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PARTICIPATORY WATER MANAGEMENT AND CULTURAL HERITAGE IN GREECE

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SUMMARY - This document shows, in its first part, the water resources management in Greek's agricultural sector with special emphasis in it's relation to the Participatory Irrigation Management, showing aspects that need to be improved, but as well a successful project experience. Irrigation land in Greece covers an area of more than 1,400,000 hectares, with the Common Reclamation Works (CRW) facing the 40% of the total irrigated land. The CRW are managed by 420 associations with administrative, operational and conservation duties. As a case study, a successful example for a good participatory water management in Greece is that of the Organization of Development of the West Crete, established in 1979, is given. In its second part, the paper exhibits a review of the rich Greek history, giving the agricultural hydraulic works in ancient times and a catalog of ancient Greek philosophers with their contributions, revealing a correct understanding of water related phenomena.

Keywords: common reclamation works, irrigation methods, water users associations, ancient hydraulic works, ancient Greek philosophers.

PARTICIPATORY WATER MANAGEMENT

Law status for the water resources management

In Greece the water resources management is governed by the provision of the laws 1739/1987 and 3199/2003. According to these laws the water resources management is coordinated by the Ministry of Environment, Physical Planning and Public Works. Responsible for the agricultural sector is the Ministry of Agriculture.

The organization of the water resources management is based on the division of the country in 14 water districts (Fig. 1). Each district contains one or more river basin areas (watersheds) or island areas and they include integrated hydrographic networks.

The last and most important resolution is the Directive 2000/60 EC of the European Parliament and of the Council for establishing a framework for integrated Community action in the field of water policy. As far as the water resources are concerned, the EC regards the water as a product that is not commercial like other but, rather, a heritage which must be protected, defended and treated as such.

The Member States shall identify the individual river basins lying within their national territory for the implementation of the EC Directive. The EC Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with the Directive at the latest by 22 December 2003. The EC Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, on the basis of an economic analysis conducted according to certain methods, including in particular "the polluter pays" principle.

The Member States shall ensure the appropriate administrative arrangements, including the identification of the appropriate competent within each river basin district lying within their territory.

Fig. 1. Water districts of Greece (Source: Ministry of Development, 2003)

WATER RESOURCES MANAGEMENT IN THE AGRICULTURAL SECTOR

A) *Structural and organizational framework of the common reclamation work management (participatory water management)* (Papastamatiou and Pergialiotis, 2001)

The common reclamation works cover irrigated land that corresponds to 40% of the total irrigated land in Greece.

The common reclamation works are managed by 420 associations with administrative, operational and conservation duties. There are:

- 10 General Organizations of Land Reclamations (GOLR).
- 382 Local Organizations of Land Reclamations (LOLR).
- 2 Special Associations. (The one of them is the autonomous organization in Stymphalia Korinthos, and the other is the Organization of Kopais. They are legal entities with a board of 7members from which 3 members are elected from the farmers lived inside the province where the reclamation works exist).
- 20 Provisional Administrative Committees (coming from farmer–members of the LOLRs).
- 6 Local Irrigation Committees that are legal entities composed from civil servants and farmers according to the law 608/48.

Members of the LOLRs are obligatory the persons and legal entities that they are owners of properties which benefit from the operation of the common reclamation works.

The LOLRs are directed from boards of 3- or 7-members elected from the general assembly of representatives. The representatives are elected from the Local Assemblies of farmer-members. They are entitled with a number of votes depending on the size of the holdings within the area covered by the common reclamation works.

Members of the GOLRs are the LOLRs functioning in the area of their rights as well as persons that profit from the reclamation works. They are directed by a board of 7 members from which 5 members are appointed by the General Secretary of the district where the GORL belongs and 2 members are elected from the LOLR of the region. In order to serve:

a. A planned strategy of the Reclamation Works (RW)
b. The maintenance and development of the existing RWs
c. The rational management of water resources (participatory water management)

The General Direction of Land Reclamation of the Ministry of Agriculture has the following services.

