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THE EFFECT OF SMALL EARTH DAMS AND RESERVOIRS ON WATER MANAGEMENT IN NORTH GREECE (KERKINI MUNICIPALITY)

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ABSTRACT

The water supply and irrigation efficiency is extremely crucial for several places, especially in the dry period and the proper water management should be a matter of first priority. Small earth dams, taking advantage of the runoff water by blocking and accumulating all the amount of water in reservoirs, constitute a significant measure in water management. The current study presents an optimal and representative example of efficient water management in the area of North Greece, achieved using several earth dams and reservoirs. All the earth dams and reservoirs of the municipality of Kerkini in Serres Prefecture were recorded, measuring also the dimensions, the exact area, the capacity and the conditions of all the works. The total capacity of the 20 reservoirs, detected in Kerkini municipality, was measured to be 244 277 m^3, a water amount that is continually replenished by the available water of the area (3 446 155.15 m^3/year). The total water requirements of the local community were estimated to be 4 139 074.7 m^3/year and a considerable part of them is satisfied by the constructed reservoirs. The value of the specific earth dams and reservoirs tends to be even more critical nowadays, due to the recorded decrease of annual precipitation in the research area and the continual increase of water demand.

Key words: drainage basin, irrigation, runoff water, water demand, water management

INTRODUCTION

As it is widely known, the Mediterranean climate is characterized by a dry period of four to six months and a wet period during the winter season. Therefore, the distribution of annual precipitation is abnormal, in winter and autumn significant amounts of rainfall are recorded, while in spring and summer drought phenomena of great intensity are recorded. In a country like Greece, the need for water supply and irrigation that emerges especially in the dry period, are of such a great extent that the efficient water management is imperative. Due to the social - economic conditions of the past, the development strategy model of Greece was based mainly on technical works in order to exploit the groundwater, while the construction of dams and reservoirs, that exploited the runoff water, is a recent activity (Minagric, 2006).

Of primary importance for the water management of an area is to record the amount of water coming from rainfall and springs, which enables the proper management and efficient exploitation of the possessed water. Sofios et al. (2008) described and analyzed the existing status of water resources in Greece, as well as, the framework of applied policy and proposed measures and actions for the management of water resources. It is undoubtedly significant to take advantage of the runoff water, constructing small earth dams, that block and accumulate all this amount of water that would run off, in reservoirs valuable for agriculture and water supply (Kotoulas, 1989). This kind of solution offers the opportunity to store significant amounts of water and satisfy the water needs that appear in dry period. Earth dams and reservoirs could be constructed, especially when the amount of water is high enough to justify the cost of the construction and maintenance of the works. A work like that, could offer a variety of benefits such as flash flood protection of the area, water storage for the satisfaction mainly of the agriculture and livestock water needs and the water supply of residents for all kinds of domestic uses, except drinking (washing up, cars washing, garden irrigation etc.).

The reservoirs could be constructed across the stream by blocking the free flow of water with earth dam or beside the stream, using a pipe in order to transfer the water from the stream to the reservoir. The knowledge of the number and the exact dimensions of earth dams and reservoirs, the amount of water they contain, the potential secure works that have been done so far and the schedule of the dams and reservoir maintenance is very important. Studies have been done in order to give instructions for the proper construction of earth dams and reservoirs (Smout, Shaw, 1996; Alberta Agriculture and Food, 2002; Nissen-Petersen, 2006; Stephens, 2010; Cowan, Sawyers, 2010). Additionally, much research has been conducted, in order to record and evaluate the efficiency of earth dams and reservoirs in agriculture and community prosperity and some of them are summarized here. Ashraf et al. (2007) evaluated the impact of three small dams, Jawa, Kasala and Dhok Sanday Mar, on agriculture and groundwater development in the area and provided guidelines for the effective utilization and sustainable management of small dams in Pakistan. Mugabe et al. (2003) accomplished a study within the catchment of Mutangi dam, a small reservoir in a semiarid area in Southern Zimbabwe. They measured the amount of water caught by the dam (run in), in relation to the catchment runoff and quantified the losses of dam water. Furthermore, Senzanje et al. (2008), in an attempt to evaluate small dams, used a questionnaire among small dam users, key informant interviews, secondary data and observation on four communal dams in the Limpopo basin to establish the uses, volume of water abstracted and water productivity for some uses and the interrelationship between various organizations and the community in the management of small dams. Liebe et al. (2005) have developed a method in order to estimate the storage of the reservoirs in relation to their surface.

The **objective** of the current study is to present an optimal and representative example of water management policy in an area of North Greece, achieved through constructing many earth dams and reservoirs. An extended record of all the earth dams and reservoirs of the municipality of Kerkini, in Serres Prefecture is conducted, measuring also the dimensions, the exact area, the capacity and the conditions of all the works and their efficiency in satisfying the water requirements of the area, as well. The research will generate knowledge, valuable to draw some conclusions about the works and water management not only in the specific area in North Greece, but also in other areas of similar climate and geological characteristics worldwide.

