

# The Water Framework Directive for the Determination of New Hydrologic Prefectures in Greece

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## 1. Introduction

The Water Framework Directive constitutes the tool for the long-term, sustainable management of water resources and ecosystems in the territory of Europe. The success in the application of the directive is expected to depend on two crucial factors: one being the coordination between the physical procedures and the human activities that affect the water cycle inside the boundaries of a basin and second, the early taking of appropriate management measures, which will ensure the desired 'good condition' of the surface and groundwater resources for the next years (EU, 2000). The difficulty in the implementation of the directive derives among others from the principles that are included in the directive, regarding the water resources and their relations with the environment and relevant sectors. Authorities with different roles, jurisdictions, responsibilities and interests are involved in the management of water resources (Mimikou, 2000). This diversity of jurisdictions is often the foremost factor in the bad management and for this reason a different approach is necessary to the management practices. In the case of transnational basins, the collaboration between the involved countries is necessary, the creation of complementary agreements and the renewal of the existing ones according to

## Abstract

The Directive of the European Parliament and of the Council 2000/60 established a new legislation for the sustainable management of water resources on the basis of drainage basin area. The implementation of such policy in Greece would encounter great difficulties due to the fact that the region is split into a large number of drainage areas. Especially in Northern Greece the implementation is more difficult due to transnational water resources. The determination of seven hydrologic prefectures is attempted, based on the hydrologic - hydrogeologic criteria and taking into account the existing administrative structure, as well as the existing management problems regarding the internal, coastal and transnational water resources. A smaller number of hydrologic prefectures would meet the EU requirements and would mean easier and more complete study and organization, as well as their more systematic control, supervision and management.

## Résumé

*La directive du Parlement Européen et du Conseil 2000/60 a établi une nouvelle législation pour la gestion durable des ressources en eau sur la base des bassins de drainage. En Grèce, l'application de cette politique rencontrerait de grandes difficultés étant donné que la région est divisée en un grand nombre de bassins de drainage. Spécialement en Grèce du nord l'application est plus difficile à cause des ressources en eau transnationales. Les sept préfectures hydrologiques sont déterminées sur la base de critères hydrologiques - hydrogéologiques, en tenant compte de la structure administrative existante et des problèmes de gestion concernant les ressources en eau nationales, côtières et transnationales. Un nombre plus limité de préfectures hydrologiques répondrait aux exigences de l'UE, ce qui implique une étude et une organisation plus faciles et plus complètes, aussi bien qu'un contrôle, une surveillance et une gestion plus systématiques.*

the directive. In each case, the adaptation of the planning and management actions at an appropriate scale is a necessary principle that should be implemented in all of the directive's components on a vertical way. From bottom to top (e.g. the actions should be coordinated effectively on a local level so that the aim of 'good condition' of water on a basin level would be achieved), as well as in reverse. The economic growth of the last decades has formed new conditions to the use of water resources, since they constitute a means for the achievement of the various sector economic aims, remaining constantly one of the most important fac-

tors for the survival of human and the conservation of the ecological balance (Koumouli, 2001). Greece is a country of small extent (area of 132000 km<sup>2</sup>) with intense ground relief, limited back land and great extent of coasts. The result of that special geomorphological structure is the division of the area into small basins, each of which has different problems and therefore requires a different management policy. The transnational water resources of the country, according to the Directive, require a single and special treatment for the implementation of the most rational management policy, in order that their best utilization inside the national boundaries is achieved, as well as the disruption of the relationships with the neighboring countries is prevented. Contrary to other European countries, Greece is divided into a large number of water districts (14), a fact which does not keep up with its small extent (Ministry of Development, 1987). France, which is much larger than Greece, consists of 4 water districts, while Spain consists of 9 (Ministry of

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Development, 1997). The European Parliament having assessed that there is a diversity of conditions and needs, that demand different special attention, decided that this diversity should be taken into account during the planning phase and the implementation of the measures for the protection and the sustainable use of water, on a basin frame (CSI-WFD, 2001; EC, 2001). The decisions should be taken as close as possible to the places where the water is used or is affected. (WWF/EC, 2001; <http://forum.europa.eu.int/Public/irc/env/>

Home/main). The determination of seven hydrologic prefectures is attempted in the present study, based on the hydrologic, hydrogeologic, geographic and geomorphologic characteristics of the 14 existing water districts (Figure 1), the existing administrative structure, as well as the important management problems regarding the internal, coastal and transnational water resources.