1. A network of meteorological and surface/groundwater hydrological stations. The network concludes:
   - 216 meteorological stations
   - 80 flow measuring stations in river networks
   - 104 flow measuring places in river networks
2. A network of monitoring the quality of the water resources which comprises:
   - 90 sites on rivers (monthly sampling)
   - 30 sites on lakes (monthly sampling)
   - 100 sites on irrigation systems (sampling during the irrigation period)
   - 250 sites on drilled wells

B) ***Technical and economic data of services*** (Papastamatiou and Pergialiotis, 2001)

The preparation of the annual program of the organizations is based on the available quantity of water for irrigation. They draw up a crop plan and, according to the expected administrative expenses, operational costs and maintenance of the reclamation works set up an annual budget taking also into account other expenses as loans, indemnifications etc. These expenses are distributed among the beneficiaries of the participatory management of reclamation works according to the area of the irrigated land.

Despite of the above bureaucratic organization, an over-consumption of irrigation water was observed which was attributed to:

a. The wrong management and maintenance of the reclamation works. This is due to the old structures of services, the insufficient equipment, the non-specialized staff, and the lack of a preventive conservation of the networks.
b. The wrong policy of water prices of irrigation water. The farmers pay for the used irrigation water according to their irrigated area and not according to their water consumption. This results in a waste of water.
c. The deficiency of technical advisory support to the farmers on the application of irrigations.
d. The low irrigation water efficiency in the field.

C) ***Case Study*** (ODWEC, 2001)

A successful example for a good participatory water management in Greece is that of the Organization of Development of the West Crete (ODWEC). Established in 1979, the ODWEC is an administratively and financially independent organization under the supervision of the Ministry of National Economy. It is directed by 15-member board in which they participate:

a. The General Secretary of Crete island district.
b. The Head of the Prefecture of Chania (West part of Crete).

c. Representatives of local governmental organizations, associations and cooperatives.
d. Representatives of the Technical, Industry, Commerce and Trade Chambers.
e. Representatives of the Hotel industry Chamber.
f. Representatives of the union of the staff employed in the ODWEC.

The ODWEC irrigates an area of 18,000 hectares with an annual water consumption of 26 million m^3. On the completion of the land reclamation works by 2006, the total use of water will be raised to 50 million m^3.

The ODWEC is a non-profit Organization and the price of irrigation water is charged according to the consumptions monitored with hydrometers. An example of the price list is shown in Table1.

Table 1. Economical aspects of the water resources management

	Total charge	
	15.847,40 €	For **600.000 m^3** under the supervision of LOLR **irrigation with free flow** with price of m^3: **0,026 €**
	374.174,61 €	For **7.500.000 m^3** under the supervision of LOLR **irrigation through pumping from one reservoir** with price of m^3: **0,05 €**
	28.760,09 €	For **350.000 m^3** under the supervision of LOLR **irrigation through pumping from two reservoirs** with price of m^3: **0,08 €**
	438.738,08 €	For **6.500.000 m^3** straight to individual farmers (region A) **irrigation through pumping from one reservoir** with price of m^3: **0,067 €**
	396.184,89 €	For **4.500.000 m^3** straight to individual farmers (region A) **irrigation through pumping from two reservoirs** with price of m^3: **0,088 €**
	625.091,71 €	For **5.325.000 m^3** straight to individual farmers (region B) **irrigation through pumping from one reservoir** with price of m^3: **0,117 €**
	171.680,12 €	For **1.300.000 m^3** straight to individual farmers (region B) **irrigation through pumping from two reservoirs** with price of m^3: **0,132 €**
	4.695,52 €	For **20.000 m^3** for **other uses** with price of m^3: **0,235 €**
Total	2.055.172 €	

	Analysis of the expenses	
	733.675,72 €	For Public Company of Electricity
	381.511,37 €	For conservation, consumables, general expenses
	939.104,92 €	For salaries of the staff
Total	2.054.292 €	

Every week, it is estimated a recommended quantity of irrigation water and it is given as an irrigation report. This report is drawn up by the Agricultural Service of the prefecture with the collaboration of ODWEC and the Subtropical plants and olive tree Institute.

Crop water requirements are estimated using evaporation pans and rain gauge meters. The values are suitably corrected with factors experimentally found in the region.

The case/history of Land Reclamation Works (LRW) Progress (Papastamatiou and Pergialiotis, 2001)

The development of public (common) LRW in Greece has been achieved in two separate periods differing in organization, technology and financial resources.

The construction of the great majority of the LRWs (drainage, irrigation and flood controls) started in 1922. The only works that had been constructed during the 19th century were the flood controls of the Acheloos River (1856), some draining works in Peloponnese, as well as the draining works (20.000 hectares) of Kopais Lake.

