restored and conserved. Useful guidance for the assessment of the ecological status, potential, and classification of water bodies is given by ECOSTAT (2003); important methodological elements for the WFD preparation and the links between habitat and aquatic biota are described by Logan and Furse (2002). The water authorities should create a central decision-making body (in this case the Alfeios Basin Council), which should consider information related to public consensus and regulate all basin resources to be allocated to stakeholders or resource users, recognizing the impact of the prevailing social culture. Thus, lack of environmental sensitivity by farmers because of insufficient education and awareness would result in uncontrolled usage of fertilizers, thereby deteriorating surface and groundwater quality, whereas lack of a modern water culture would reflect low water consumption for recreation. The activity rates applied by the stakeholders or resource users, in conjunction with the assessment of resource availability and environmental quality, should be monitored and then changes in climate and infrastructure should be considered; then resources and ecosystem status would enable a feedback route for making new regulations directed to the responsible authorities. For example, gravel extraction at excessive rates that would result in environmental deterioration and scoring effects on the foundations of bridges and dams should be restricted or forbidden by the responsible regional authority.

Each Basin Council will be linked directly, or through the Regional Water Council, to the Central Water Authority, which is charged with the total responsibility for the protection and management of water resources; prefectures, municipalities, and the public participate in the basin council, safeguarding social

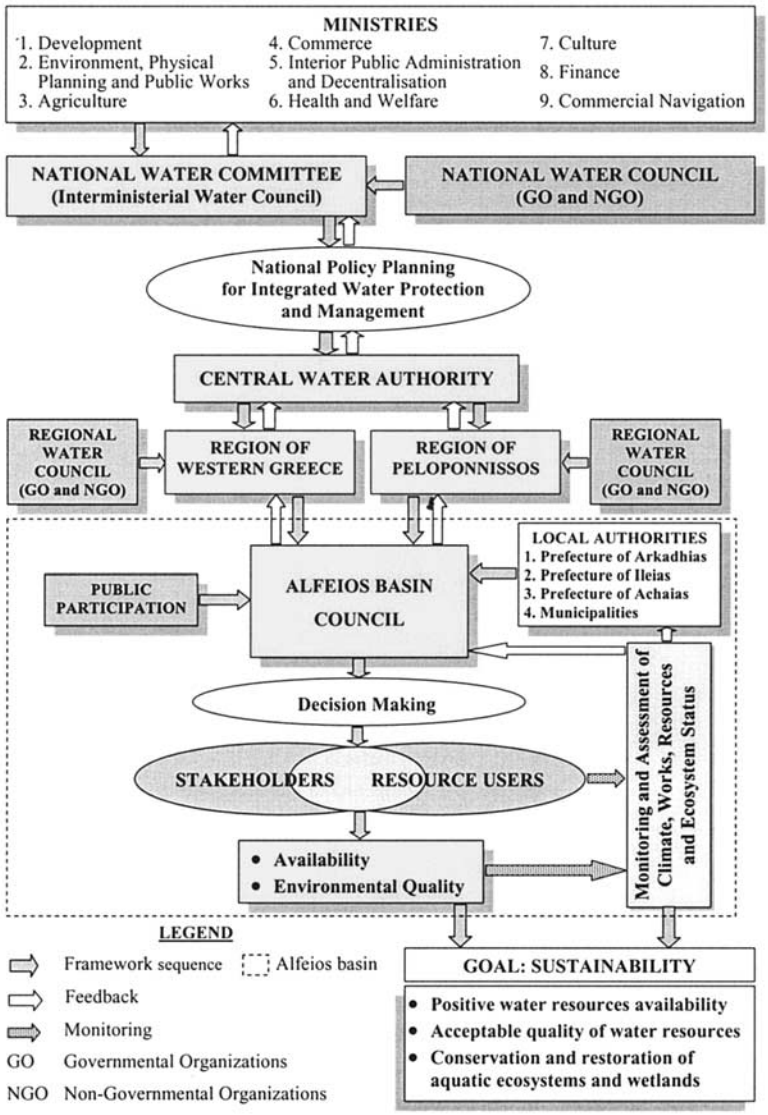

Figure 2. Structure of a central policy system for Alfeios River Basin decision-making.

consensus in decision-making. The Interministerial Water Council with the consent of the National Water Council plans the national policy for integrated water protection and management. Policy plans are allocated to the responsible basin councils or regional water authorities and feedback information flows in the opposite direction. Responsible authorities at each level should be involved in forming regulations and standards regarding basin management plans, water-quality monitoring projects, and abatement strategy programs for the catchment areas, and they should provide administrative restrictions and penalties to stakeholders or resource users concerning abuse, resource or ecosystem deterioration, and activities counter to rules and regulations.

