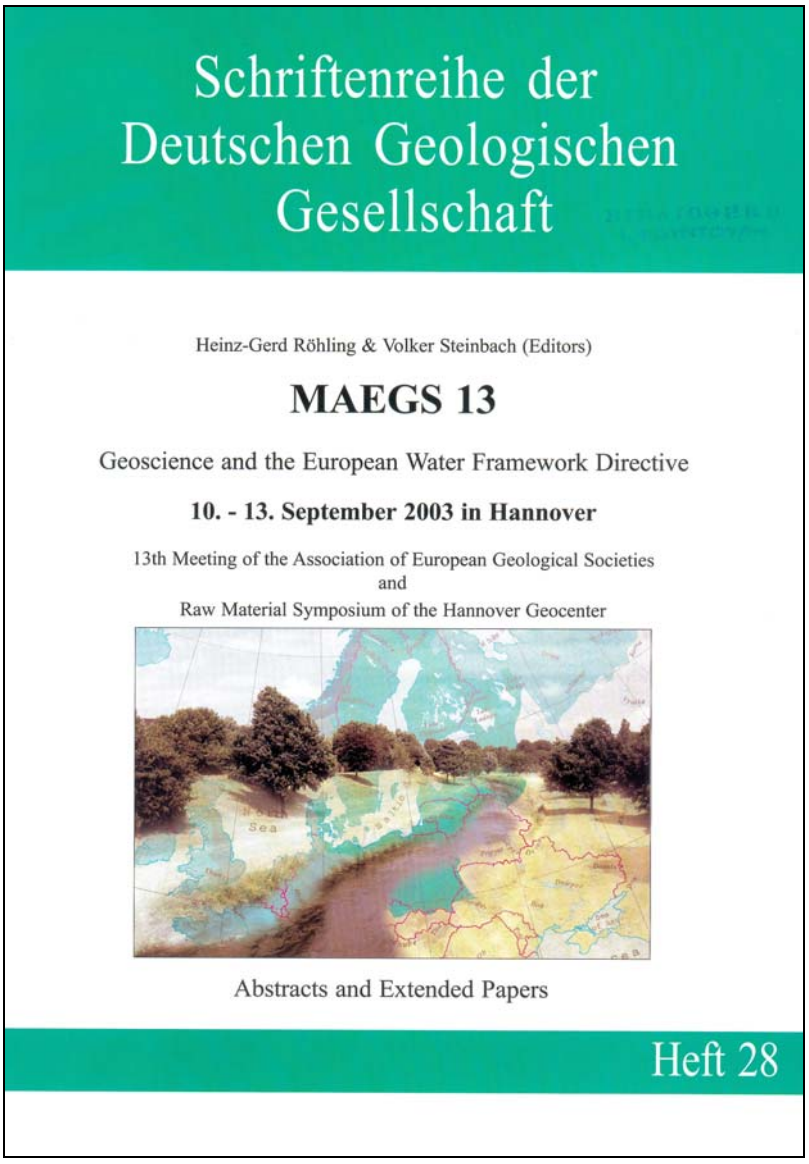
ΔΗΜΟΣΙΕΥΣΗ No 91



MARIOLAKOS, I., FOUNTOULIS, I., SPYRIDONOS, E., ANDREADAKIS, EMM., KAPOURANI, E. & VOULOUMANOS, N. (2003). – Application of a multi-parametric research methodology in water resources management on a municipal scale – The case of the Municipality of Therapnes (Laconia Prefecture, Greece). *In: Roehling & Steinbach (Eds.): MAEGS 13, Geoscience and the European Water Framework Directory, 10-13 September in Hannover, 13th Meeting of the Assotiation of European Geological Societies and Raw Material Symposium of the Hannover Geocenter, Schriftenreihe Deutsche Geologische Gesellschaft*, Heft **28**; 68-74.

In: Roehling & Steinbach (Eds.): MAEGS 13, Geoscience and the European Water Framework Directory, 10-13 September in Hannover, 13th Meeting of the Assotiation of European Geological Societies and Raw Material Symposium of the Hannover Geocenter, Schriftenreihe Deutsche Geologische Gesellschaft, Heft **28**; 68-74.

Application of a multi-parametric research methodology in water resources management on a municipal scale – The case of the Municipality of Therapnes (Laconia Prefecture, Greece)

[1]Mariolakos, I., [1]Fountoulis, I., [1]Spyridonos, E., [1]Andreadakis, Em.,
[1]Kapourani, E., [1]Vouloumanos, N.
Univ. of Athens, Fac. of Geosciences, Dep. Dyn., Tect., Appl. Geology, Panepistimioupolis 15784, Athens, Greece

1. TEMPORAL AND SPATIAL ANALYSIS OF WATER NEEDS

Water needs of Therapnes Municipality were calculated on the basis of data provided by the city council and the National Statistical Service of Greece. The calculations included water needs by category on a daily, monthly, seasonal and annual basis, as much as geographical distribution of needs by category of use, so that the municipal authorities are handed over with a complete estimation of **how much**, **when**, **where** and **what quality** of water is needed.