A. Development period of LRW

1st phase of action (1925-1940)
Flood control works 369.000 hectares
Exsiccation works 89.900 hectares
Irrigation works 14.000 hectares

2nd phase of action (1949-1958)
Flood control works 600.000 hectares
Exsiccation works 60.000 hectares
Irrigation works 120.000 hectares
Land drainage works 390.000 hectares
Amelioration of saline soils 8.000 hectares

B. Period of LRW development

This period begun on 1959 when the Land Reclamation Service (LRS) was founded in the Ministry of Agriculture.

1st phase of action (1959-1969)
Flood control works 100.000 hectares
Irrigation works 83.000 hectares
Land drainage works 140.000 hectares

2nd phase of action (1970-1980)
A large number of common sprinkler irrigation systems as well as large and medium ground water extraction works were installed.

3rd phase of action (1981-1988)
It was observed an intense activity from individual farmers to drill private wells for ground water extraction. All these activities were done without any central (Ministerial) planning.

4th phase of action (1989-1994)
The main characteristic of this period is the effort to conserve surface waters.

5th phase of action (1995-)
Construction of reservoirs and preparation of and pilot projects on:

- Surveys on the applicability of artificial recharging.
- Investigation on the possibilities of reclamation and reuse of waste water.

The progress of irrigated areas both total and in LRW is shown in Figure 2.

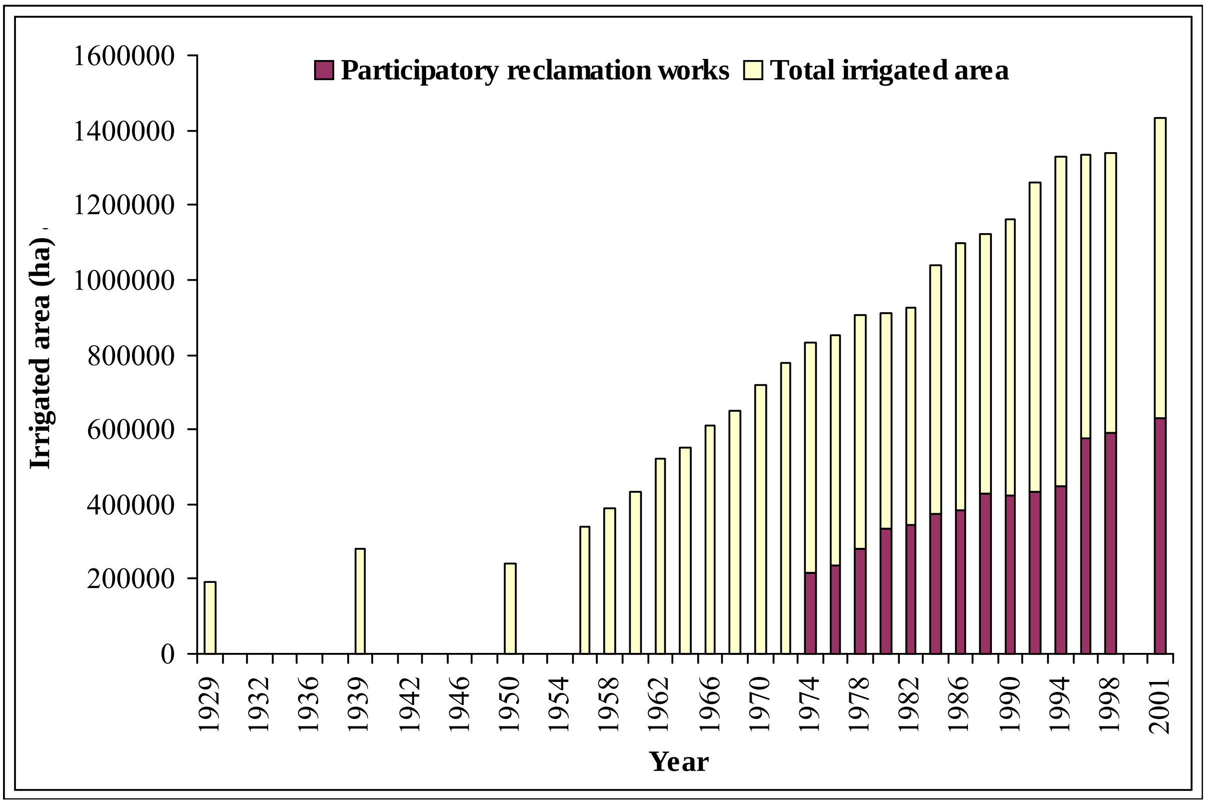

Fig. 2. The total irrigated area in Greece from 1929 to 2001 (Source: Ministry of Agriculture, 2000)

