DRIVING FORCES AND IMPACTS OF RANGELAND CHANGES ON WATER RESOURCES
THE STATE OF RESEARCH IN GREECE

ABSTRACT

The aim of the report is: (a) to offer an overview of the state of the research and summarize the main findings on the driving forces and impacts of rangeland changes in Greece and (b) to identify critical research and data needs that have to be addressed to support informed water resources planning and policy making in relation to rangeland changes in the country.

The report first outlines the main issues related to the state of research on the topic in Greece. Then, it presents available information on the state of rangelands, rangeland changes and water resources in Greece. Based on available formal documentation and expert opinion, the principal types of driving forces of rangeland changes as well as their impacts on water resources in Greece are discussed and analysed. The principal policies (of the last 50 years) that are directly involved in rangeland changes are presented briefly in this context. The status of water resources management in Greece is outlined as well as the status of management of other related resources – rangelands and agricultural land. Adaptive and mitigation measures that have been introduced to cope with the detrimental impacts of rangeland changes on water resources in Greece are presented. Lastly, based on the preceding analysis, the principal research and data needs are identified with the aim to support the information needs of water resources planning and policy making in the particular case of the impacts of rangeland changes on water resources.

INTRODUCTION – THE STATUS OF RESEARCH ON THE TOPIC IN GREECE

The original intent of this report was to provide a summary account of the impacts of rangeland changes of water resources in Greece based on expert opinion and available documentation. It turned out, not unexpectedly though, that locating and compiling the literature and getting in touch with the experts to provide a reliable account of the situation was a Herculean task that necessitated human, time and financial resources which were not readily available. Hence, the authors settled for something more modest within the limits of the resources they availed.

The reasons underlying the difficulties met with the present endeavour are multiple and frequently overlapping. First, the issue of land use change has not been systematically researched yet although a considerable number of studies touch it either directly or indirectly. More specifically, there are no comprehensive and systematic studies of the driving forces and impacts of land use change on various resources. Consequently, the particular topic of rangeland changes and their impacts on water resources is not supported by systematic and widely publicized research.

Secondly, the issue of water resources and their management has not been systematically researched too and efforts to rationalize the exploitation and management of water resources and to secure their sustainable use have started only in the last decade in Greece. It is true that there exists a significant number of research and pilot projects in the country and technology is being developed for the exploitation of water resources adapted to local conditions (e.g. exploitation and enrichment of groundwater resources, processing and reuse of liquid wastes, assessment of water requirements of crops, water savings, etc.). Thirdly, research is not systematically monitored and recorded in general – a situation that is now being reversed given the efforts of the General Directorate of Research and Technology. However, priority is usually given to particular sectors and areas of research. As a result, researchers and research institutions working on the same or related subject(s) do not communicate adequately and efficiently creating, thus, an information and, eventually, cooperation and action gap. Thus, this research area lacks continuity and consistency and research results, however valuable, are not fully exploited and do not support decision making as should be the case (Angelakis 1999).

The reader of this report is, therefore, cautioned against assuming that this is a complete and well-documented report based on an exhaustive, comprehensive and up-to-date reconnaissance of the state of the

research on the topic. The contents of this report reflect readily available information to authors and their personal knowledge and experience on the subject. It should be noted also that, due to the limited time available, no effort was made to provide detailed references for several of the statements made although such literature did exist and is known to the authors. A limited number of research projects, funded mainly by the European Commission, are provided in an Appendix to this report.

The report has five sections. The first section offers a broad account of the state of rangelands, rangeland changes and water resources in Greece. In the second section, the driving forces of land use changes in Greece are discussed while the third section presents their most well-known impacts on water (and land) resources. The fourth section sketches briefly the state of water resources, rangeland and agricultural land management in Greece. The reports concludes with an account of the principal research and data needs to support water resources analysis, policy making and planning in relation to rangeland changes in Greece.

THE STATE OF RANGELANDS, AGRICULTURAL LAND AND WATER RESOURCES IN GREECE

The state of rangelands and agricultural land in Greece

The National Statistical Service of Greece conducts a decennial pre-census (of population) survey of the distribution of land to main land use categories at the national and sub-national (geographic departments, prefectures, municipalities and communes) levels. Six land use categories are distinguished at all these levels for the purposes of this survey – cultivated land (including fallow), pastures (municipal or communal and private), forests, areas covered with water, built areas, other areas. Indicatively, the changes in the total area of the country and in the individual land use categories are shown in the following Table 1.

Year	Total area (thous. stremmas	Cultivated land	Municipal ommunal pastures	Private pastures	Forests	Areas cove-red with water	Built areas	Other areas
1971	131990	39638,6	30187,5	22517,9	29674,6	3116,9	4661,4	2192,9
1981	131.957,4	39452	30003,8	22546,4	29510,9	3086,3	4893,1	2464,9
1991	131.957,4	39435,9	30026,1	22165,4	29378,1	2996	5303,2	2652,8

Source: National Statistical Service of Greece, 1991

Table 1 - Changes in the main land use categories in Greece 1971, 1981, 1991

The above table shows that, at the national level, the area of cultivated land decreased slightly between 1971 and 1991. This is because the country's food situation had substantially improved already before its accession to the European Union in 1981. Since 1981, agricultural production intensified resulting in intensive arable cropping on all fertile, irrigable lands. Further mechanisation and expansion of the irrigated area to 1 million hectares were realised soon after the country became a full member of the European Union (Figure 1). The slight reduction of the area of cultivated land indicates its conversion to other non-agricultural uses – mainly urban, industrial and tourist uses.

The irrigated land in Greece presently covers about 1,327,000 hectares or 32% of the total cultivated land. Of this total amount, about 37% is served by public irrigation and drainage systems, while the rest is served by private irrigation systems. As Fig. 2 shows, two irrigation methods are used mainly: surface or sprinkler irrigation. Considering that irrigation efficiency increases in the order: drip >sprinkler>surface irrigation, considerable water savings are expected from a shift of irrigation methods to the drip and sprinkler, reducing, thus, the area irrigated by surface irrigation.

Table 1 reveals a general decline in the area of cultivated land, pastures and forests and a general increase in the area of built and other areas. This was and continues to be the general trend of land use change in Greece where the former land use types are replaced by the latter ones under the heavy residential, industrial and tourism development pressures that are discussed in the next section.