The study took into account:

- Population data and long term and seasonal fluctuations.
- Land use data.
- Cultivation and cattle breeding categories.
- Actions planned by the city council for the development of the area (i.e. alternative tourism, herb cultivation).
- Active regulations concerning limits of water usage by category and commonly accepted estimations for consumption by category.
- Water needs by manufacturing units in the area (mostly concerning olive oil production and olive processing and packaging).
- The efficiency of irrigation methods by type.

The data analysis and processing lead to the following results for the water needs of Therapnes Municipality:

- The annual water needs of the municipal area rise to a maximum (if all agricultural land is cultivated and systematically irrigated) total of 35.5 million m^3.
- The annual needs of human consumption (drinking) water are 335 thousand m^3 (920m^3/day).
- The annual irrigation water needs are 35 million m^3 (including the planned herb cultivation).
- The daily irrigation water needs during the dry period (April through September) amount to a maximum total of 192.5 thousand m^3.

The spatial analysis of these data in GIS (Figures 1,2) shows a comprehensive view of the water needs characteristics in the municipal area, once the development profile of the area is evidently affecting the picture, as much as the interaction with all neighbouring areas, which have also been taken into account for the reliable extrapolation of spatial data.

The agricultural identity of the area is expressed in all results, once the water needs of the area are mainly due to irrigation (98-99%) (Figure 3), and located at the central – southwest part of the municipality (Chrissafa – Goritsa – Ag. Anargyroi area), and mainly during the dry period (Figure 4).

2. WATER BODIES OF THE AREA

A prerequisite in realizing management programs is the assessment of the overall capacity of the groundwater system under study. In this direction, the research had to outline the hydro-meteorological setting and combine that with the hydrogeological setting of the area. This means that precipitation, evaporization, drainage and infiltration features had to be calculated and applied

to the distinctive geological formations that outcrop in the area, in order to make an estimation of the expected mean annual recharge of the aquifers. Hydro-meteorological data coming from all available sources and concerning the whole river basin of Evrotas were taken into account, so that a conservative value of the mean annual precipitation and its relation to the altitude of the area were calculated for the municipal area (613mm). The municipal area accepts annually a total volume of precipitation of more than 158 million m^3, while the karstic aquifers (58% of the area) accept at least 22 million m^3 through infiltration during the wet period, and other, less capable aquifers, develop in the porous formations that cover 35% of the municipal area (estimated annual income through infiltration during wet period: 5 million m^3). The porous aquifers along Evrotas River are expected to gain some extra recharge from the river.