Irrigation methods

The irrigation methods used in Greece are surface irrigation, sprinkler irrigation and drip irrigation. Their relative percentages in participatory reclamation works is shown in changes with time as it is shown in Figure 3. These works cover approximately 40% of the total irrigated area. The other 60% is being served by private irrigation systems, where surface irrigation covers 7%, sprinkler irrigation 49% and drip irrigation 44% (informal data from the Ministry of Agriculture).

The general trend is to abandon gradually surface irrigation and move on to more water saving methods like the two others. This trend is supported financially by the state by means of the loan policy in the last 40 years. The increasing trend in sprinkler and drip irrigation is shown in figure 3.

The water saving prospects of the different irrigation systems is expressed by means of their water application efficiency. It is accepted that the water application efficiencies for surface, sprinkler and drip irrigation are 75%, 85% and 90% respectively (Ministry of Agriculture, 1991).

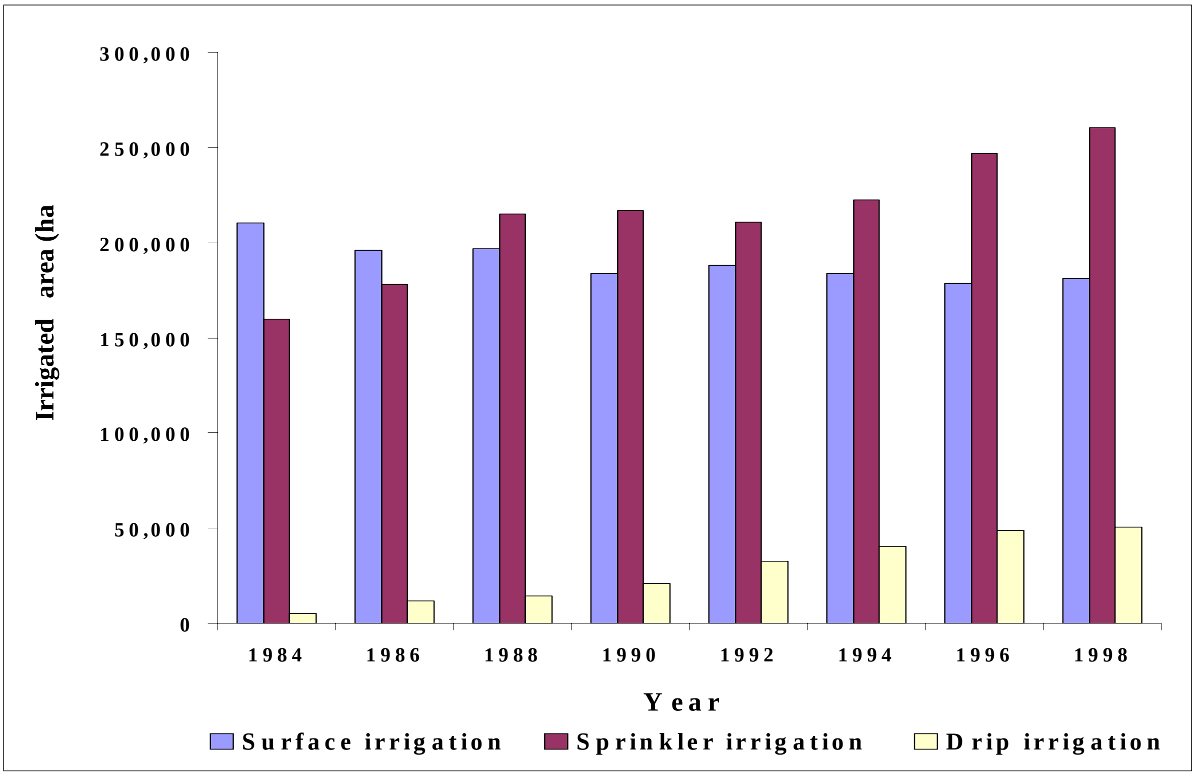

Fig. 3. The trends of irrigation methods used in common reclamation works (Source: Ministry of Agriculture, 2000)

CULTURAL HERITAGE

Agricultural hydraulic works in ancient Greece (Koutsoyiannis and Angelakis, in press)

Archeological evidence traces the earliest important hydraulic works in Greece to the Minoan civilization at Crete. These, however, were related to urban water developments and no traces of agricultural hydraulic projects have been found so far in Crete. Nevertheless, some researchers believed that the Minoans had practiced irrigation and developed irrigation and land reclamation projects and many of contemporary agricultural crops, such as vegetables, cereals, olives, grapes and aromatic species, were grown in Minoan Crete.