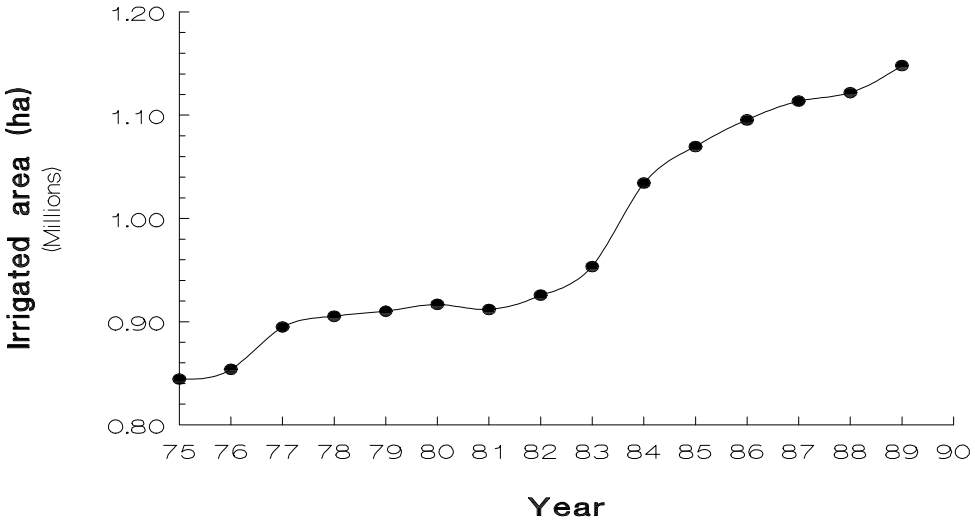

Figure 1 - Change in total irrigated land in Greece
(Source: Ministry of Agriculture, Department of Land Reclamation)

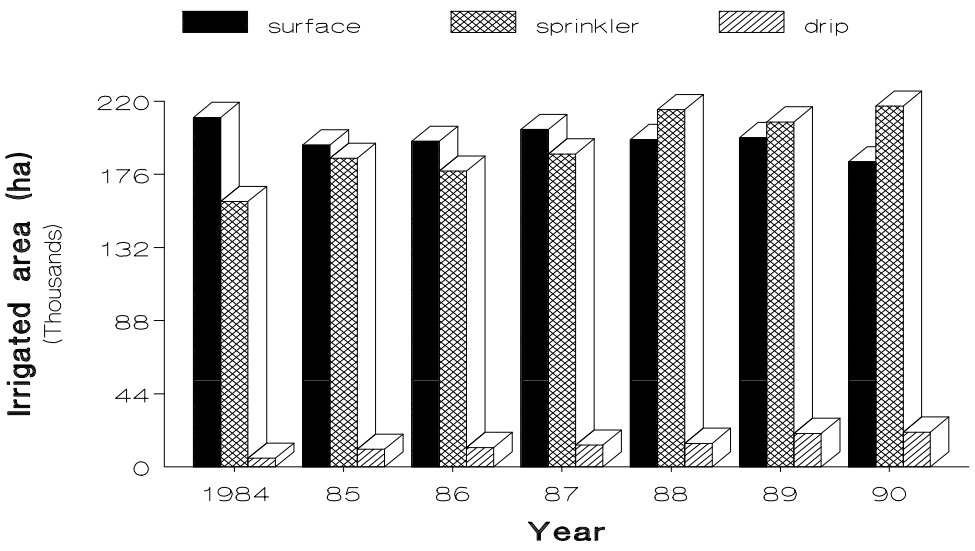

Figure 2 - Change in the area irrigated with various irrigation systems by public irrigation systems
(Source: Ministry of Agriculture, Department of Land Reclamation)

The state of water resources in Greece

The main water resources in Greece include surface waters – such as rivers, natural lakes and water reservoirs – and ground water. The main rivers of Greece originate in mountains located in Bulgaria and the Former Republic of Yugoslavia. They flow through the northern part of Greece and they debouch into the Aegean Sea. These rivers are: the Evros river (550 km) originating in the mountain of Aemos, the Nestos river (234 km) originating in Rodopi and Orvilos mountains, and the Strimon (115 km) and the Aliakmon (285 km) rivers originating in the mountain of Grammos.

The main rivers that have their origin within Greece are the Pinios river (185 km) originating from the mountain of Erymanthus (Peloponessos) and the Evrotas river (80 km) originating in mountain of Taygetus (Peloponessos, Southern Greece). A number of rivers originate in the mountain range of Pindus and debouch

into the Ionian Sea, such as the Kalamas river (99 km), the Louros river (75 km), the Arachthos river (120 km), and the Acheloos river (215 km).

The main natural lakes of Greece are the Pamvotis lake in Ioaninna (depth 23 meters), the Trichonis lake in Akarnania (97 meters), the Prespa lake (Greek part 37 m), and the Kastoria lake (30 m). All of them are located in western Macedonia. The Doirani (Greek part 22 m) and the Tachinou lakes are located in eastern and central Macedonia.

Ground water is present mainly in alluvial plains located along the coast or in the valleys. This water is intensively exploited for irrigation of summer crops with adverse consequences on the soils due to saltwater intrusion.

According to a study for the management of water resources in Greece (YVET 1996), total water consumption in Greece is estimated to be 5.5km^3/year of which 80-84% is consumed by agricultural activities (irrigation), 13-15% is used for domestic (drinking water) purposes and 2.5-4% is consumed by industry and for energy production.

More information on extant studies on water resources in Greece is contained in a study commissioned by the Ministry of Development (ex. Ministry of Industry, Energy and Technology) that has recorded the details of all studies conducted in Greece in the last decades concerning water resources (cited in YVET 1996).

MAIN TYPES OF LAND USE CHANGES

It has been mentioned before that there is a general trend for the conversion of agricultural land, forests and pastures to urban, industrial and tourism uses in Greece. The changes in the uses of land in Greece can be distinguished broadly into qualitative and quantitative. *Qualitative changes* refer to those changes where the dominant, basic category of land use does not change – e.g. cultivated land – but the particular features of this use change. The most prominent case is changes in agricultural land caused by agricultural intensification. The land use classification remains the same but the types of crops and the cultivation and land management techniques have changed – sometimes dramatically – causing important environmental and socio-economic impacts.

Quantitative changes refer to changes from one land use type to another. The most important types of these changes, in an approximate decreasing order of importance, include:

- changes of agricultural land to residential (mostly on the urban fringe), industrial and tourism (especially in coastal areas) uses;
- changes of forest land to agricultural, urban and tourism uses and to pastures;
- changes of pastures to agricultural land as well as to non-agricultural uses;
- changes of agricultural land to pastures and forests (the latter caused by abandonment of agriculture).