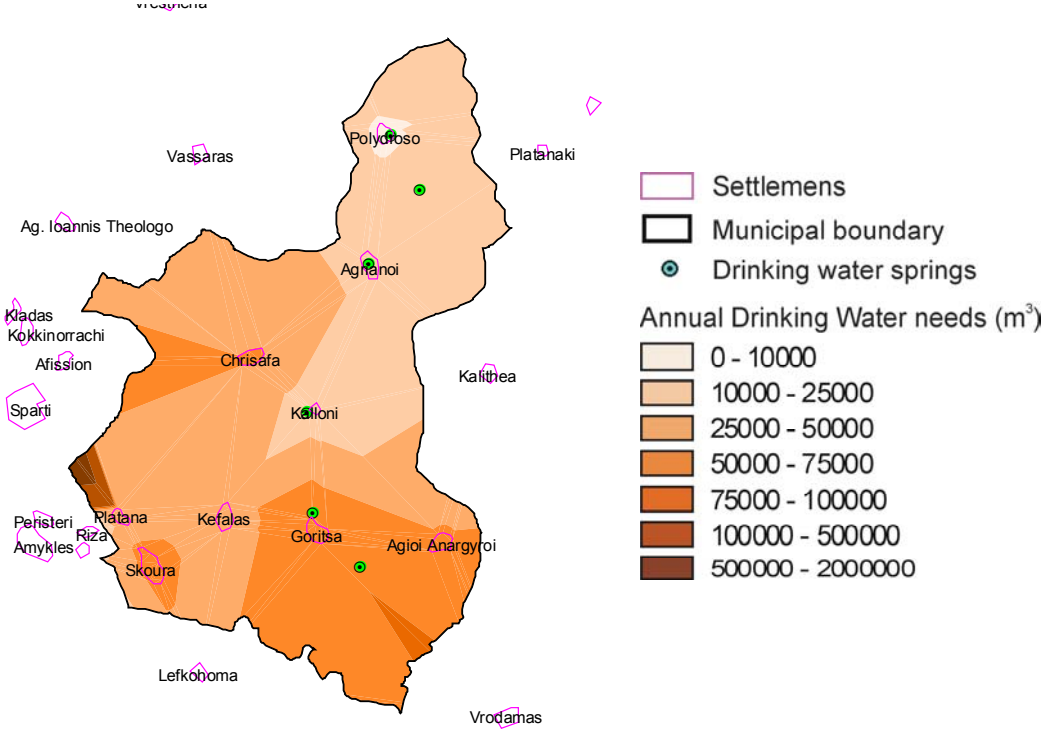


FIGURE 1. Spatial distribution of the annual drinking water needs within the boundaries of Therapnes Municipality based on the population statistics of 2001. Extrapolation has taken into account the water needs of all surrounding settlements, external to the municipality.

In order to identify the geometry and the attributes of the aquifers developing in the area, geological and tectonic data were combined with all available information concerning data from wells exploiting the aquifers, spring discharge, physical attributes of water, that could help distinguish water bodies (i.e. water level, yield, electrical conductivity, depth of drilling, elevation of springs etc). In this way, the geological map (Figure 5) was transformed into a three-dimensional model of the aquifers of the area (Figure 6), so that further spatial, temporal and numerical calculations on water quality and quantity could be applied to the distinctive water bodies more accurately. As shown in Figure 5, two major types of karstic limestone occur in the area, that is, Tripolis limestone, tectonically overburden to Mani limestone, with a clastic (partly or non permeable) series (either Mani flysch or Tripolis clastic basement) in between. Tripolis limestone forms relatively shallow aquifers, discharging mainly through springs (which are the major drinking water suppliers for the municipality) at the central and higher (east-northeast) part of the area. Mani limestone forms mainly deep karsic aquifers that are exploited through wells with a depth of several tenths and, more often, hundreds of meters. Moreover, neotectonic faults controlling the boundary between the graben of Sparti (west-southwest) and Parnonas mountain (east-northeast) have disturbed the original relation between the two types of limestone. Thus, the originally isolated karstic formations of the two units are in many areas in direct contact through faults. In this way, it is expected that a percentage of the Tripolis karstic groundwater escapes to the Mani aquifers, adding extra quantities to the direct recharge through their outcrops. The

stratigraphic and tectonic boundaries restricting the aquifers of the area, have hence been used as barriers to the spatial analysis of features attributed to each aquifer, such as yield of aquifer in wells, physical and chemical attributes of water, and pollution pressure (Figures 7, 8). It has to be pointed out that unless this procedure is followed, so that the hydrogeological setting is cleared, spatial statistics are non-realistic and cannot be reliably based upon. Further more, management scenarios involving exploitation, restoration or degradation of water resources can only be realistic if water bodies are thoroughly studied and described, so that the impact of each changing factor upon them can be estimated individually, and only after that, on the whole system, taking into account the interrelations between them.