After the violent termination of the Minoan civilization (ca. 1450 B.C.), the Mycenaean civilization in mainland Greece achieved supremacy. The great Mycenaean cities (Mycenae and Tiryns in north-east of Peloponnese, Pylos in Peloponnese and Thebes and Orchomenos in Boeotia, north of Athens in Central Greece) were noted for their heavy fortifications with their massive, cyclopean walls, while Minoan cities were totally unfortified. Close to Thebes and Orchomenos, there was a large shallow lake, named Kopais, where the Boeoticos Kephisos River discharged. Natural karstic sinkholes (katabothres) discharged some of the water, above a certain level, towards the sea. At the end of the 19th century A.D. the lake was permanently drained and converted into an irrigated plain, one of central Greece's most fertile agricultural areas. The modern drainage of Kopais has also revealed massive hydraulic engineering works that most probably drained it in late Mycenaean times (ca. 1450-1300 B.C.). According to Strabo (Θ 406-407, 414-415), the draining of Kopais was achieved by the Minyae people that lived there. Huge earthen dykes furnished with cyclopean walls were built in Kopais. Three main canals with length 40-50 km, width 40-80m and parallel walls up to 2-3 m thick traverse the former lake area. The whole project also included the construction of polders and artificial reservoirs for flood water retention and storage, and the improvement of the drainage capacity of the natural sinkholes. The scale of this vast project, which includes the construction of the enormous citadel at Gla, another Mycenaean palatial site on a low limestone island rising up from the floor of the basin, exceeds any other Mycenaean building project. According to Knauss (a German researcher of this area), the sophisticated hydraulic system in the Kopais and its advantages in developing the country and especially agricultural production, allows the hypothesis that Kopais was the “fat province” of Boeotia mentioned by Homer in Iliad (Z, 219-224). Knauss is so much impressed by the system as to write “As a hydraulic engineer of today, always advised to look for the best economic and ecologic solution of given hydrotechnical problems, I admire my early colleagues in what they could do and what they did, with simple tools and materials, but with an intensive and sensitive observation of natural processes, some thousands years before modern hydraulic engineering could reach a similar standard”.

According to Strabo and newer evidence, the area became re-flooded sometime later, probably due to earthquakes (ca. 1100 B.C.). Interestingly, in the case of Kopais, the myth relates Heracles with the destruction, rather than construction, of the project and the flooding of the area, thus probably indicating that war actions (related to the intra-Mycenaean rivalry) contributed to the collapse of the project.

Another important project of the same Mycenaean period (ca. 1250-1200 B.C.) is the Tiryns dam. It seems that, during a flood, a stream south of Tiryns abandoned its bed and shifted to the north of the city. To protect the lower town from future floods the inhabitants of Tiryns installed an artificial river diversion consisting of a 10 m high and 300 m long dam and a 1.5 km long canal. The dam is a huge earthen embankment lined with Cyclopean masonry across the earlier western streambed.

There is evidence, however, that the draining of the Kopais plain was also attempted at later times. Thus, another salient work, a tunnel 2.5 km long, 1.8 m high and 1.5 m wide leading from Kopais to the sea has been revealed. This would provide discharge capacity, additional to that of the natural sinkholes, for draining the lake. Shafts up to 60 m high were lowered at distances 40 to 200 m that helped excavating the tunnel, allowed some daylight and made orientation easy. This tunnel has not been explored so far and it is not known whether the project was completed and operated until it went damaged some time later, or it was never completed. Strabo (Θ 406) mentions that draining works were executed in the Kopais Lake by Crates the Olynthian, engineer of Alexander the Great in 336-323 B.C.

The hydrotechnical skill achieved by the Mycenaean engineers on their land reclamation activities was lost in the centuries after the decline and finally the collapse of the Mycenaean world (ca. 1100-900 B.C.). Later, in the classical Greece civilization, the construction of hydraulic projects progress was accompanied by an improvement in the understanding of water related natural phenomena. However, most findings of hydraulic works of that period are related to the urban rather than agricultural water use.