Lastly, it should be mentioned that land degradation is a form of land use change that is both qualitative and quantitative in the sense that land, under a given use – usually agricultural, changes in quality – by being degraded – that leads to a quantitative change (decrease) in the amount of land of a given (good) quality. The driving forces behind the land use changes in Greece as well as their impacts on water resources are discussed in the next sections.

DRIVING FORCES OF LAND USE CHANGE IN GREECE

Land use changes are driven by a multitude and variety of factors that cause various impacts on water resources. This section presents briefly the principal driving forces of land use change in Greece focusing on those that relate more closely, to the extent possible, to the concerns of RICAMARE's Activity 1, Task 1; namely, rangeland changes.

For the purposes of a systematic discussion of the driving forces of land use change and their subsequent impacts, a distinction is drawn between ***driving forces*** – macro biophysical and societal forces underlying change and ***proximate causes*** – direct actions causing land use (and environmental) change (e.g. fires, cultivation practices, etc.) (Meyer and Turner 1996). Driving forces and proximate causes can be of bio-physical or of socio-economic origin although these two frequently interact to produce the land use changes observed in the real world. In the following, bio-physical and the socio-economic driving forces and proximate causes of land use change in Greece are discussed.

BIO PHYSICAL FACTORS INFLUENCING LAND USE CHANGE IN GREECE

Among the principal bio-physical factors influencing land use change in Greece are climate, landscape (topography/relief), hydrology (water resources), soil types and the vegetative cover that act not in isolation but interdependently within particular geographical regions and time periods. Greece is characterized by the hydrological regime of the Mediterranean region that exhibits strong seasonal and spatially highly variable precipitation combined with a complex vertical and horizontal configuration of the landscape. The vegetative cover shows a similar pattern of abrupt spatial and temporal changes following the climatic and topographic variations. Under these characteristic hydrological conditions, the annual recharge rate of water resources (by rainfall and water transfer) in the country is not always sufficient to meet contemporary demand for water.

Landscape and especially topography affects the types of land use and the rate of land use change. Rainfed extensive cultivations (cereals, olives, almonds) and pastures are mainly found on sloping areas, while in flat areas irrigated or rainfed crops (vegetables, cotton, corn, pears, apple, vines) are cultivated mainly. Land use change occurs more frequently in flat rather than in sloping areas. This is due to the fact that in sloping areas, restrictions of water availability and soil erosion, do not encourage the conversion of land to other (more profitable) uses as it is the case in flat areas on the plains.

As it known, the amount of soil water available to vegetation is highly related to the infiltration process and, more particularly, to the infiltration rate and the soil water storage capacity. The movement of water within the ground and its distribution are influenced by rainfall intensity, soil characteristics, vegetative cover and, especially, organic matter content. Infiltration and overland flow as well as the processes below the soil surface interact and are influenced by the vegetation and soil characteristics. Such hydrological-soil-vegetative cover interactions markedly affect biomass production and therefore the type of land use. Furthermore, these processes highly affect ground water recharge. In Greece, changes in agricultural land use from sensitive to salt, highly water consuming crops to tolerant, low water consuming crops have taken place because of degradation of soil and irrigation groundwater that have been caused by the following factors: (a) increases in water consumption to meet agricultural, especially irrigation, demand, (b) changes in semi-natural vegetation and the corresponding changes in the consumptive use of water by plants, (c) reduced inputs into the ground water system due to declining rainfall trends; as a result the quality of ground water has declined by intrusion of salty water causing salinization of soils and imposing limitations to the plant growth.

SOCIO-ECONOMIC DRIVING FORCES OF LAND USE CHANGE IN GREECE

The most important driving forces of land use change, however, are the socio-economic factors underlying the decisions to change the uses of land from one type to another. A variety of interdependent and intricately related factors are discussed below that are responsible for the observed land use changes in Greece in the last decades. Overall, these factors generate demand for particular types of land use and various proximate causes trigger the changes from one type to another.

Economic factors

The rising affluence of the population and the improvement of the income situation of larger numbers of households have generated demand for particular activities and the corresponding uses of land. The technological and socio-economic changes that took place after the Second World War in Greece and the resulting economic restructuring have caused massive outmigration of the rural population to countries abroad as well as internal migration to towns and cities in search of job opportunities and higher wages since the 1950s. This movement has generated demand for residential land – especially in the urban fringe. Strong pressures on peri-urban farmland eventually resulted in its conversion to first or second home developments.

The rural to urban movement has caused land use change not only in urban areas but in rural areas as well. Agricultural land abandonment and the related abandonment of the associated complex set of rural activities have spurred the conversion of agricultural land to pastures or forests. Where farmland was located in places experiencing high tourism pressures – such as along the coasts and in islands – farming has been abandoned and

farmland has been converted to tourism accommodation and ancillary facilities. Recently, however, there is a trend towards preservation of the farmland and the development of agro-tourism in rural areas although this taking place and gaining ground in mountainous areas lacking the comparative advantages of coastal areas.

Similarly, the same factors – rising affluence and income – combined with improvements in transportation means and changes in life styles have resulted in the rapid development of tourism and the consequent demand for land for tourism purposes. Tourism development has had other consequences also. The higher wages offered in the tourist sector created new job opportunities for the rural population and exacerbated the abandonment of farmland and of associated activities such as the construction and preservation of terraces in hilly and mountainous areas of the country – especially in the islands – that protected land against erosion. The higher income earned from tourist activities was not invested in the rural areas (for the exploitation of land resources in general) but it was and is invested in the cities where most people working in tourism live in the off-tourist season.

Demographic factors

The demographic changes that occurred in Greece in the post-1950s period account for a variety of land use changes. The rural exodus to the cities and the resulting increase of the population in urban areas contributed to augment the demand for land for housing purposes as well as for a variety of other urban activities – commerce, transportation, recreation, etc. Urbanization, combined with changes in life style and other economic circumstances, increased also the demand for food and, thus, contributed to the intensification of agriculture that was made possible with the parallel changes in technology (farm mechanization, agrochemicals, etc.).

The rural-urban migration deserted the countryside of its inhabitants and brought the rural labor force down to very low levels. The result was the gradual abandonment of agriculture and of traditional methods of cultivation. Moreover, the existence of higher income-earning activities attracted rural workers away from agriculture. Recently, however, a new situation is developing that may have partly resulted in the preservation of agriculture in several areas. Urban dwellers – in particular, those residing close to rural areas – may hold two (or more than one) jobs, the second job being related to rural activities. Pluri-employment of the population is already impacting variously the economy and the uses of land in rural areas. Also, many urban dwellers may reside in villages close to the cities and commute to work in the city. Hence, the rural population may be stabilizing and the decline of the agricultural labor force may be reversing. This latter reversal is reinforced by the influx of large numbers of migrants from foreign countries – Albania, Bulgaria, Romania, Middle East, etc. – who are sources of cheap labor and, frequently, work in farms and related agricultural activities.