MATERIALS AND METHODS

The municipality of Kerkini is located at the North-West part of Serres Prefecture (Fig. 1), at the foothill of Mpelles mountain and covers an area of 353.15 square meters (km^2) (8.9% of Serres Prefecture), consist of eighteen villages, the population of the area was recorded to be 10 037 and the majority of the residents had agriculture as their main occupation (EL. STAT., 2001). The reservoirs, that were constructed, supplied with water nine of the villages of the area and a population of 6083 people.

The topography of the area was characterized by smooth and moderate slopes until the altitude of 600 m, while from 600 m and up the mean slope was very intense

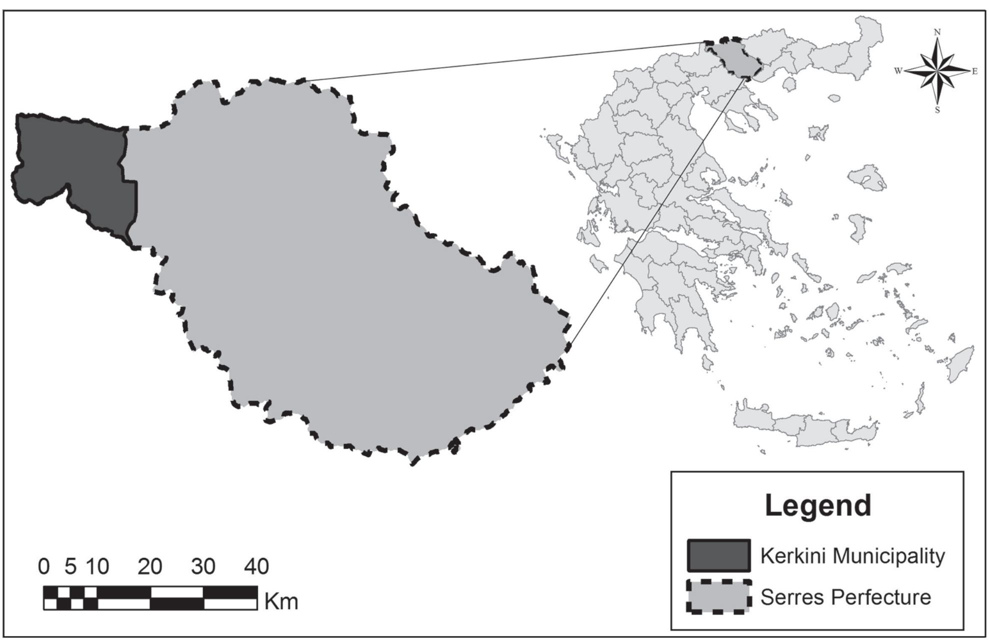

Fig. 1. Study area

(ANESER, 2005). The relatively steep relief of the area was ideal for reservoir construction, because earth dams with significant capacity of water could be constructed, without the use of great quantities of materials. The authority that was responsible for the planning, constructing and maintaining of the earth dams and reservoirs of the study area was the Water Supply and Sanitation Public Utility (WSSPU).

Referring to the geological substrate of the area (Fig. 2), where the drainage basins and the corresponding reservoirs are located, it consisted mainly of Gneiss and Amphibolites (188.1 km^2, 53.26%). Alluvial deposits made up 30.63% (108.16 km^2) of the area, while clay and marls covered 16.11% (56.89 km^2).

The 48.12% (169.96 km^2) of the municipality area was covered by forests (broadleaf 45.23%, coniferous 2.9%). Agricultural lands covered 112.48 km^2 (31.15%) of the area (40.65 km^2 non- irrigated), while grasses and wetlands covered the 6.8% and 6.69%, respectively. Lower percentages acquired the pastures and settlements, recording the percentages of 3.15% and 1.16%, respectively (Fig. 3).

The data for this study were obtained from field research and analytical observation of topographical and geological maps. The morphological, hydrographical characteristics and the relief of the area were estimated using a topographical map of 1:50 000 scale, provided by the Hellenic Military Geographical Service (HMGS,