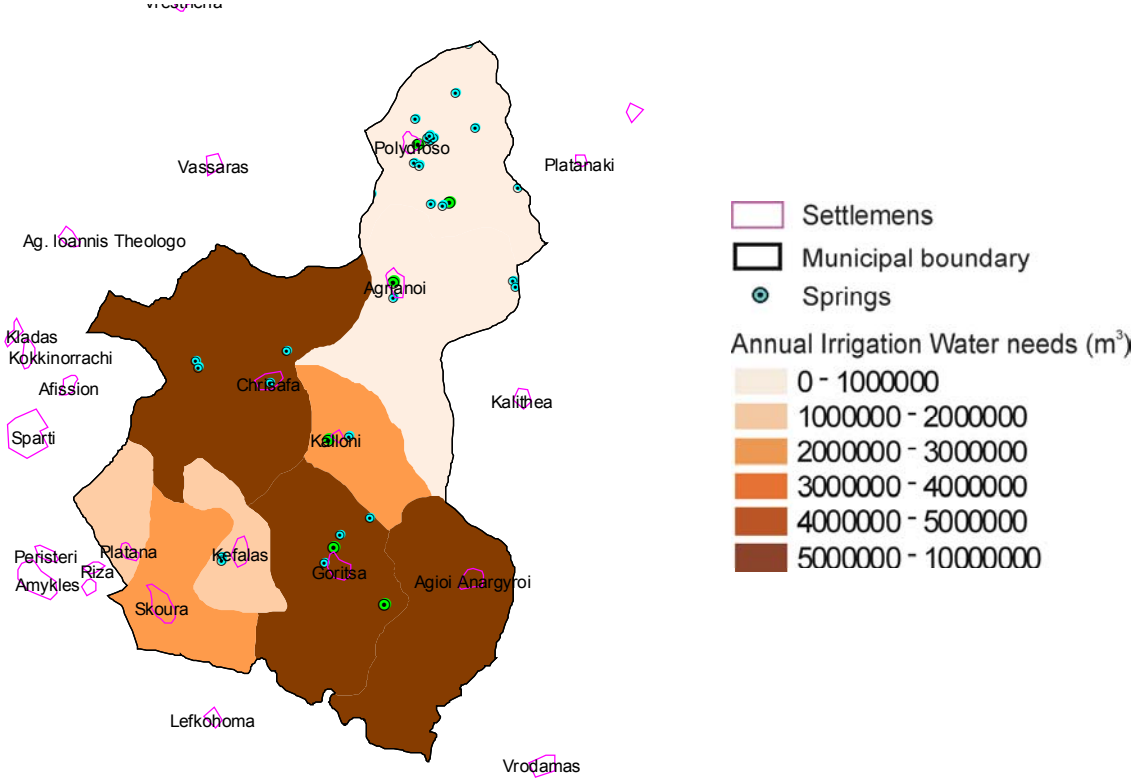


FIGURE 2. Spatial distribution of the annual irrigation water needs within the boundaries of Therapnes Municipality based on the land use statistics of 1991, by commune.

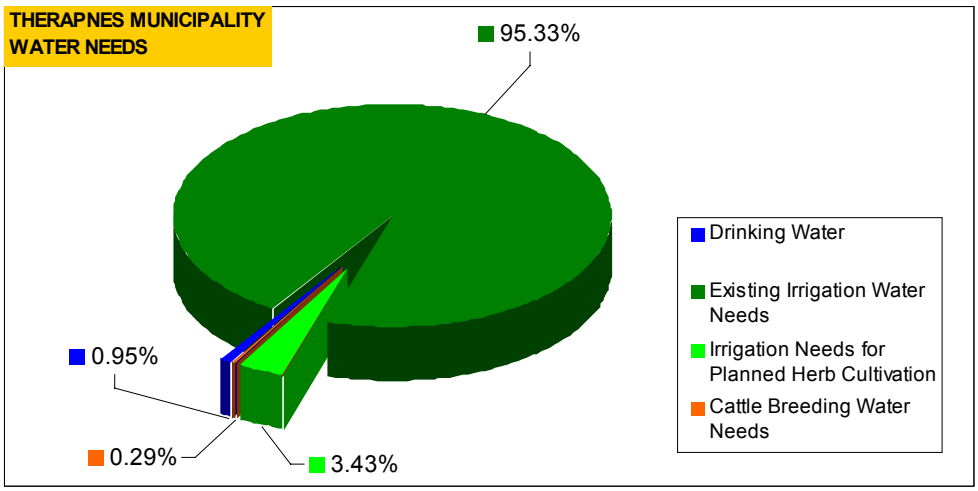


FIGURE 3. Annual water needs of Therapnes Municipality by type of use.

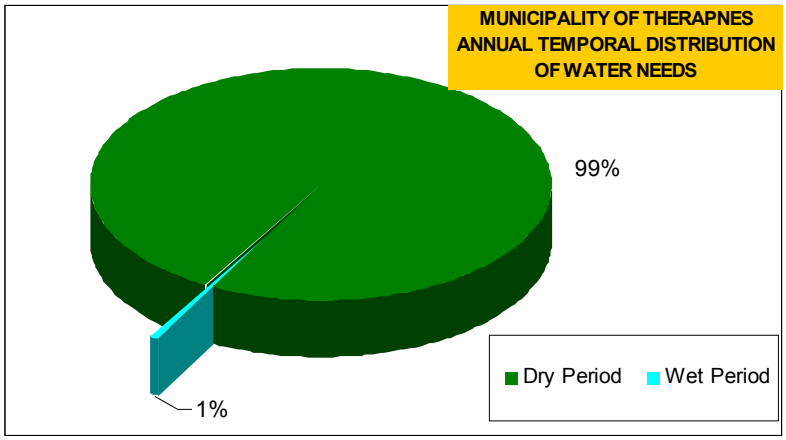


FIGURE 4. Annual temporal distribution of water needs of Therapnes Municipality.