Fig.1. The 14 water districts of the country



The smaller number of hydrologic prefectures that accords entirely with the Directive would mean easier and more complete study and organization, as well as more systematic control, supervision and management.

## 2. Difficulties in the implementation of the directive

Greece has a geomorphologic peculiarity, owing to the intense relief and the great extent of coasts and comprises small basins, each of one demanding a different management plan. In particular, the most important problems that could be highlighted relating to the state of water resources, are:

- The difficulty and deficiency in the systematic and reliable recording and evaluation of the physical and artificial water systems from a quantitative and qualitative point of view, as well as the deficiency in adequate measurements of hydrologic, meteorological, hydrogeological and qualitative parameters.

- The deficiency and difficulty in the alignment of independent hydrogeological basins inside the boundaries of each water district.
- The interaction between coastal waters owing to nearby streams or rivers that end up to the sea.
- The difficulty and deficiency in the recording of the existing uses of water and in the measurement of the water quantity that is consumed in each use.
- The difficulty in the coordination of the authorities at a national and peripheral level, regarding studies and research on the infrastructure relating to the water resources.
- The occasional and uncontrolled exploitation of specific water resources beyond the boundaries of one water district, without established knowledge of its capabilities, which leads to the gradual degradation of quality and quantity.
- The difficulty in making long-term predictions about hydrologic, population, economical trends, production sectors etc, in the frame of the developing program, so that corresponding predictions about utilization structures could be made.
- The difficulty or non-existence of a total encounter of problems relating to the plan and management of water resources.
- The need for assuring the rational management of the transnational water resources and their common utilization based on the needs for water of the involved countries.
- The lack of a single management authority on the water sector.

## 3. Proposal for the determination of the Hydrologic Prefectures for the needs of the directive

The criteria that were taken into account for the final proposal to determine the hydrologic prefectures are:

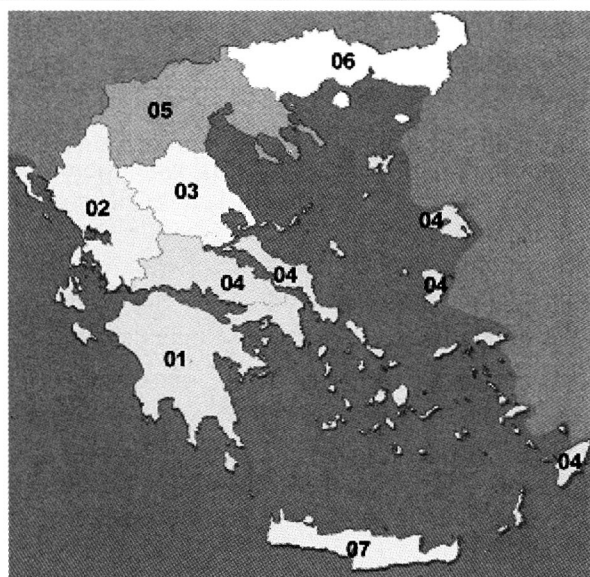
- The hydrologic similarity based on the precipitations, of the existing water districts.
- The extent of the water districts and prefectures of the basins.
- The geomorphology - terrain structure of the regions that constitute the water districts.

More specifically, the mean hyper-annual surface precipitation is the most important characteristic for the evaluation of a region's hydrologic identity and response; thus, its examination provides reliable results on the hydrologic status of each water district. The extent of the water districts and the resulting hydrologic prefectures is considered an important criterion for the achievement of uniformity on the extent of the proposed prefectures, for a single management and planning policy to be attainable. The geomorphology-topography of the areas that constitute the water districts is described, so that the combination of the areas with common geomorphologic characteristics could provide hydrologic prefectures, uniform in morphology and functional in management. The criterion of landuses and

management characteristics of each water district, which was examined only for ancillary reasons, was proved to be particularly useful for the evaluation, as it implied the connections between the water districts, as well as their developing peculiarities, so that these will be taken into account in their final integration into a prefecture. The hydrologic prefectures that came up taking into account the total of the above criteria are seven and are reported in Figure 2.