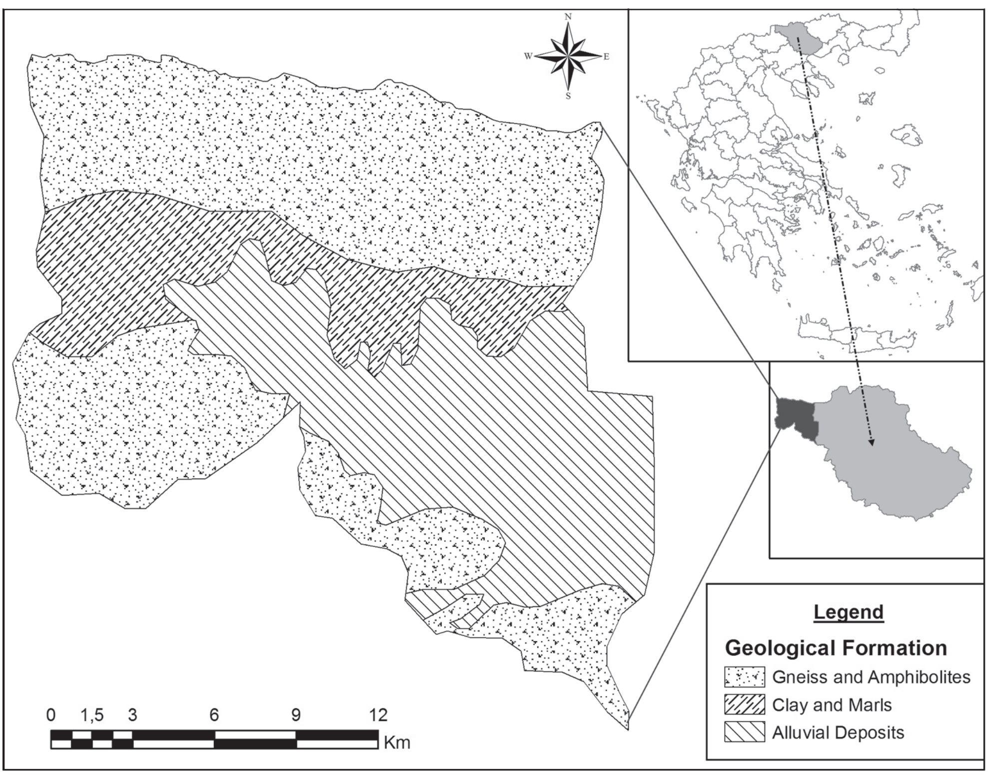

Fig. 2. Geological Formations of the study area

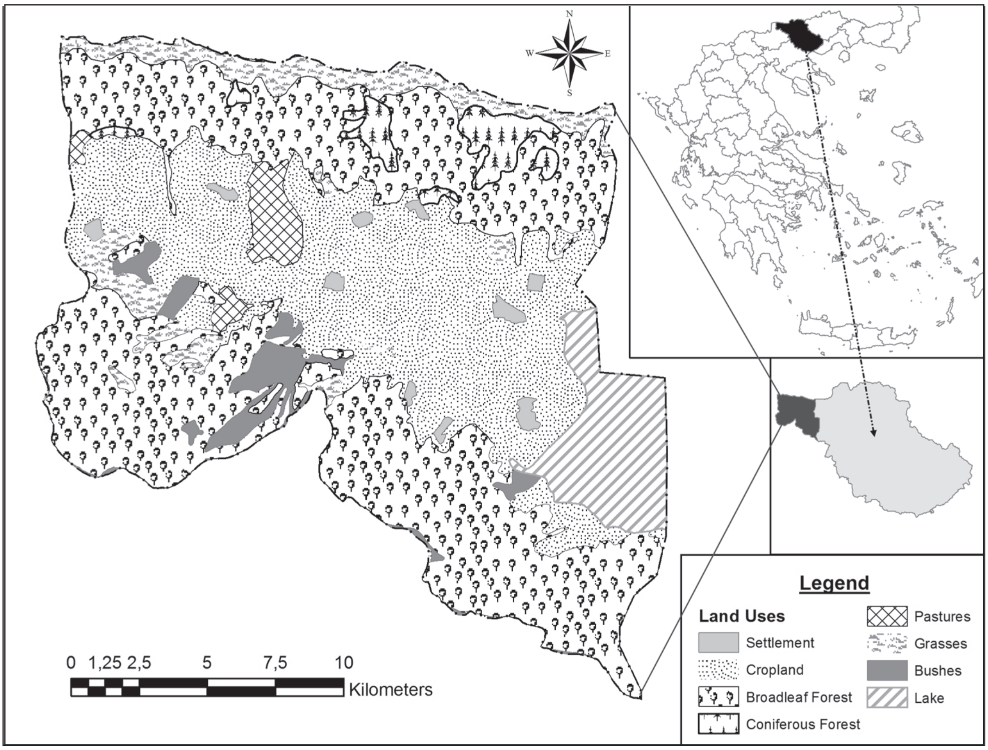

Fig. 3. Land uses of the study area

1971).The digitization of the maps was accomplished using the Arc GIS software of ESRI. Furthermore, the geological substrate (rocks) of the drainage basins was determined after extensive field research and also, using a geotechnical map from Institute of Geological and Mineral Exploration (IGME, 1993) of 1:500 000 scale, as well. The land uses of the study area were determined using the CORINE (2000). Meteorological data were obtained from the meteorological station of Ano Poroia, located in the research area (Fig. 7). The period of data is from 1955 till 2008, the altitude of the station is 394 m and the coordinates are 23°02΄00΄΄N - 41°17΄00΄΄E. Mann-Kendall statistical method was used (Hossein, Hosseinzadeh, 2012), in order to detect potential change on climate and determine the trend of the time series of annual precipitation. Also, for all the reservoirs of Kerkini municipality, the corresponding earth dams and the majority of works such as spillways, outlet pipes and river diversion, constructed aiming to serve the transfer of water from the stream to reservoir and the evacuation of the reservoirs, were recorded. The exact coordinates of each reservoir were measured using GPS, in order to accurately position all the reservoirs on the topographical map. The depth of the reservoirs was measured during the winter period, when the reservoirs were evacuated, in order to be maintained, while the perimeter was measured using wheel meter. For the estimation of the available water, produced by each drainage basin, the following equations (1, 2) were used:

$$VR = A * R \quad (1)$$

$$VW = \frac{0.10 * VR}{1000} \quad (2),$$

where VR is the volume of rainfall (lt), A is the area of the catchment (m^2), R is the annual rainfall (mm) and VW is the volume of the available water of the catchment (m^3) (Lifewater, 2012).