Scientific views of hydrologic phenomena and hydraulics (Koutsoyiannis and Angelakis, 2003)

It has been believed by many contemporary water scientists that ancient Greeks did not have an adequate understanding of water related phenomena, and had a wrong conception of the hydrologic cycle. This belief is mainly based on some views of Plato (ca. 429-347 B.C.), who in his dialogue *Phaedo* (14.112) expresses an erroneous theory (based on Homer’s poetical view) of the hydrologic cycle; notably, his wrong theory was adopted by many thinkers and scientists from Seneca (ca. 4 B.C.–65 A.D.) to Descartes (1596-1650).

However, long before Plato, as well as much later, several Greek philosophers had developed correct explanations of the hydrologic cycle, revealing a good understanding of the related phenomena. In fact, the first civilization in which these phenomena were approached in an organized theoretical manner, through reasoning combined with observation, and without involving divine and other hyperphysical interventions, was the Greek civilization. A catalog of ancient Greek contributions revealing a correct understanding of water related phenomena is given below. The Ionic philosopher, Anaximenes (585-525 B.C.) studied the meteorological phenomena and presented reasonable explanations for the formation of clouds, hail and snow, and the cause of winds and rainbow. The Pythagorean philosopher Hippon (5th century B.C.) recognizes that all waters originate from sea. Anaxagoras, who lived in Athens (500-428 B.C.) to Empedocles (ca. 493-433 B.C.) and is recognized equally as the founder of experimental research, clarified the concept of hydrologic cycle: the sun raises water from the sea into the atmosphere, from where it falls as rain; then it is collected underground and feeds the flow of rivers. He also studied several meteorological phenomena, generally supporting and complementing Anaximenes' theories; his theory about thunders, which was against the belief that they are thrown by Zeus, probably cost him imprisonment (ca. 430 B.C.). In particular, he correctly assumed that winds are caused by differences in the air density: the air, heated by the sun, moves towards the North Pole leaving gaps that cause air currents. He also studied Nile's floods and attributed them to the snowmelt in Ethiopia. The "enigma" of Nile's floods (which, contrary to the regime of Mediterranean rivers, occur in summer) was also thoroughly studied by Herodotus (480-430 B.C.), who seemed to have a clear knowledge of the hydrologic cycle and its mechanisms.

Aristotle (340-323 B.C.), in his treatise Meteorologica clearly states the principles of the hydrologic cycle, clarifying that water evaporates by the action of sun and forms vapor, whose condensation forms clouds; he also recognizes indirectly the principle of mass conservation through the hydrologic cycle. Theophrastus (372-287 B.C.) adopts and completes the theories of Anaximenes and Aristotle for the formation of precipitation from vapor condensation and freezing; his contribution to the understanding of the relationship between wind and evaporation was significant. Epicurus (341-270 B.C.) contributed to physical explanations of meteorological phenomena, contravening the superstitions of his era.

Archimedes (287-212 B.C.), the famous Syracusan scientist and engineer, considered by many as the greatest mathematician of antiquity or even of the entire history, was also the founder of hydrostatics. He introduced the principle, named after him, that a body immersed in a fluid is subject to an upward force (buoyancy) equal in magnitude to the weight of fluid it displaces. Hero (Heron) of Alexandria, who lived after 150 B.C., in his treatise *Pneumatica* studied the air pressure, in connection to water pressure, recognizing that air is not void but a substance with mass consisting of small particles. He is recognized as the first person who formulated the discharge concept in a water flow and made flow measurements.

Unfortunately, many of these correct explanations and theories were ignored or forgotten for many centuries, only to be re-invented during Renaissance or later. This was not restricted to water related phenomena. For example, the heliocentric model of the solar system was first formulated by the astronomer Aristarchus of Samos (310-230 B.C.), 1800 yr before Copernicus (who admits this in a note). Aristarchus also figured out how to measure the distances to the Sun and the Moon and their sizes. In addition, not only did ancient Greeks know that Earth is spherical, but also Eratosthenes (276-194 B.C.) calculated, 1700 yr before Columbus, the circumference of the earth, with an error of only 3%, by measuring the angle of the sun's rays at different places at the same time; in addition, the geographer Strabo (67 B.C.–23 A.D.) had defined the five zones or belts of Earth's surface (torrid, two temperate, and two frigid) that we use even today.

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