Socio-cultural factors

Life style changes have occurred both in urban areas and in the countryside as a result of globalization and the associated technological and other changes. These have reduced demand for certain commodities and increased the demand for certain others and may have reinforced the tendency towards changes from one land use type to another and the intensification of agriculture to meet the additional and new demand for crops. Life style changes have increased demand for particular activities also – like recreation, vacations, tourism, etc. – and, thus, the demand for land to accommodate second homes, tourist and recreational facilities (for example, the demand for golf courses is currently increasing in Greece inducing farmland and rangeland conversion to the new use).

Changes in value systems are, however, the deeper driving forces of changes in the social and economic structure of both urban and rural areas; namely, the rejection of the traditional ways of living and modes of production and the adoption of “modern” habits and modes of production. The material manifestation of these changes is changes in the uses of land that are, generally, in the direction of overexploitation of land and water resources for immediate economic gain. The proximate causes of land use change – fires to convert rangelands and farmland to non-agricultural uses, application of unsuitable technology, etc. – are the result of these deeper changes. This trend is partially counterbalanced by the tendency to return to the countryside and the revival of traditional activities but its effects on land use are yet to be documented.

Technological factors

Technological change has contributed considerably to the changes identified above and have reinforced the trends towards abandonment of agriculture, the traditional methods of land cultivation and the loss of the labor force to non-agricultural occupations. Firstly, mechanization of agriculture has reduced the need for large numbers of farm workers and has facilitated the intensification of agriculture with its concomitant adverse effects on soil and water conditions. Secondly, the development of modern irrigation and drainage systems and of large waterworks (dams, etc.) has facilitated the shift towards more intensive forms of agriculture and the abandonment of the traditional farming techniques. Thirdly, the development of transportation and communication means has eliminated the need for farm workers to live in rural areas and has increased the demand for land for transportation infrastructure. Transportation and communication infrastructure improvements have favored and intensified the rural exodus and, recently, are favoring pluri-employment. The same changes have contributed to the rapid rise in tourism and recreation activities and the associated demand for land.

The introduction of agrochemicals has reduced the risk to agricultural production bringing, among others, qualitative changes in agricultural land use – towards crops with higher market demand and prices. Agrochemicals make it easier also to maintain golf courses that are in high demand recently in tourist areas in Greece. Thus, land use changes away from agricultural and towards non-agricultural activities are facilitated by a broad range of technological factors that influence production and consumption processes in both the cities and the rural areas.

Policy factors

Among the most prominent contemporary driving forces of land use change in Greece are those related to European Union farm subsidies and to other forms of national level policy intervention. Subsidies to farmers have contributed to the maintenance of particular uses of land (e.g. olive groves), to the expansion of others (e.g. olive groves in hilly areas), to the conversion of pastures to farmland (sometimes in marginal areas). The provision of subsidies to cattle raisers has contributed to the increase in the number of animals that have led and are leading to overgrazing without parallel efforts to improve the grazing potential of pastures. Thus, qualitative land use changes – towards degraded pastures – have occurred as a result of subsidies. Subsidies may be also the "hidden" factor behind several forest fires that destroy the forests to produce land for pastures, a phenomenon facilitated by the lax enforcement of current forest legislation. Recently, the revisions of the CAP are introducing different forms of subsidies though – the agri-environmental and other measures – that may have different impacts on land use change.

In addition to subsidies that are direct policy instruments affecting the owners of land, other policies are acting indirectly inducing particular changes of land. Characteristic examples include: (a) the construction of large infrastructural projects – roads, dams, reservoirs, sanitation systems, irrigation systems, etc., (b) tax policies favoring particular occupations, areas (e.g. border regions) and activities, (c) regional development policies creating job opportunities in non-agricultural activities, (d) tourism development incentives. These policies change the range of opportunities offered to various economic activities favoring some of them and discouraging some others. Recently, the trend towards policies that aim to achieve economic development with environmental protection – e.g. agri-environmental regulations, agro-tourism and eco-tourism initiatives, etc. – may induce new types of land use change that may be, hopefully, more beneficial to the environment and to the broader socio-economic structure of affected areas.

Administrative, legislative and institutional factors

A host of other factors are influencing the decisions of the owners of land (both public and private) to convert or modify the use of their land from one type to another among which the administrative, legislative and institutional setting within which economic activities take place are of primary importance. These factors are discussed in greater detail in a subsequent section. Here certain general but important points are noted. The administrative division of Greece does not favor always the exercise of rational land and water resources management. The planning and management of ex-urban space is problematic and, as a consequence, the

management of land and water resources is far from rational. Legislation for the planning and management of ex-urban space in general is weak, missing or inefficiently and ineffectively implemented (or not enforced at all). This is particularly important for the management of water resources as most water and land consuming activities take place in ex-urban space. Finally, the small size of most land parcels and the inheritance system still in effect leads to land fragmentation, the creation of many small landowners who act independently and without any coordination. The result is land use conflicts with their concomitant negative environmental impacts on land and water resources.

IMPACTS OF RANGELAND CHANGES ON WATER RESOURCES IN GREECE

The combined action of the driving forces of land use change in Greece discussed in the previous section and the new patterns of land use that have resulted have caused significant impacts on environmental receptors, water and soil resources being the most important among them. It is important to note that impacts are not always direct but also indirect and induced. Moreover, some impacts occur over the short whereas others occur over the longer term and affect the sustainability of local, regional and national development in more important ways. Finally, impacts on water and soil resources are interdependent and closely related and are usually discussed together.

Agricultural intensification has resulted in soil degradation due to waterlogging, salinization, alkalinization, soil erosion and soil contamination with agrochemicals. Extensive irrigation combined with lack of adequate drainage systems and the use of poor quality of water (caused by sea water intrusion in coastal areas) in areas with high moisture deficits have further aggravated the land degradation problems. About 150,000 hectares in the lowlands, especially along the coast, contain appreciable amounts of soluble salts to such a degree that they need reclamation before any use.