A widely accepted formula for the calculation of the odd shaped storages assumes that the average depth of a reservoir or dugout is one third of the maximum depth. Therefore, the estimated capacity of the reservoir is determined using the following equation (3) (BC Ministry of Agriculture and Fisheries, 2003):

$$EC = \frac{A * D}{3} \quad (3),$$

where EC is the estimated capacity (m^3), A is the reservoirs surface area (m^2) and D is the maximum depth (m).

The average amount of water, demanded for typical crops in Greek region is considered to be 10 000 m^3/year per hectare (Aggelides et al., 2005). The seepage in the reservoirs was estimated about 10% of the annual total stored water. The domestic use (mainly for outdoor use) was determined to be 25 liters/day per person, not including drinking, cooking, etc. (Stephens, 2010). The evaporation was calculated using the Dalton Law for the evaporation (Flokas, 1997).

RESULTS AND DISCUSSION

The site selection for the construction of the works was very critical and was closely related to the continual and efficient function of the reservoirs. Relief, geology, land uses and climate were the basic criteria that determined the available water, the capacity of the reservoirs, the total water losses, the construction, maintenance and water transfer costs and the possible hazards. All these basic criteria that influence the efficiency of the reservoirs were presented in the study site section and discussed here.

Geology of the area

Generally, the rocks that dominated in the research area (Gneiss and Amphibolites) are impermeable to water. As a consequence, these geological formations allowed the construction of earth dams and reservoirs in the study area, reducing the seepage, total water losses, erosion problems and supplied, also, quite satisfying quantities of materials needed for the construction of these works. Therefore, there was no need of material transfer from other areas, which reduced the construction cost. Also, these rocks enabled the formation of springs with permanent flow, even in dry period, a fact that ensured the continual water supply of the reservoirs of the area.

Land uses

The percentage of agricultural land was quite large, indicating the need of continual irrigation, especially in the dry period. On the other hand, the area was covered to a great extent by dense vegetation, which prevented sediment generation and transfer into the reservoirs. Consequently, the need of draining the reservoirs of water to clear them out of sediments was not so imperative and frequent, a fact that minimized the operation and maintenance cost. Additionally, the dense forest vegetation created propitious hydrological conditions that ensured stable, slow and permanent water supply.

Climate

The annual precipitation depth of the area is closely related to the available water, which is going to be stored in the reservoirs. The annual rain and temperature diagram (Fig. 4), was designed using the mean monthly values of precipitation and temperature of the study area. The highest values of monthly precipitation were recorded in November and the lowest in July, August and September.

Precipitation and temperature lines presented two intersection points, between

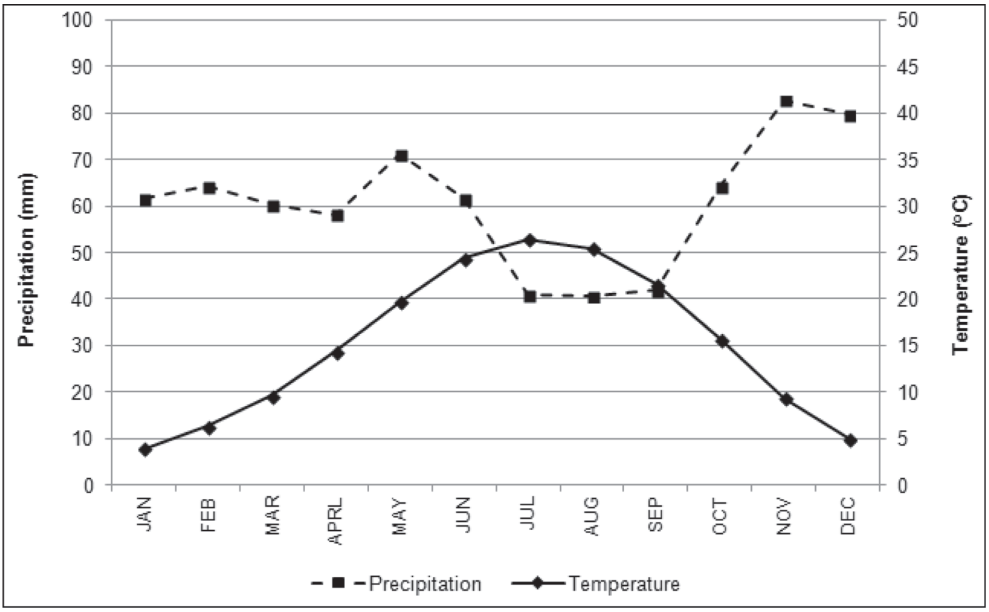

Fig. 4. Rain-Temperature diagramme of the study area

of which lies the dry-thermal period, that Mediterranean climate is characterized by. During the dry-thermal period, the minimum mean monthly values of precipitation parallel to the maximum mean monthly values of temperature were recorded and that period was characterized by an extended scarcity of water. Reservoir water was used mainly during this period, when the maximum values of evapotranspiration were recorded.