The above separation is a proposal that is based on scien-

Fig. 2. The seven hydrologic prefectures.



tific data, available today by the use of new technology and mainly geographic information systems, on the infrastructure of the National Data Bank of Hydrological and Meteorological information (NDBHM) (Mimikou, 2000). This proposal constitutes an initial approach to the complicated issue of the total management of the country's water resources, covering the hydrologic aspect. That management should be planned taking into account a plethora of other parameters, such as the water consumption and the utilization structures of the country's water potential. In each case, the hydrologic data and the conclusions that resulted from the study that was accomplished in the frame of NDBHM, will be the base towards that direction.

### 3.1. Hydrologic Prefecture of Peloponnese

The Prefecture of Peloponnese is a distinguished geographic entity resulting from the union of three water districts 01, 02 and 03.

The water districts present relevant differences regarding the geomorphologic structure, the climate, the availability of water resources, but also significant common characteristics, such as common boundaries, similar extent, type and rate of development, thus providing the capability of a total study. The prevailing climate is Mediterranean in the

coastal and flat areas, while it alters into overland towards interior areas and into mountainous at the mountainous areas. The duration of the warm period, which is an important parameter for the management of water resources, is from up to over 6 months. The aquifers are independent; spatially they constitute subgroups of the three water districts and contribute to the urban and mainly to the agricultural demand. The union of the three districts may help to the best total management of the water resources and to the spherical encounter of problems regarding ground waters, due to the fall of the water level, which is attributed to the overexploitation of the aquifers. The groundwater is downgraded in many coastal areas, due to the movement of sea towards the interior. The hydrologic prefecture of Peloponnese has the longest coastline. The effect of a coastal area, situated near the boundaries of a water district, on another area of the neighboring water district, is controlled more rationally by a single authority compared to the case of more authorities that may have different criteria, programs, equipment, etc. The uses of water for the hydrologic prefecture of Peloponnese and the corresponding percentages are shown in Table 1.

Tab. 1. The water uses for the hydrologic prefecture

Domes tic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Ind ustrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
77	807	10	19	913
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
8.4	88.4	1.1	2.1	100

### 3.2. Hydrologic Prefecture of Western Sterea - Epirus

The prefecture of Western Sterea - Epirus resulted from the union of the water districts 4 and 5, which present common boundaries, nearly the same extent and similar geomorphologic, climatologic and hydrologic conditions.

These water districts present a surplus of hydrologic balance, the highest in the whole country. Furthermore, the demand for water is limited due to the low level of the region's development. Consequently, the great water potential that stays unutilized should be integrated into a common management plan for the rational fulfillment of the needs inside the boundaries of the water district, but also for the increase in water potential of the eastern part of the country, where the natural supply does not suffice to cover the growing demand. A great part of the water district of Western Sterea and more specifically the basins of Evinos and Mornos should be integrated into the hydrologic prefecture of Eastern Sterea - Attica, owing to the fact that these basins supply water to the Metropolis. The climate is Mediterranean in the coastal areas of the water district and in the island of Lefkada, while in the eastern mountainous areas the climate is mideuropean with spots of alpine. The mean annual tem-



perature varies between 17 and 18 °C. The annual temperature range is 18 to 19 °C, while in the mountainous areas it exceeds 20 °C. The duration of the warm period, which is an important parameter for the management of water resources, is 5 months (Ministry of Development, 1997).

The hydrologic prefecture of Western Sterea-Epirus is located in the western part of the country, which is remote from the eastern developed continental axis. It is an agricultural area that is characterized by a dearth of development and isolation. The water resources are used for irrigation and for the production of hydroelectric energy. The uses of water and the corresponding percentages are shown in Table 2. The ground waters of the two hydrologic prefectures belong to different aquifers that consist parts of the water basins and are fed by the mountainous areas of the basins. Regarding the coastal areas (e.g. Gulf of Ambrakikos, Arta), where the waters have been qualitatively downgraded due to the fertilization of crops, the administration from a single central authority is much more efficient.

Tab. 2. *The water uses for the hydrologic prefecture.*

Domestic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Industrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
65	757	2	32	856
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
7.6	88.4	0.2	3.8	100

### 3.3. Hydrologic Prefecture of Attica - Eastern Sterea

The prefecture of Attica-Eastern Sterea has resulted from the union of the water districts 06 and 07 that are characterized by common boundaries, climatic conditions and geomorphology. The water potential of eastern Sterea is much greater than that of Attica. Therefore, it is essential that these two water districts have a common management policy and the Evinos and Mornos river basins should be incorporated into this plan. These actions will allow the utilization of water resources of the areas that are sufficient in water for the benefit of the areas that present a deficiency in water resources (solution to the urgent problem of water supply in Attica), on a efficient base (Eastern Sterea and the part of western should be supported by a specific policy for the contribution of their privileges). The headquarters of the prefecture will be in Athens and districts will be placed at the capitals of the districts. Furthermore, it should be noticed that a part of the hydrologic prefecture is given to Thessaly. This area is situated in the northern part of the District of Fthiotida and consists of many small basins that operate on a transient base. The hydrologic prefecture of Attica - Eastern Sterea is situated at the eastern developed axis of the country. Its distinguishing feature is the relatively balanced development of the three productivity sectors.