A Master Management Plan (MMP) must develop particular environmental terms to guarantee the principal uses of groundwater and surface water in the entire river basin, safeguarding all aquatic and riparian ecosystems. Water-quality deterioration is closely related to factors such as inadequate environmental protection facilities, malfunctioning or nonexistent wastewater-treatment units, poor compliance with environmental law, lack of environmental awareness, insufficient environmental planning and lack of coordination, nonexistence of environmental monitoring, and generally limited funds allocation for implementing environmental measures. The MMP will need to provide operational tools and measures to overcome such problems; it should summarize public participa-

tion measures taken and evaluate their results and impact on the plan, and it should specify where and how background information can be obtained. In particular, the MMP should address the following specific actions:

1. Rationalization of the principal uses of the basin groundwater and surface water, and the environmental terms required along the river.
2. Monitoring the river basin physicochemical parameters and ecosystem quality, with feedback to the decision-making authority in order to take measures toward sustainability.
3. Reexamining the operation of dams, and especially the increase in allowed sediment transport from upstream in order to facilitate restoration of the eroded and degraded river bed downstream.
4. Providing fish and eel access between downstream and upstream river waters mainly in dams.
5. Upgrading municipal and industrial wastewater treatment facilities in order to avoid episodes of operational breakdown; discharge of untreated wastewater should not be allowed directly to the river.
6. Prohibiting any actions which might abuse the biotic and abiotic elements of the river and riparian ecosystems.
7. Taking measures for the effective protection of riverine forest and riparian vegetation against fires.
8. Promoting tourism expansion on the principles of ecotourism.
9. Assuring law enforcement over all activities in the river basin.

Finally, it should be noted that a MMP for the Alfeios basin (Alfeios MMP) is not available yet; however, according to the WFD, it needs to be implemented by December 2009, and it is hoped that information presented herein will materially aid in this formulation.

Conclusions

The restoration of the riverine and aquatic environments of Alfeios River and its basin and the rationalized usage of the basin natural resources in terms of sustainable development require the implementation of an integrated river basin management plan according to the WFD. The plan would additionally address the safety of infrastructure works minimizing expenditures for foundation maintenance, help reduce the drop in groundwater table, and provide for systematic monitoring to enable appraisal of environmental impact and responsibility. Indicated strategy and key elements needed for the formulation of this plan, which should be urgently established for the Alfeios basin, are proposed.

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Literature Cited

Argiropoulos, P. 1960. The morphologic evolution of the rivers of the Greek realm and the influence of the transported sediments on the relief of the country. *Praktika tis Akadimias Athinon (Minutes of the Academy of Athens) (in Greek)* 34:33–43.

Bakalis, N., P. Markantonatos, G. Gianatos, E. Zalahori, N. Robos, and L. Panetsos. 1995. Environmental impact assessment study for the relocation of the Alfeios River bank in Arkadhias Province, Stages I, II, III. A study conducted for the Public Power Corporation, Hydroelectric Projects Development Department, Athens (in Greek).

Bernauer, T. 2002. Explaining success and failure in international river management. *Aquatic Sciences* 64(1):1–19.

Burton, J. 1995. A framework for integrated river basin management. *Water Science and Technology* 32(5–6):139–144.

Dafis, S., E. Papastergiadou, K. Georghiou, D. Babalonas, T. Georgiadis, M. Papageorgiou, T. Lazaridou, and V. Tsiaoussi. 1996. Directive 92/43/EEC. The Greek 'Habitat' Project NATURA 2000: An overview. Life Contract B4-3200/94/756. Commission of the European Communities DG XI. The Goulandris Natural History Museum—Greek Biotope/Wetland Centre, Thessaloniki.

Dalezios, I., O. Ballassopoulos, and D. Sarletakos. 1977. Pollution of the Alfeios River area. Confidential report of the work team for the protection of the environment. Agricultural Bank of Greece, Athens (in Greek).

EC (European Commission). 2000. Towards sustainable and strategic management of water resources. Regional Policy of the European Union Study 31. Office of the Official Publications of the European Communities, Louxembourg.

ECOSTAT (Ecological Status). 2003. Overall approach to the classification of ecological status and ecological potential. Water Framework Directive; Common Implementation Strategy; Working Group 2 A; Ecological Status (ECOSTAT). Final version agreed at the Water Directors' meeting on 24–25 November 2003 in Rome. Available at http://forum.europa.eu.int/Public/irc/env/wfd/library.