The mean annual precipitation of the study area was measured to be 727.55 mm. A decrease in annual precipitation of approximately 27 mm per decade was recorded (Fig. 5).

Mann-Kendall statistical analysis (Fig. 6) showed that there was a change in time series of annual precipitation. This change was found in 1973 and appeared to present a significant downward trend in 1979, with a confidence level of 95%. The decrease of annual precipitation seemed to stabilize in 1996, but as was observed, continued to decrease. This annual precipitation decrease, detected in this study, decreased also the available water for the reservoirs, indicating the need of storing higher amounts of water, constructing more earth dams and reservoirs, especially for irrigation in the future years.

Available water

The available water coming from the 8 drainage basins of the study area was adequate to ensure the efficient and continual supply of the reservoirs (Table 1). The total area of the drainage basins was measured to be 47.38 km^2, while the total water available from them was 3 446 155.15 m^3/year. Also, a part of the available water came from snow melting from Mpelles Mountain and as a result, main streams of the area had permanent flow providing the reservoirs with water, even in the dry season.

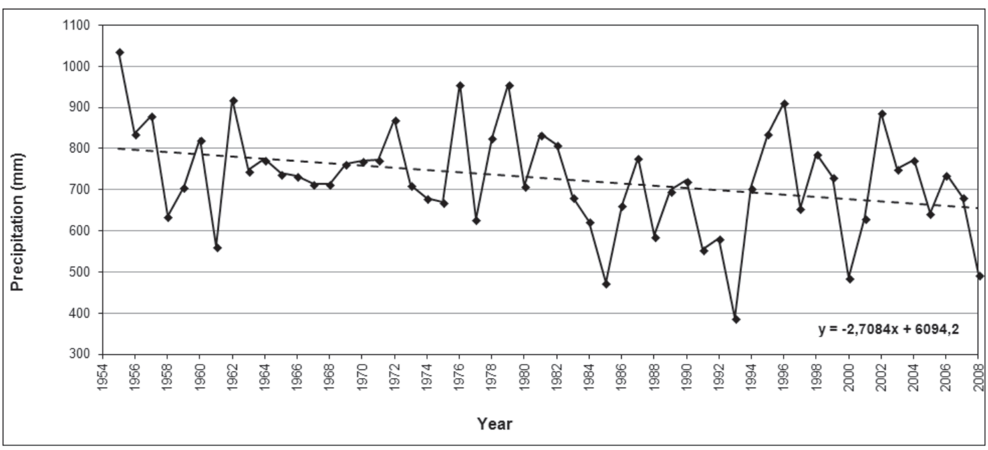

Fig. 5. Annual precipitation time-series of the study area for the period 1955-2008

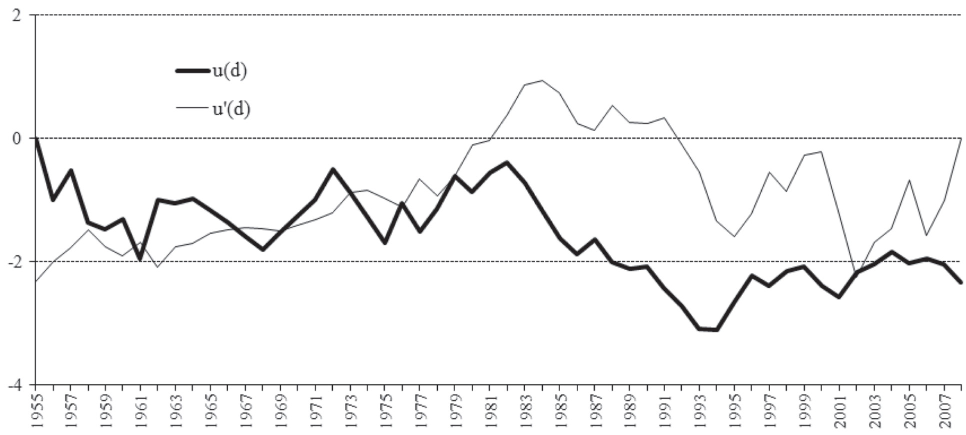

Fig. 6. Graphical illustration of the series *u(d)* and the backward series *u΄(d)* of the Mann-Kendall rank statistic for the annual precipitation

Reservoirs capacity and characteristics

The 20 reservoirs that were detected in the municipality of Kerkini were supplied constantly with water by eight drainage basins, situated in the North part of the municipality at Mpelles Mountain (Fig. 7).