Water resources have been seriously affected by agricultural intensification. Surface waters and coastal areas have suffered and are suffering from significant reductions in quantity and quality. Groundwater is depleted as aquifers are overexploited and used without management plans (haphazard waterlogging by independent users); the water table in many areas has lowered to the point that water is not available for plant growth; freshwater springs “disappear” periodically causing serious problems of water supply for domestic and agricultural purposes in rural areas. These problems are more serious in coastal areas where lowering of the groundwater table causes the gradual intrusion of sea water, both in the upper and lower parts of the aquifers and presents a potential hazard for salinization.

Changes in the types of crops grown – from those with low water requirements to other with higher water requirements for which there is high demand (due to tourism development and changes in life styles and diets) – have increased the demand of water. This demand is difficult to meet, however, due to the adverse impacts of agricultural intensification mentioned on soil and water resources as well as the fact that water demand is high in the summer season when water supply is low (no rain and high temperatures). In addition, the spatial distribution of the demand for water does not always coincide with the spatial distribution of its supply. Water supply is high on the mountainous areas whereas most of the demand is concentrated on the islands and the coastal areas especially during the summer period.

Land abandonment caused by rural outmigration, tourism development and urbanization has aggravated the fragile conditions of the mountainous and hilly areas of the country that were traditionally cultivated using the system of terraces. Terraces protected land from erosion. Their deterioration and collapse produced massive erosion of valuable soil and the formation of skeletal soils. The loss in volume of hilly soils beyond a critical point and under climatic conditions producing large water deficits that largely affect plant productivity drastically reduces the potential for biomass production of any value. The rate of restoration of natural vegetation on sloping degraded land with shallow soils and dry climatic conditions, as it is the case in many parts of Greece, is low. The consequence of such disturbance is increased flooding, landslides and silting up of rivers and dams.

The development of non-agricultural activities had a number of indirect impacts on land and water resources. The high demand for land by these activities (tourism, industry, housing) has pushed the price of land up, the result being the replacement of agricultural by non-agricultural uses. These non-agricultural uses create usually impervious surfaces that affect the infiltration rate of the land surface and its capacity to store rainwater and giving rise, at the same time, to floods. In addition, several of these activities – especially tourism – have

created additional demand for crops especially during the summer season. Hence, agricultural intensification becomes even stronger to meet the increased seasonal demand. As a result of the increased demand for land, water and agricultural products, their prices have increased the consequence being the increase of the cost of agricultural production.

Land use change and land degradation in Greece have several other subtle effects on soil and water resources. As productive and fertile soils become even scarcer, agriculture tends to be concentrated in the remaining areas with rich soils. This reinforcing dynamics aggravates the problem of land degradation because higher inputs are increasingly concentrated in those areas over-loading their land resources and creating further land degradation.

At the same time, old agricultural systems based on human and animal power, serving local or regional needs, cannot survive in areas where uses of land associated with higher wages and increasing job and development expectations compete for land with agriculture. They are therefore, replaced by more capital and energy intensive systems and uses of land that are dependent on national and international markets and, thus, more subject to the volatility and uncertainty of international economic developments.

Finally, a characteristic of all impacts identified above is that several of them can be attributed to the fact that the spatial and temporal distribution of demand for water by the various activities do not coincide frequently with the spatial and temporal distribution of the supply of water and land resources in the country. This spatio-temporal incompatibility between demand and supply gives rise to land use conflicts and their concomitant impacts.

WATER RESOURCES, RANGELAND AND AGRICULTURAL LAND MANAGEMENT IN GREECE

This section first provides a brief overview of the main pieces of legislation and of selected policy measures that concern the management of water resources as well as the management of rangelands and agricultural land that are in effect and/or have been implemented in Greece. Secondly, it outlines selected adaptive and mitigation measures that are promoted to protect water resources from the detrimental impacts of land use changes (including) rangeland and other in the country.

General legislation and policy measures

The basic pieces of legislation that concern all three subjects of the present discussion – water resources, rangelands and agricultural land – are Article 24 of the Greek Constitution of 1975 and Law L.1650/86.

Article 24 of the Greek Constitution of 1975 is considered the first piece of general legislation on environmental protection in the country. This article defines the term “environment” clearly to include both natural and manmade elements and processes. It states that it is the responsibility of the Greek state to protect the environment for the public good as well as to take counter measures against degradation of the environment. In this sense, all actions that impact negatively on environmental resources and media should be mitigated or avoided to safeguard the environment and comply with this constitutional imperative. Moreover, Article 117 of the Greek Constitution of 1975 defines the obligation of the state to take actions for the reforestation of all the public and private forests that they have been deforested or burned.

Law L.1650/1986 constitutes the broad legal framework for the protection of the environment in Greece. It is based on the premise that man should live in a high quality environment that should be protected from the negative impacts of human activities. This law covers issues of protection of all environmental media and resources and provides precise definitions of the relevant terms: environment, pollution, contamination, degradation, wastes, and ecosystems. It suggests that land use should be based on the physical properties of the soil and their potential for crop production and provides that necessary measures should be taken for soil protection. It includes measures for the protection of surface and ground waters that are considered both as natural resources as well as ecosystems. The law suggests that measures for the conservation of nature and of landscapes of high ecological and aesthetic importance should be established. It supports efforts to increase the interest of the citizens in the protection of the environment by means of education and information through the mass media. To implement the provisions of L. 1650/86, presidential decrees and ministerial decisions are

issued. This process accounts greatly for the delays observed in the implementation of a variety of environmental protection measures.

A last piece of general legislation that should be mentioned is the Common Ministerial Decision 69269/5387/1990 that has been issued in order to harmonize Greek environmental legislation with European Union legislation concerning the requirement for Environmental Impact Assessments of major development projects. A number of other pieces of European Union legislation have been introduced in the Greek environmental legislation under the country's obligation to harmonize her legislation with that of the European Union.

WATER RESOURCES LEGISLATION, POLICY MEASURES AND MANAGEMENT

Circa 300 legal arrangements exist, dating since 1930, that refer in one way or another to issues related to research, exploitation, use and protection of water resources in Greece. These arrangements include founding laws, laws, decrees, administrative decisions, organizations of ministries and other agencies. Frequently, these legal arrangements have serious overlaps or are in conflict among them. The main features of these legal arrangements are the following:

- the agencies that have issued them try to advance their own positions;
- sectoral and, consequently, fragmented treatment of the problems;
- their irrelevance to the nature of contemporary problems because some of them are obsolete;
- lack of coordinated plans and programs for the collection and evaluation of field data that are essential for their implementation;
- lack of provisions for monitoring and customisation of their application;
- lack of connection and harmonization to the development goals of the productive sectors and regions of the country;
- delay in meeting the obligations related to the application of European Community directives.