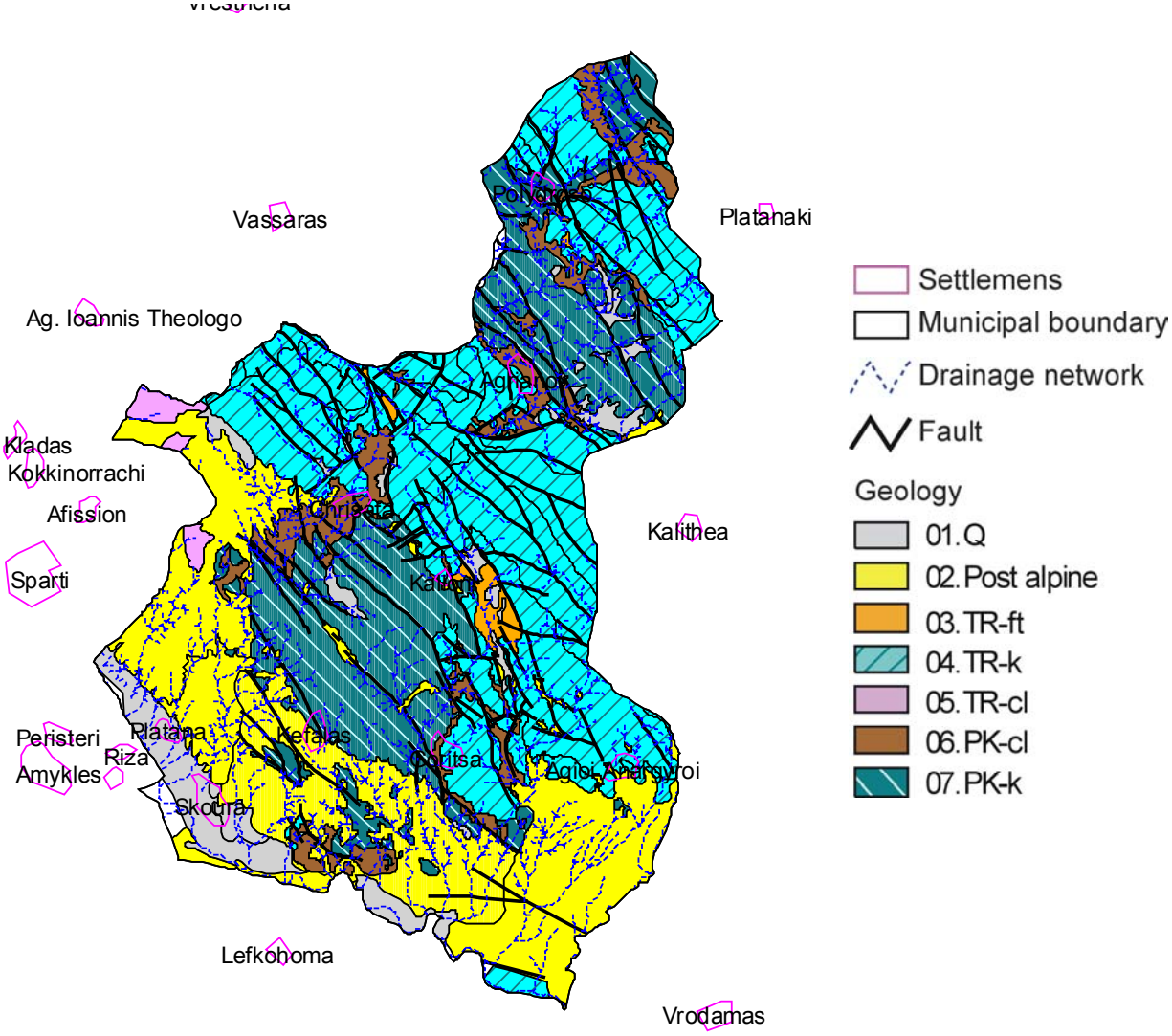


FIGURE 5. Geological map of Therapnes Municipality (01: Quaternary deposits, 02: Post alpine deposits, 03: Flysch of Tripolis Unit, 04: Limestone of Tripolis Unit, 05: Clastic – volcano-clastic formations of Tripolis Unit, 06: Flysch of Mani Unit, 07: Limestone of Mani Unit).

It is also necessary to point out that the reliability and spatial and temporal density of primary data is crucial to this effort. Lack of data causes uncertainty, and although European and Greek

legislation and regulations are very strict and clear on the matter of collection of data and monitoring of exploitation and attributes of water resources, the phenomenon is very common in Greece, not excluding Laconia prefecture, which Therapnes municipality belongs to.