Some of the reservoirs of the study area and specifically the reservoirs 13, 19 and 20 were made of reinforced concrete and the water supply was accomplished using water pipes. Small earth dams have been built across the stream of D catchment for the construction of the reservoirs 5, 6, 7, 8, 9 and 10. The rest of the reservoirs were mainly dugouts, which were constructed using materials from the local area. For the water supply of the concrete reservoirs and the dugouts as well, technical works were constructed to divert the course of water out of the streams and lead it

Table 1. Determination of the area and available water per year of each drainage basin.

Drainage basin	Area (Km^2)	Available water (m^3 / year)
A	5.02	365,301.44
B	4.72	343,116.15
C	5.07	369,005.52
D	4.44	322,724.32
E	5.51	400,736.09
F	11.54	839,592.70
G	5.57	405,082.97
H	5.51	400,595.97
Total	**47.38**	3,446,155.15

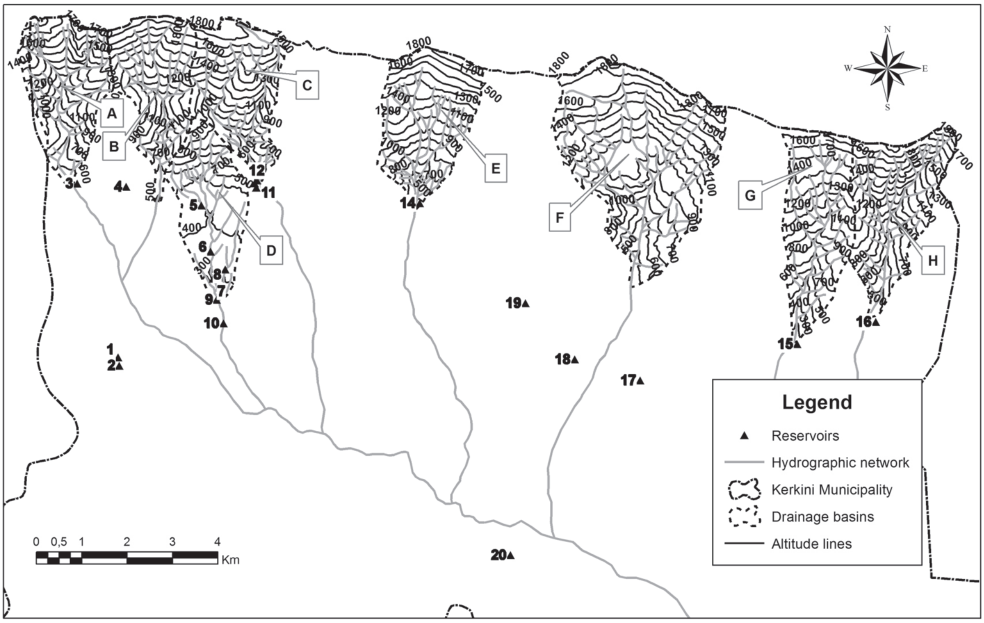

Fig. 7. The 8 drainage basins (A, B, C, D, E, F, G, H) that supply water the 20 reservoirs of Kerkini municipality

into the reservoirs using pipe or superficial flow. Also, measures have been taken in order to avoid sediments transfer into the reservoirs.

The topography of the area promoted the construction of reservoirs, in a way that they were able to store the maximum amount of water behind the smallest feasible dam. Additionally, the mean altitude (MA, Table 2) of the reservoirs was measured to be 350 m and the altitude difference between the reservoirs and the areas, that intend to be irrigated, contributes to an easy and of low cost water transfer, providing the necessary pressure to the pipes without the need of pressure machinery. According to Table 2, the total capacity of all the reservoirs of the study area was proven to be 244 277 m^3, an amount of water that was continuously replenished by the available water of the area. This water satisfied a part of the water needs for crops irrigation that emerge during the dry season.

Water demands

The reservoirs were constructed to supply with water nine villages of Kerkini municipality and a crop land approximately 400 ha. The total water requirements were approximately 4 139 074.7 m^3/year. The mean water amount annually needed only for the crop species irrigation of the area was 10 000 m^3/year per ha. Network losses range between 10% (24 427.7 m^3/year) of the stored water. The water capacity of the reservoirs is adequate to cope with the total losses coming from seepage and evaporation (81 027.7 m^3/year), as well as the domestic use (54 747 m^3/year) (Ta-