The geographic location and the terrain of the prefecture contribute to the extended climatic variety, which ranges from the Mediterranean sea to mountainous areas. The mean annual temperature range is 16 to 18 degrees Celsius. The duration of the warm period, which is an important parameter for the management of water resources, is from 5 up to over 6 months. The uses of water and the corresponding percentages are shown in Table 3.

Tab. 3. *The water uses for the hydrologic prefecture.*

Domestic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Industrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
368	973	25	10	1376
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
26.8	70.7	1.8	0.7	100

The contribution of the underground water potential is remarkable for supplying water to the capital. The groundwaters belong to independent aquifers that are located at the flat areas of the basins. Furthermore, the union of the water districts may contribute to the best management of the coastal waters.

### 3.4. Hydrologic Prefecture of Thessaly

The water district n° 8 was not joined to another water district due to its great extent, as well as for its geomorphologic, climatic, agricultural and financial characteristics.

However, a small part of the Eastern Sterea water district was joined to that of Thessaly. The main reason of that incorporation is the union with other small basins with transient torrent flow, located in the water district of Thessaly and their common feature is the sediment yield in the cases of intense rainfall events. The greatest flat terrain of the entire country is located in that hydrologic prefecture. There is a dearth of water resources in the region and the demand for water of the existing crops is not covered. Therefore, a special management policy should be applied in order to reinforce the water potential through the rational use of the water resources (extension and modernization of the irrigation network), as well as through the conveyance of water capacities from other water districts. The water district of Thessaly has a shortage of water and the existing water resources do not cover the theoretically expected demand for irrigation water.

- The water district of Thessaly almost coincides with the Prefecture of Thessaly, which is one of the central, relatively developed regions of the country. The region's development depends on the promotion of intensive, irrigated agriculture and tourism.
- The hydrologic prefecture is divided into three sections:
  - the eastern coastal and mountainous area, with Mediterranean climate;
  - the central flat area, with continental climate;
  - the western mountainous area, with mountainous climate.

The mean annual temperature varies between 16 and 17 °C. The annual temperature range exceeds 22 °C. The duration of the warm period, which is an important parameter for the management of water resources, is from 5 up to over 6 months (Ministry of Development, 1997). The uses of water for the hydrologic prefecture of Thessaly and the corresponding percentages are shown in Table 4.

Tab. 4. *The water uses for the hydrologic prefecture.*

Domestic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Industrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
54	1581	7	9	1651
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
3.3	95.8	0.4	0.5	100

### 3.5. Hydrologic Prefecture of Western and Central Macedonia

The prefecture of Western and Central Macedonia resulted from the union of the water districts, n° 9 and 10.

The districts of Western and Central Macedonia occupy the greatest extent compared to other water districts. The geomorphologic and climatologic conditions of the water district of Western Macedonia, especially the districts of Imathia, Pieria and Pella, present significant similarities with the water district of Central Macedonia. Despite the fact that the water district of Central Macedonia includes transnational water resources (Axios river and Doirani lake with FYROM), it was joined to that of Western Macedonia due to the supply of water to the city of Thessalonica from the river of Aliakmona. In addition, the basin of Thessalonica city connects to that of Imathia and Pieria districts through groundwaters, due to the favorable conditions of common aquifers. Furthermore, as the rivers end up at the Gulf of Thermaikos in close proximity, there is an interaction between the river deltas, as well as between the coastal waters.

A remarkable feature of that hydrologic prefecture is the production of hydroelectric energy from the utilization of the water potential of the Aliakmona river. The uses of water for the total of the hydrologic prefecture are shown in Table 5.

### 3.6. Hydrologic Prefecture of Eastern Macedonia - Thrace

The prefecture of Eastern Macedonia - Thrace resulted

Tab. 5. *The water uses for the hydrologic prefecture.*

Domestic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Industrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
122	1030	54	20	1226
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
10.0	84.0	4.4	1.6	100

from the union of the water districts No 11 and 12.