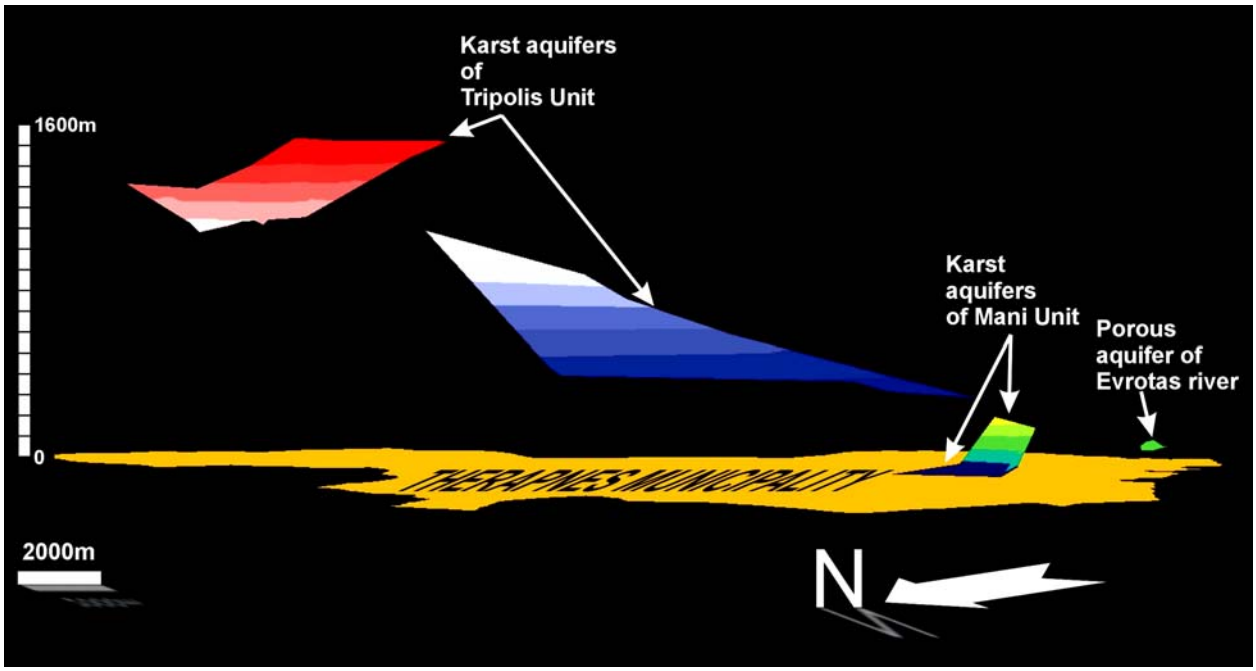


FIGURE 6. 3D-representation of aquifers under exploitation within Therapnes Municipality (view from northwest).

Characterization of the "quantity and quality" status of water bodies requires periodical examination of a number of parameters and comparison to the thresholds very clearly defined in the 2000/60 Directive of the European Union, as much as presentation with a specific colour code (green for good status and red for bad status), together with indicators of the tensions towards quantity and quality improvement or degradation. In this direction, all data were processed and presented in maps according to the guidelines provided by the Directive, once they should soon be embodied to the River Basin District (or Water District) Master Plans. In Figure 7, one of the quality status indicators (Total Dissolved Solids) of groundwater is presented. Although nowhere in the municipality has the water exceeded the limit set as a standard for human consumption, it is very clear that in the lower (south-west) areas aquifers are being degraded, and actions should be taken. Comparison of this picture to Figure 8 shows that urban pollution pressure peaks are concentrated in the same area, a fact showing that urban pollution (combined with industrial pollution also concentrated in the same area) contributes highly to the degradation of aquifers. Pollution pressure though, is not due to urban pollution and industrial activities within the municipal boundaries, but also to adjacent areas (i.e. the city of Sparti and industrial units of Sparti municipality along the riverbed of Evrotas, on the border between the two municipalities). It has to be pointed out that the presented maps are only a minimum indicative sample of the set of maps that have to be produced in the process of determination of water status and prerequisite documentation of a water resources master plan, even on a municipal scale. Moreover, the objectives of sustainability require continuous updating and revision, in order to integrate the dynamic changes in both natural processes and human activity [1], [2].