Table 2. Characteristics of the reservoirs of the study area

Res.	Res. surface area (m^2)	Depth (m)	Perimeter (m)	Capacity (m^3)	Altitude (m)	Coordinates (W.G.S. 84)	
						X	Y
1	1,485	6	184	2,970	330	41° 16’ 24.64”	22° 54’ 08.07”
2	3,639	6	259	7,278	324	41° 16’ 21.25”	22° 54’ 08.89”
3	6,734	6	306	13,468	528	41° 18’ 29.19”	22° 53’ 27.12”
4	7,715	15	364	38,575	500	41° 18’ 27.23”	22° 54’ 13.60”
5	6,822	10	330	22,740	430	41° 18’ 14.56”	22° 55’ 24.59”
6	3,075	8	310	8,200	336	41° 17’ 41.74”	22° 55’ 33.76”
7	6,186	7	442	14,434	290	41° 17’ 22.44”	22° 55’ 37.14”
8	2,481	8	203	6,616	318	41° 17’ 29.07”	22° 55’ 47.63”
9	1,243	4	131	1,657	257	41° 17’ 07.54”	22° 55’ 40.39”
10	1,591	3	147	1,591	220	41° 16’ 50.79”	22° 55’ 47.26”
11	3,521	10	221	11,737	520	41° 18’ 33.12”	22° 56’ 16.95”
12	3,966	10	239	13,220	524	41° 18’ 31.07”	22° 56’ 14.96”
13	1,559	4	158	2,079	507	41° 18’ 28.14”	22° 56’ 16.62”
14	3,419	8	210	9,117	490	41° 18’ 18.37”	22° 58’ 51.48”
15	1,588	5	155	2,647	250	41° 16’ 40.64”	23° 04’ 49.79”
16	11,950	10	441	39,833	420	41° 16’ 57.22”	23° 06’ 03.88”
17	9,770	6	378	19,540	210	41° 16’ 13.50”	23° 02’ 21.76”
18	2,162	10	176	7,207	215	41° 16’ 28.03”	23° 01’ 19.53”
19	1,800	3.5	180	6,300	220	41° 17’ 08.16”	23° 00’ 32.32”
20	400	4	82	1,600	110	41° 14’ 08.01”	23° 00’ 21.11”
To-tal	**81,106**	-	-	**244,277**	**MA: 350**	-	-

ble 3). Livestock consisted mainly of free pasturage goats and sheep that use many sources of water (not only reservoirs water), a fact that made even more difficult the estimation of livestock water needs. Furthermore, the available water (3 446 155.15 m^3/year), which was calculated based on the mean annual precipitation of the last 55 years, supplied constantly the reservoirs, which means that the average area that could be irrigated was 331.1 ha, not including the losses and domestic use.

Consequently, the reservoirs could not satisfy the total water needs every year, due to potential changes in annual precipitation, losses in the network system and livestock use, which could not be accurately calculated. Therefore, some years the water needs were satisfied by the available water, while some others not. Undoubt-

Table 3. Water losses and water use

Available water from the watersheds (m^3/year)	Reservoirs capacity (m^3)	Water losses		Water use	
		Seepage (m^3/year)	Evaporation (m^3/year)	Domestic use (m^3/year)	Irrigation needs (m^3/year)
3,446,155.15	244,277	24,427.7	56,600	54,747	4,000,000

edly, the specific reservoirs manage to irrigate every year a quite large crops area and offer valuable services to the local people.

Positive and negative aspects of reservoir construction

In the east part of Greece, where the study area was located, the annual precipitation was decreased compared to the rest of the country and as a result, crop species, of low water requirements, mainly tobacco and grain, used to be cultivated. Although, the available water ranges from year to year, following the annual precipitation depth, the calculated average value (3 446 155.15 m^3/year) was adequate to satisfy a significant part of the water requirements (83%). Additionally, the capacity of the reservoirs could cover the total water losses and domestic use per year. Very important is also the fact that prior to the reservoirs construction, irrigation was not possible there. The construction of reservoirs provided to the local population the chance to increase the range of crops, adding more water demanding species, such as beetroot, tomato, maize, rice, etc. This was also an opportunity for local people to adapt to the crops market demands and as a consequence, increase their income. Similar findings about the positive effects of small reservoirs were indicated by different researchers around the word (Ashraf et al., 2007; Mugabe et al., 2003; Senzanje et al., 2008; Carvajal et al., 2014, etc.). Furthermore, the use of reservoir water has contributed to livestock increase, a decrease of the cost of domestic use water, the ecotourism development of the area and also, the breeding of wildlife species, intended for hunting. Additionally, reservoir use has provided habitats for local wildlife species in order to protect and expand the biodiversity of the area.

Generally, the function of small reservoirs may bring also negative impact, such as water contamination from wild animals and livestock, diseases coming from the contaminated water, people deaths from drown, etc. In the case of the research area, the water comes from a wild and pure area covered by dense forest, while it refreshes the reservoirs continuously.

Furthermore, all the reservoirs were fenced around, preventing animals or people to have access, limiting the contamination hazards. The only threat that the local community faces is the possibility of the reservoirs destruction from flash-floods. Taking all the above into account, it could be claimed that the policy of reservoirs construction contributed not only to water management and irrigation water supply, but also affected the environment, the economics of local communities and their welfare.

CONCLUSIONS

The current study presented an optimal and representative example of water management policy in North Greece. An extended record of all the earth dams and reservoirs of the municipality of Kerkini, in Serres Prefecture was conducted, referring to the exact dimensions, the area, the capacity and the conditions of all the works.

The study area fulfilled the basic factors, necessary for the low cost construction and efficient function of small earth dams and reservoirs. These reservoirs appeared to satisfy a significant part of the total water needs for crops irrigation of the area, emerging during the dry period of spring and summer and domestic needs of the municipality population. After the construction of the reservoirs, was feasible for the local people to cultivate more water demanding crops in relation to the past and as a consequence improve their income.