From the total legislative work available, two are the most important pieces of legislation: the provisions of the law L.1650/86 mentioned before and Law L.1739/87 that concerns the management of water resources. These pieces are complementary and both are distinct for their intersectoral outlook and the integrated approach they adopt for the management of water resources.

Law L.1739/87 is the only law that links water resources management to development planning in the country. This law and the accompanying legislative acts that are provided for its implementation establishes the instruments and the procedures that will permit the management of water resources at the regional and the national level. According to this law, management of water resources is the sum of all works and activities that are necessary to meet completely all needs for water by every use. The main purpose of management is to cope with the problems of inadequate provision of water, of conflicting and competing uses as well as of the maintenance of high quality water according to its use now and in the future. In parallel, the management of water resources aims to orient demand for water towards uses that are included in the development plans of the country, as well as towards the rational development of activities that concern research, exploitation and protection of water resources.

The basic provisions of Law L.1739/87 for the achievement of its goals are the following according to type of activity.

Administrative structure for the management of water resources

- the division of the country into 14 water departments is legislated; these are regions that are divided by watersheds or they are island regions and they include integrated hydrographic networks that sharing similar hydrologic-hydrogeologic conditions;
- the Ministry of Development (ex. Ministry of Industry, Research and Technology) is responsible for the management of natural resources; it has central headquarters as well as a system of 14 regional offices that correspond to the 14 water departments;

- decision making units are constituted for taking decisions on important issues; these are: the Interministerial Water Committee at the national level and the 14 regional Water Committees at the regional level;
- competent authorities for the management of water resources for each use are defined as well as competent agencies for water resources research.

Planning the development of water resources

- long-term, medium-term and short-term programs are provided at the national and the regional (water department) level;
- the principal instrument of the water management authorities in their coordinating role with respect to the activities of research, exploitation, use and protection of the water resources of the country is the programming process and the monitoring of the implementation of the programs and plans at the national and the regional level;
- the basis of the above-mentioned process is a water demand and supply balance sheet that is based on the existing conditions of water resources and predicts as well as prescribes their future development. To secure the requisite knowledge for the development of this balance sheet, the organization of a central archive of hydrological data and information at the Ministry of Development is planned (and partly implemented); in parallel, a permitting system for water use rights is legislated.

Regulations to influence water demand and support the programming process such as

- water is legally considered as a means to satisfy public needs;
- the water use right is determined as the maximum limit of the real necessary quantities of suitable water, quality for every use, while the remaining water is provided by the competent services for other purposes;
- water is priced according to its use and the option to set its cost is provided.

Regulations that concern protection of water resources

- the binding of a certain quantity of water for the protection and conservation of the environment is defined as one of the uses of water;
- necessary restrictions on water use are imposed when this is considered necessary for their protection;
- the determination of the minimum maintenance capacity of water in rivers and the minimum level of the water table in lakes are provided,
- activities that impact on water resources are subject to control.

It is noted that the above Law is not fully implemented yet. Its implementation meets several difficulties that are due to the extant administrative structure for the management of water resources in Greece. According to YVET (1996), the administrative division of the country did not provide for criteria that are related to the management of water resources. More specifically, the problems related to the current administrative division of the country as regards the management of water resources are the following:

- the division of the country into administrative departments (regions) on the basis of criteria that are not related to those corresponding to water-related issues (watersheds). The result is the inability to express various quantities in water-related spatial units;
- the compartmentalization of competencies related to the various uses of water resources among many public agencies;
- the difficulty of coordinating the actions of the many agencies involved especially when competition for the use of water exists at the national, regional and the local level.

In addition to the main Law L.1739/87, a number of other legislative arrangements exist that concern various aspects of water resources. These are found in the context of the following groups of legal provisions:

- use for drinking water;
- agricultural use;
- protection of water resources;
- international running waters;

- urban Legal Code.

Moreover, a number of European Community directives concerning various aspects of water resources have been adapted/incorporated in the Greek legislation (the latter are those concerning the drinking water and nitrate pollution directives).

As mentioned before, responsibility for various management issues related to water resources in Greece lies with several Ministries and other agencies. The agencies involved are the following:

- *Ministries of:*

- *Foreign Affairs* (transboundary water resources, international organizations),
- *National Defence* (National Meteorological Service),
- *Public Administration and Decentralization* (general and water supply, water disposal),
- *Development* (water resources management agency, industry, energy – small hydroelectric works, tourism – thermal waters, research-technology, commerce-bottling),
- *Agriculture* (according to Law L.402/1988, the Directorate of Environmental Protection of the Ministry of Agriculture is responsible for the management and protection of soil and water resources in agricultural use – agriculture, forestry, cattle raising, fisheries),
- *Environment, Planning and Public Works* (agency for the design and construction of large public works for water supply, disposal, irrigation and responsible for water quality protection),
- *Public Health* (drinking water safety).

- *Organizations – Institutions – Research Centers*

- Public Utility Corporation (hydroelectric power, refrigeration, electric trains),
- Institute for Geological and Mineralogical Research,
- Water Supply and Disposal Companies of 75 towns,
- National Observatory of Athens (meteorology),
- National Center for Marine Research (water resources research),
- Greek Bank of Industrial Development (water supply of industrial areas, thermal waters),
- National Center of Research in Physics "Demokritos",
- National Center for Agricultural Research,
- IDE.

- Universities (various departments)

Finally, a number of water resources-related projects have been carried out to serve various purposes. Fourteen large water dams have been constructed along major rivers for electricity production and irrigation. The total water storage capacity of these dams is 9,551 millions m^3. The storage capacity of each dam is as follows: Kremasta 4,495 millions m^3, Kastraki 785 millions m^3, Polyphitou 1,939 millions m^3, Tauvropou 300 millions m^3, Pournari I 730 millions m^3, Sphikias 99 millions m^3, Stratos 80 millions m^3, Piges Aoou 214 millions m^3, Louros 1 million m^3, Ladonas 46 millions m^3, Asomaton 80 millions m^3, Thisauros 705 millions m^3, Platanovrysi 73 millions m^3 and Pournari II 4 millions m^3. The last three dams are under construction.

Thirteen dams of a total storage capacity of 38.74 millions m^3 have been constructed or are under construction for irrigation purposes only. The dams of Yliki, Marathon, Mornos and Evinos (under construction) with a total storage capacity of about 850 millions m^3 are mainly used to meet water demand in the region of Attica.