HMA (Hellenic Ministry of Agriculture). 1997. River and lake water quality characteristics, water sector of western Peloponnisos, Alfeios River water quality characteristics 1983–97. Directorate of Land Reclamation Works, Department of Protection of Irrigation Water Recources, Athens (in

Greek). Available at http://www.minagric.gr/greek/2.9.3.alfeios.html.

HMEPPPW (Hellenic Ministry of the Environment, Physical Planning and Public Works). 1997. Protection works of Flokas Dam of the Alfeios River. General Directorate of Public Works, Directorate of Land Reclamation, Athens, Appendix 6 and Appendix 8 (in Greek).

Howard, J. R., M. E. Ligthelm, and A. Tanner. 1995. The development of a water quality management plan for the Mgeni River catchment. *Water Science and Technology* 32(5–6):217–226.

Kallinskis, A. 1957. The big reclamation works to develop the Alfeios river basin, as well as the lakes of Agoulinitsa and Mouria. Summary Report. Ministry of Transportation and Public Works, Hydraulics Section, Direction of Studies, Athens (in Greek).

Logan, P., and M. Furse. 2002. Preparing for the European Water Framework Directive— making the links between habitat and aquatic biota. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:425–437.

Lorenz, C. M., A. J. Gilbert, and W. P. Cofino. 2001. Environmental auditing: Indicators for transboundary river management. *Environmental Management* 28(1):115–129.

Manariotis, I. D., and P. C. Yannopoulos. 2001. Environmental impact of riverine activities on Alfios River and measures toward sustainability. Pages 131–139 *in* V. A. Tsihrintzis and P. Tsalides (eds.) Proceedings of an international conference Ecological Protection of the Planet Earth I, 5–8 June 2001, Xanthi.

Mance, G., P. J. Raven, and M. E. Bramley. 2002. Integrated river basin management in England and Wales: A policy perspective. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:339–346.

MDDWPR (Ministry of Development, Directorate of Water and Physical Resources). 1996. A plan of project management of country water resources. Ministry of Development, Directorate of Water and Physical Resources, Athens (in Greek).

Morris, G. L., and J. Fan. 1997. Reservoir sedimentation handbook: Design and management of dams, reservoirs, and watersheds for sustainable use. McGraw-Hill, New York.

Newson, M. D. 2002. Geomorphological concepts and tools for sustainable river ecosystem management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:365–379.

Newson, M. D., and C. L. Newson. 2000. Geomorphology, ecology and river channel habitat: Mesoscale approaches to basin-scale challenges. *Progress in Physical Geography* 24(2):195–217.

Nicholas, A. P., J. C. Woodward, G. Christopoulos, and M. G. Macklin. 1999. Modelling and monitoring river response to environmental change: The impact of dam construction and alluvial gravel extraction on bank erosion rates in the lower Alfios basin, Greece. *in* A. G. Brown, and T. A. Quine. Eds, Fluid processes and environmental change. John Wiley & Sons, New York.

Shin, P. K. S. 1999. Planning for water management in the Daqinghe river basin, northern China. *Environmental Management* 24(1):85–97.

Thorne, C. R., R. D. Hey, and M. D. Newson. 1997. Applied fluvial geomorphology for engineering and management. John Wiley & Sons, West Sussex.

UN (United Nations). 1992. Report of the United Nations Conference on environment and Development, Annex I: Rio declaration on environment and development. A/CONF.151/26 (Vol. I). United Nations, New York. Available at http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm.

Vossos, I., T. Kallitsis, and V. Xipolitidis. 1993. Alfeios River pollution sources and level. Diploma thesis, Department of Civil Engineering, University of Patras, Patras (in Greek).

WCED (World Commission on Environment and Development) 1987. Our common future. Oxford University Press, London.

WFD (Water Framework Directive). 2000. Directive 2000/60/EC, Establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities* L327, 22.12.2000, Vol. 43:1–72.

WG (Working Group). 2002. Guidance on public participation in relation to the water framework directive; active involvement, consultation, and public access to information. Final version after the Water Directors' meeting (Working Group 2.9). Available at http://forum.europa.eu.int/Public/irc/env/wfd/library.

Yannopoulos, P. C., and I. Tsivoglou. 1992. Impact of riverine activities on Alfeios River water quality. Pages 197–204 *in* S. Kaimaki (ed.). Proceedings of the 1st National Congress of the Greek Committee for the Water Resources Management, 18–20 November 1992, Athens (in Greek).