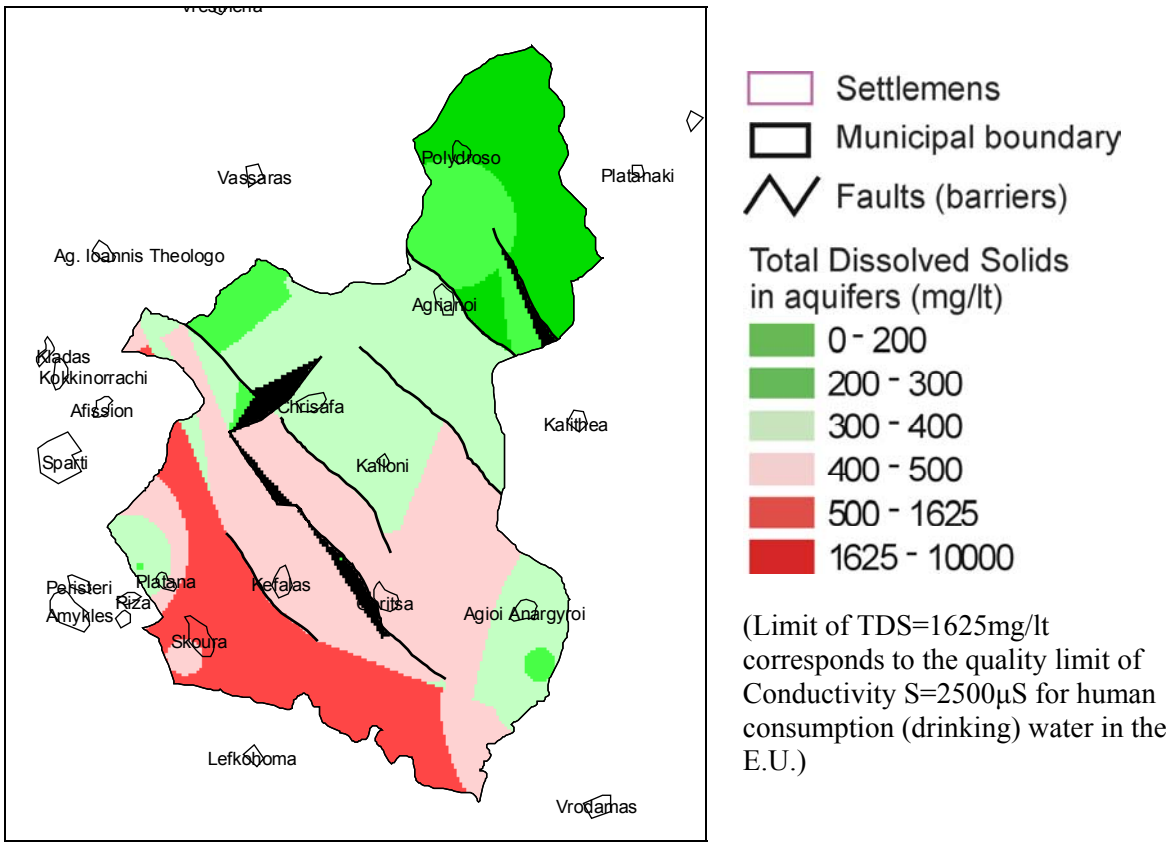


FIGURE 7. Water quality in Therapnes Municipality (according to the Directive 2000/60 of the European Union).