To meet the high water requirements, especially in the islands, multiple use water reservoirs (irrigation and domestic water supply) have been constructed or are under construction currently. According to the Department of Land Reclamation of the Ministry of Agriculture, the following projects had been undertaken until 1995:

- reconnaissance studies of 120 sites for the construction of water reservoirs or small dams in Crete, Evia and in 50 islands of the Aegean and Ionian seas.;
- detailed studies of 108 sites, 68 of which concern water reservoirs and 40 concern small dams with a total storage capacity of 156,000,000 m^3;
- construction of 8 water reservoirs or small dams with a total storage capacity of 6,192,000 m^3; another 26 reservoirs are under construction;
- transfer and storage of the Zourmpou springs for irrigation and domestic consumption.

The water stored in the above mentioned water reservoirs or small dams will be used for the irrigation of about 5,500 ha of land as well as to meet the water consumption needs of 25,000 persons in the islands.

Rangeland management

The management of rangelands – as defined in the context of Task 1, Activity 1 of RICAMARE – in Greece is governed by the general pieces of legislation mentioned in Section 5.1 above as well as by special legislation concerning forests and pastures. These resources are under the responsibility of the Ministry of Agriculture mostly (General Directorate of Natural Resources) mostly.

Representative laws that provide for the protection and management of rangelands are: (a) L.360/1976 – for the conservation of the natural environment and its protection against degradation resulting from human activities, (b) L. 998/79 – the basic legislative framework for forest protection, (c) L.1032/1979 – for the protection, improvement and development of forested areas, (d) L.1734/1987 that concerns the management of grazing lands where the term «grazing land» includes areas with annual or shrubby vegetation that can be used for feeding wild or domesticated animals. This latter law was followed by more specific regulations that concern the separate management of forests and grazing lands. It should be noted that, as it is the case with other pieces of legislation, several of the laws mentioned before are difficult to implement because the required legislative instruments and processes are difficult to pass and enforce.

A number of legal provisions that have been adopted to adapt national legislation to European Union's legislation as well as the application of several EU level policies are affecting rangeland management such as NATURA 2000, INTERREG, ENVIREG, etc.

Agricultural land management

A significant number of policies have been adopted at the national and European Union level that concern the management of agricultural resources. Traditionally, the focus of national interventions was on irrigation and drainage schemes – mainly, the institutional and administrative structure for the management of these works, their financing, planning and implementation – and on land reclamation schemes. Since 1981, when the country became a member state of the European Union, the Common Agricultural Policy went into effect and its provisions were implemented – such as agricultural product price and income support systems (subsidies), restructuring of land uses, early retirement schemes for farmers, support measures for young farmers, etc.

Greek agriculture has been and is affected greatly by European Union policies. According to Commission's Regulation 797/85, Article 19, member states are explicitly permitted to introduce their own national aid schemes for supporting farming practices that preserve or improve the environment. Regulation 1760/87 of the European Union encouraged member states to define areas of "sympathetic" agricultural practices. The member states were able to claim a quarter of the cost of such schemes up to a limit of 100 ECU per hectare. 319 million ECUs were allocated to protect soil from erosion, to biotope management and to selective afforestation. In the decade 1982-92, the strategy was progressively modified to allow greater support for the conservation of the landscape and its component parts.

The Maastricht Treaty (1992) recognized that the European Union must promote measures at the international level to deal with environmental problems and ensure "sustainable growth respecting the environment". For the coming years, it is planned to put 15% of the land cultivated with crops such as cereals and sugar beets in fallow (the farmers have to exclude 15% of their land from any cultivation). Extending the fallow land could mean an improvement of soil fertility and its protection from erosion.

Other policies impacting on water resources and their management

In addition to the policies mentioned in the previous sections, various other policies impact in one way or another, on water resources and influence their management whose discussion is beyond the limits of the present report. These are sectoral policies in the areas of energy production and use, infrastructure development, industrial development, tourism development, regional development, rural development, water supply and sewage disposal, environmental protection, research (on surface and groundwater resources) and monitoring and information management.

The use, exploitation and management of water resources in Greece is influenced greatly also by the development priorities and related actions of the Second and Third Community Framework Programmes for the 1994-99 and 2000-2006 periods respectively. These Programmes constitute basic intervention instruments for

the social and economic development of the country, the achievement of convergence of the country's basic economic and social conditions to those of the European Community's averages, the resolution of regional problems, and the reinforcement of the role of the country in the Balkans and the Mediterranean region. The development priorities of these Community Framework Programmes distinguish five main axes of intervention: (a) investments in large infrastructure works, (b) improvement of the conditions of quality of life, (c) development and competitiveness of the economy, (d) development and utilization of human resources and (e) reduction of regional inequalities and of the isolation of the islands. A number of development plans and related works have been implemented or are in the design phase to achieve the goals of the above development axes that are expected to have significant direct and indirect (by inducing socio-economic and land use changes) impacts on the water resources of the country (YVET 1996).

Adaptive and mitigation measurs to protect water resources against the detrimental impact of rangeland changes in Greece

The extension services of the Ministry of Agriculture offer advisory services on issues related to soil erosion and environmental protection. For example, farmers are advised to construct dams or small water reservoirs along waterways in hilly areas for irrigation purposes as well as for protecting the land from erosion and flooding of the lowland and for the conservation of ground water by increasing soil infiltration. This effort is especially important on the islands that face serious problems of erosion and water shortage.

Conservation tillage is recommended also in order to reduce drastically rill and inter-rill erosion in hilly areas cultivated with rainfed cereals. The incorporation of plant residues into the soil after harvesting is proposed in order to increase the organic matter content and aggregate stability and to protect soil from erosion. Farmers usually prefer to burn the wheat, corn or cotton residues rather than to incorporate them into the soil. This type of management drastically reduces the organic matter content and aggregate stability of the soil.

Contour farming is recommended in large areas cultivated with winter crops. Farmers used to cultivate crops in straight rows uphill and downhill or in oblique lines. This type of cultivation was preferred for security reasons and because of the small size of the fields belonging to each farmer. However, this type of ploughing has led to accelerated soil erosion and deposition in the low-lying areas. Although contouring may be an attractive economic alternative for land protection, it cannot alone control erosion.