Constructing small earth dams and reservoirs, even of low cost and extent, could contribute to the solution of crucial problems, like summer drought and water scarcity, which can be devastating for agriculture and livestock. Based on Kerkini municipality experience, it could be claimed that other areas that respond to the requirements of these works construction, should follow the specific example of North Greece and set in first priority the storage of the necessary water amounts constructing earth dams and reservoirs.

REFERENCES

Aggelides, S., Karamanos, A., Londra, P. 2005. Irrigation systems performance in Greece. - In: Lamaddalena N., Lebdi F., Todorovic M., Bogliotti C. (Eds.). Irrigation systems performance. Bari: CIHEAM, 2005, 99 -110.

Alberta Agriculture, Food and Rural Development. 2002. Small Earth Fill Dams, Technology and Innovation Branch Agdex 716 (A20).

ANESER 2005. Kerkini Municipality Business Plan. Retrieved from http://www.aneser.gr.

Ashraf, M., Kahlown, M.A., Ashfaq, A. 2007. Impact of small dams on agriculture and groundwater development: A case study from Pakistan. Agricultural Water Management 92, 90-98. (doi:10.1016/j.agwat.2007.05.007).

BC Ministry of Agriculture and Fisheries. 2003. Farm Water Storage, Water Supply Fact sheet, Order No. 510.100-1, Agdex: 754, August 2003.

Carvajal, F., Agüera, F., Sánchez-Hermosilla, J. 2014. Water balance in artificial on-farm agricultural water reservoirs for the irrigation of intensive greenhouse crops. Agricultural Water Management, 131, 1 January 2014, 146-155. DOI:http://dx.doi.org/10.1016/j.agwat.2013.09.006.

CORINE. Corine land cover 2000. European Environment Agency (EEA). Retrieved from http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000-clc2000-seamlessvector-database.

Cowan, J., Sawyers, M. 2010. Small Earth Dam Design, Considerations for Design of SWM Facilities, ESI course No. P 517-10. 5-13-2010.

EL.STAT. 2001. Census of Greece Population 2001. Retrieved from http://www.statistics.gr/portal/page/portal/ESYE.
Flokas, Ap. 1997. Μαθήματα Μετεωρολογίας και Κλιματολογίας. [Lessons of Meteorology and Climatology]. Aristotle University of Thessaloniki. University edition.
HMGS. 1971. Topographical Maps 1:50 000 scale. Retrieved from http://web.gys.gr/portal/page?_pageid=33,46034&_dad=portal&_schema=PORTAL.
Hossein, T., Hosseinzadeh, T. 2012. Moisture Index for Iran: Spatial and Temporal Analyses. Global and Planetary Change, (http://dx.doi.org/10.1016/j.gloplacha.2012.08.010)
IGME. 1993. Geotechnical Map of Greece 1:500 000 scale.
Kotoulas, D. 1989. The low-height dams. Edition of Geotechnical Board of Greece. Thessaloniki, 38-43.
Liebe, J., Giesen, N., Andreini M. 2005. Estimation of small reservoir storage capacities in a semi-arid environment. A case study in the Upper East Region of Ghana. Physics and Chemistry of the Earth 30, 448–454. (doi:10.1016/j.pce.2005.06.011).
Lifewater. 2012. Water for the world, Designing Small Dams, Technical Note RWS 1.D.5. Retrieved from http://www.lifewater.org/resources/rws1/rws1d5.pdf, 2012.
Minagric. 2006. Dams and Reservoirs, 2nd Edition - New Works, Ministry of Rural Development and Food, February 2006.
Mugabe, F.T., Hodnett, M.G., Senzanje, A. 2003. Opportunities for increasing productive water use from dam water: a case study from semi-arid Zimbabwe. Agricultural Water Management 62, 149-163.
Nissen-Petersen, E. 2006. Water from Small Dams, Technical handbook for Danish International Development Assistance (Danida) in Kenya.
Samaras, V. 2010. Water requirements of Cotton, Corn, Tomato and Beetroot cultivations in Thessaly region. HYDROSENSE programme. Retrieved from http://www.hydrosense.org/eDocuments/Anages_twn_fytwn_se_ardeutiko_nero_B_SAMARAS.pdf.
Senzanje, A., Boelee, E., Rusere, S. 2008. Multiple use of water and water productivity of communal small dams in the Limpopo Basin, Zimbabwe. Irrigation Drainage System, 22, 225-237.
Sofios, S., Arabatzis, G., Baltas, E. 2008. Policy for Management of Water Resources in Greece. Environmentalist, 28, 185–194, DOI 10.1007/s10669-007-9126-4.
Smout, I., Shaw, R. 1996. Technical Brief 48: Small Earth Dams, Waterlines, Intermediate Technology Publications, London, 14, 4, 15-19.
Stephens, T. 2010. Manual on Small Earth Dams - A guide to sitting, design and construction, Food and Agriculture Organisation of the United Nations – FAO Irrigation and Drainage Paper 64, ISBN 978-92-5-106547-1, Rome.

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