These districts present common boundaries, similar geomorphologic structure and several affinities between their hydrologic and climatic conditions. An important special feature of these water districts is their dependence on transnational water resources (in water district 11 the river Strimonas with Bulgaria, in wd 12 the river Nestos with Bulgaria and river Evros with Bulgaria and Turkey) for the fulfillment of basic needs. The management of the transnational water resources is a crucial issue in this hydrologic prefecture and it should involve the following actions. Promotion of the transnational meetings so as to secure the demanded capacity and quality of water, collaboration with the upstream countries on water issues (common networks for monitoring quantitative and qualitative parameters, common automatic flood-warning systems) and minimization of the dependence on other countries, forecasting alternative ways of development. The uses of water for the total of the hydrologic prefecture are shown in Table 6.

Tab. 6. *The water uses for the hydrologic prefecture*

Domestic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Industrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
50	810	13	11	884
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
5.7	91.6	1.5	1.2	100

The aquifers of the hydrologic prefecture may connect on a hydraulic base and contribute to the urban and agricultural demand for water. The effect of a coastal area, situated near the boundaries of a water district, on another area of the neighboring water district, is controlled more rationally by a single authority compared to case of more authorities that may have different criteria, programs, equipment, etc.

### 3.7. Hydrologic Prefecture of Crete

The feature that characterizes the development identity of that hydrologic prefecture is the limited natural supply of water and the increased seasonal demand. The problem is not intense during the winter months, but it becomes serious in summer. A management that aims at the development of infrastructure and at the rational use and protection of the existing water resources is necessary in order to overcome the specific problem. The water district of Crete is 8336 km<sup>2</sup> in extent. It is the southernmost district and apart from the island of Crete, it also includes the small islands of Gavdos and Dias. That district constitutes the Prefecture of Crete (Pr.Decree 60/1998).

The water district of Crete is rich in water resources that could satisfy the growing demand. The greatest problem is their spatial distribution in relation to the needs. More specifically, the western part of the district is rich in water resources, surface and underground waters. The precipitation height decreases towards the eastern side of the island and in combination with the salinity of ground waters, it

leads to a deficit in the supply-demand balance, posing problems even for the needs of water supply (e.g. Iraklio). The basic directions of the economy have been formed by these characteristics, along with the climate that makes the island ideal for an eight-month tourist activity, as well as for early and late crops. The major and almost exclusive axis of Crete development is the northern, owing to the fact that it constitutes the island's internal front towards the continental part of the country. The climate is characterized as temperate to Mediterranean warm-semi humid. In the mountainous areas especially of the western side, the climate is mountainous. The mean annual temperature varies from 18.5 °C in the western part to 20 °C in the southern part. The annual temperature range is 14 to 15 °C. The southern and southeast coasts of Crete are among the warmest regions of the whole country. The duration of the warm period, which is an important parameter for the management of water resources, exceeds 6 months. The uses of water for the hydrologic prefecture of Crete and the corresponding percentages are shown in Table 7.

Tab. 7. *The water uses for the hydrologic prefecture.*

Domestic (X10 <sup>6</sup> ) m <sup>3</sup>	Agricultural (X10 <sup>6</sup> ) m <sup>3</sup>	Industrial (X10 <sup>6</sup> ) m <sup>3</sup>	Hydroelectric (X10 <sup>6</sup> ) m <sup>3</sup>	Total (X10 <sup>6</sup> ) m <sup>3</sup>
42	330	2	5	379
Domestic %	Agricultural %	Industrial %	Hydroelectric %	Total %
11.1	87.1	0.5	1.3	100

## 4 Conclusions

The present study is a hydrologic and geomorphologic description of the country's water districts. The difficulties and problems in the implementation of the directive for waters in Greece, and particularly in Northern Greece (due to the transnational rivers) were assessed and discussed. Finally, an approach was suggested to aggregate the fourteen water districts into seven hydrologic prefectures based on hydrologic, geomorphologic, administrative, mountainous

and spatial criteria. This suggestion comprises a first approach to the difficult issue of the total management of the country's water resources, covering mainly the hydrologic aspect. That management should be planned taking into account a host of other parameters, such as the spatially precisely defined consumptions of water, the landcover and landuse, the country's water potential and the structures for its utilization.

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