Terracing is proposed as an alternative for water conservation and soil erosion control. It is a very old practice, actually, that has been used for centuries. Many upland areas have been terraced for the cultivation of cereals, vines, olives and other crops throughout the country. In many cases, terraces constructed with stones are some hundred or even thousand years old. In the last decades, the value of such terraces has declined markedly due to their difficult access and because they cannot be easily cultivated with tractors. At present, most of these terraced areas have been abandoned and the terraces have collapsed allowing rapid removal of the soil by the runoff water, apart from some cases where the stone walls are protected by the roots of fast growing shrubs and trees. Maintaining such terraces appears to be a very expensive practice compared to most other alternatives for the control of soil erosion. Considering that such terraces protect very valuable soil that preserves the natural vegetation, these agricultural structures should be maintained with the aid of the national consolidation schemes particularly in the environmentally sensitive areas.

CONCLUSIONS – PRINCIPAL RESEARCH AND DATA NEEDS TO SUPPORT WATER RESOURCES POLICY MAKING AND PLANNING IN RELATION TO RANGELAND CHANGES IN GREECE

The effort undertaken for the purposes of this report to provide an account of the state of research on the impacts of rangeland changes on water resources in Greece revealed the serious problems that exist with respect to finding the requisite information on the subject in Greece. However, looking beneath these conspicuous problems, other dimensions of the problems are revealed; namely, the low priority given to the topic to date and, thus, the need to improve this situation given the importance of land use changes in causing environmental

change – among which rangeland changes and their impacts on water resources hold a prominent position in the Mediterranean region. This section proposes, therefore, certain steps towards two directions:

- compiling and disseminating the requisite information;
- organizing research on the subject.

To study the subject of rangeland changes and their impacts on water resources, information is needed on the following main thematic areas: (a) rangelands, (b) rangeland changes and (c) water resources. The authors' experience shows that relevant information may exist but it is dispersed in various public and private agencies and individuals currently. To compile existing information and data and to identify additional data and information needs, it is necessary to commission a special study towards this purpose. This study will aim at:

- identifying the relevant organizations and individuals working on these subjects;

locating, codifying and classifying all studies (research, projects, data collection, etc.) commissioned by various public and private organizations and conducted thus far in these thematic areas;

- identifying the basic categories of data that are provided in these studies – such as environmental, social, demographic, economic, institutional, legal, etc.;
- identifying the data needs for a comprehensive study of the subject and suggesting the requisite actions;
- proposing the organization of a data centre that will undertake and supervise the task of compiling, coordinating and disseminating existing and new information and data on the subject taking into account the needs of researchers and users.

It should be noted that a broader initiative on hydrological and meteorological data management is underway in Greece currently. More specifically, a consortium of participating organizations has established a National Data Bank of Hydrological and Meteorological Information (NDBHMI) with the broad purpose of providing the necessary technological infrastructure to support policy making on the management of water resources in the country. The consortium includes: the Ministry of Environment, Planning and Public Works, the national meteorological Service of Greece, the Public Power Corporation, the Ministry of Agriculture, the Ministry of Development and the National Observatory of Greece. The core of the project is a Data Base containing inputs of hydrological, meteorological and hydrogeological data covering the entire country acquired from the archives of the participating organizations and dating since 1895. The Data Base is linked with software applications for the analysis and synthesis of the data and the processing of secondary information. The volume of information of the Data Base is spatially distributed over the country with the use of a Geographical Information System (GIS). In parallel with these activities, several others are implemented such as: the establishment of a pilot Telemetric Station Network, the study of a National Station Network, the training and technical support of the staff in the participating organizations, and the evolution study of the NDBHMI (NDBHMI 2000).

The second direction concerns organizing research on the subject of rangeland changes and their impacts on water resources. This is a necessary activity that should run in parallel with the previous task as the data needs of researchers and research result users should inform and provide directions for the organization, collection and management of the necessary data and information. As it was mentioned in the introduction, research on the subject of land use change in general is not systematic and existing research efforts are not systematically recorded. The same is true for the particular theme of rangeland changes as well as for research on water resources. It is, thus, necessary to establish a systematic framework for coordinated research on both subjects to economize on resources and provide useful input to the integrated management of land and water resources.

Research should focus on the following main aspects of the subject: (a) bio-physical and socio-economic driving forces in specific spatial units and time frames; (b) physical impacts (e.g. changes in hydrogeomorpholical characteristics triggering changes in water resources), (c) ecological and environmental impacts, (d) social and economic impacts, (e) policy, planning and management with an emphasis on integrated approaches adapted to local conditions (e.g. islands, coasts, mainland, etc.). Funding research on this subject *explicitly* may provide a good starting point for developing a research tradition in this direction that will support both data and information management as well as policy making and planning for the rational use of water and land resources. ◆

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Appendix A: Case studies and research projects related to driving forces and impacts of rangeland changes in Greece

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Miglietta, Francesco, 1999. Carbon and water fluxes of Mediterranean forests and impacts of land use/cover changes. EC, DG XII, 4th FWP (Fourth Framework Programme). ENV4970455.

Moreno, José Manuel. 2000. Land use change interactions with fire in Mediterranean Landscapes (LUCIFER). EC, DG XII, 4th FWP (Fourth Framework Programme). ENV4960320. (East and West Mediterranean, Greece)

Natural Environment Research Council, 1997. Impact of climate change on hydrological regimes and water resources in the European Community. EC, DG XII, 3rd FWP (Third Framework Programme). EV5V0293 (Alicromon basin in Greece).

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Appendix B: List of institutions and researchers involved in water resources research

Ministries of:
Foreign Affairs (transboundary water resources, international organizations)
National Defence (National Meteorological Service)
Public Administration and Decentralization (general and water supply, water disposal)
Development (water resources management agency, industry, energy – small hydroelectric works, tourism – thermal waters, research-technology, commerce-bottling)
Agriculture (according to Law L.402/1988, the Directorate of Environmental Protection of the Ministry of Agriculture is responsible for the management and protection of soil and water resources in agricultural use – agriculture, forestry, cattle raising, fisheries)
Environment, Planning and Public Works (agency for the design and construction of large public works for water supply, disposal, irrigation and responsible for water quality protection)
Public Health (drinking water safety)

Organizations – Institutions – Research Centers
Public Utility Corporation (hydroelectric power, refrigeration, electric trains)
Institute for Geological and Mineralogical Research
Water Supply and Disposal Companies of 75 towns
National Observatory of Athens (meteorology)
National Center for Marine Research (water resources research)
Greek Bank of Industrial Development (water supply of industrial areas, thermal waters)
National Center of Research in Physics "Demokritos"
National Center for Agricultural Research
IDE
Center for Planning and Research (KEPE – socio-economic)

University Departments (selected)

Civil (and Hydraulic) Engineering
Biology/Ecology
Forest Sciences
Plant Sciences
Environmental Engineering
Geology (Physical Geography, Meteorology)