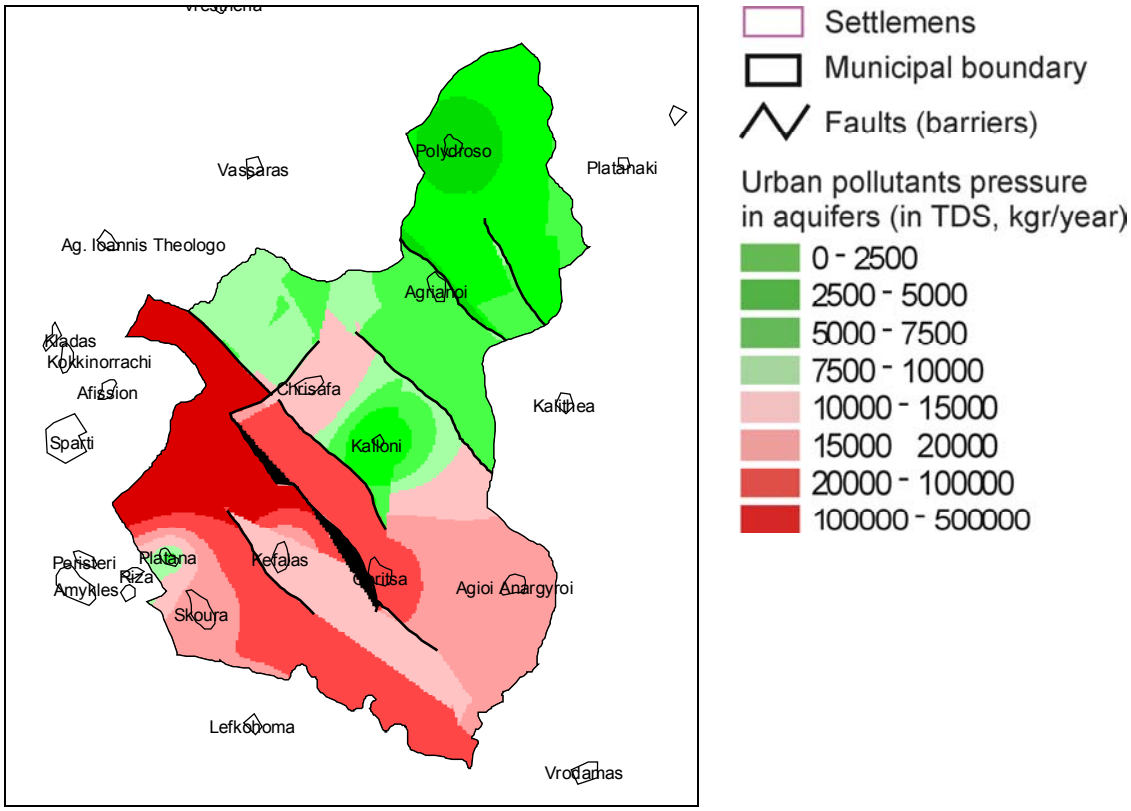


FIGURE 8. Urban pollution pressure to the aquifers in Therapnes Municipality.

3. CURRENT MANAGEMENT SCHEME – CONCLUSIONS

Water shortage is not always due to lack of resources, but very often a result of inadequate management. It is therefore necessary to overview the effectiveness of the applied management scheme and discover any drawbacks. Thus, research included outlining of the present management scheme in Laconia prefecture, which in fact is a lot more complicated than it shows in Figure 9. The lack of central and regional services with overall authorization and information on water resources has resulted to a maze, chaotic and inadequate management system [2]that needs to be revised by the State.

Nevertheless, it is evident that local authorities (municipalities and prefectures) can and should play a serious part on the effort, once they could help built the base of the pyramid of information platform, necessary for the configuration of national and district master plans for water resources management, and they can contribute a lot through the application of local scale actions in their level of authorization.

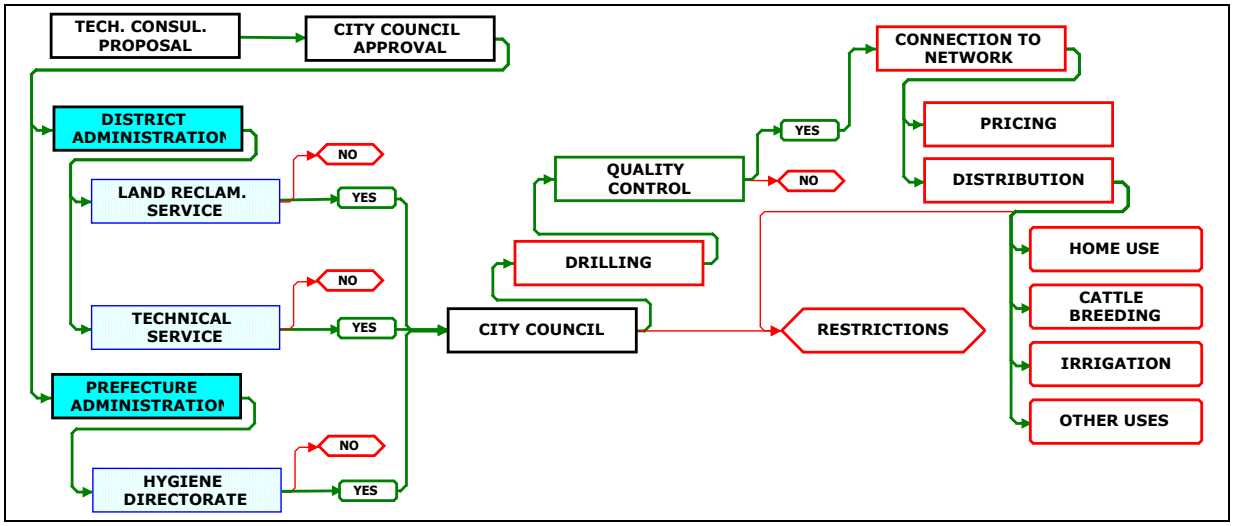


FIGURE 9. Current scheme of administration and management of water resources on municipal scale in Greece.

REFERENCES

1. Mariolakos, I., Fountoulis, I., Spyridonos, E., Dritsa, C., Capourani, E., Andreadakis, Emm. (2001). Holistic Methodology for Water Resources Management in Semi-Arid Regions. Case Study in Mani (S. Peloponnesus, Greece). In proc. *Of 10th Biennial Symposium on Artificial Recharge of Groundwater "Artificial Recharge and Integrated water management"* Arizona USA, p.31-40.
2. Mariolakos, I., Fountoulis, I., Spyridonos, E., Andreadakis, Emm., Capourani, E. (2002). A multi parametric approach of water management in the frame of sustainable development. In proc. *3rd International Forum "Integrated Water Management", HYDRORAMA 2002.* p.390-401.