



**IWA Regional Symposium on Water, Wastewater & Environment:  
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# **Past and modern water problems: progress or regression?**

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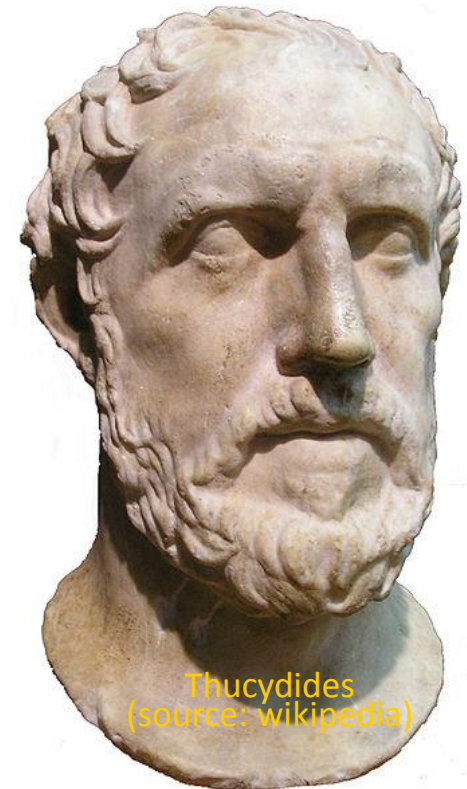
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# Preliminary notes about history

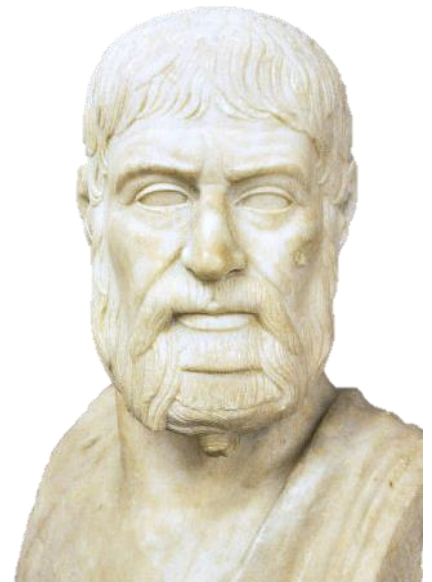
- Progress and regression are common in history and succeed one another.
- We tend to focus on the positive and progressive phases of history and hide the negative and regressive ones; however the latter are equally important and rich in lessons.
- We tend to emphasize the periods of wealth; however, scarcity, poverty and crisis are very important as they mobilize human skills and may lead to progress.
- As opposite to propaganda, the aim of science is the pursuit of the truth; therefore a honest, balanced and fact-based approach is needed.
- Unfortunately, such approach is not very common, despite being as old as Thucydides, the father of *scientific history* (= history based on high standards of evidence-gathering and analysis in terms of cause and effect).
- Unfortunately, the so-called *political correctness* (a euphemism for irrationality) has now replaced Thucydides's political realism.



## Illuminating examples: Themistocles and Pausanias

- Themistocles, was responsible for the decisive Greek victory against the Persians in the Battle of Salamis in 480 BC, and thus “*αἰτιώτατος γενέσθαι τῇ Ἑλλάδι*” (*the man most instrumental in achieving the salvation of Greece*; Plutarch, *The Life of Themistocles*, 7.3) from the Persian invasion.
- Pausanias was responsible for the Greek victory over Mardonius and the Persians at the Battle of Plataea in 479 BC, and was the leader of the Hellenic League created to resist Persian aggression during the Greco-Persian Wars.
- But how did the lives of these two glorious heroes of history end?
- *Τὰ μὲν κατὰ Πausανίαν τὸν Λακεδαιμόνιον καὶ Θεμιστοκλέα τὸν Ἀθηναῖον, λαμπροτάτους γενομένους τῶν καθ’ ἑαυτοὺς Ἑλλήνων, οὕτως ἐτελεύτησεν.*  
(*So ends the history of Pausanias and Themistocles, the Lacedaemonian and the Athenian, the most famous men of their time in Hellas.*)

Thucydides, *The Peloponnesian War*, 1.138



# The end of Themistocles's life

[Θεμιστοκλῆς] ἀφικόμενος δὲ μετὰ τὸν ἐνιαυτὸν γίνεται παρ' αὐτῷ μέγας καὶ ὅσος οὐδεὶς πω Ἑλλήνων διὰ τε τὴν προϋπάρχουσαν ἀξίωσιν καὶ **τοῦ Ἑλληνικοῦ ἐλπίδα, ἣν ὑπετίθει αὐτῷ δουλώσειν**, μάλιστα δὲ ἀπὸ τοῦ πεῖραν διδοῦς ξυνετὸς φαίνεσθαι. ἦν γὰρ ὁ Θεμιστοκλῆς βεβαιότατα δὴ φύσεως ἰσχὺν δηλώσας καὶ διαφερόντως τι ἐς αὐτὸ μᾶλλον ἑτέρου ἄξιος θαυμάσαι [...] νοσήσας δὲ τελευτᾷ τὸν βίον: λέγουσι δὲ τινες καὶ ἐκούσιον φαρμάκῳ ἀποθανεῖν αὐτόν, ἀδύνατον νομίσαντα εἶναι ἐπιτελέσαι βασιλεῖ ἃ ὑπέσχετο. [5]

([Themistocles] *having arrived at Court [of the Persian king] at the end of the year, he attained to very high consideration there, such as no Hellene has ever possessed before or since; partly from his splendid antecedents, partly from the **hopes which he held out of effecting for him the subjugation of Hellas**, but principally by the proof which experience daily gave of his capacity. For Themistocles was a man who exhibited the most indubitable signs of genius; indeed, in this particular he has a claim on our admiration quite extraordinary and unparalleled. [...] Disease was the cause of his death; though there is a story of his having ended his life by poison, on finding himself unable to fulfil his promises to the king.*)

Thucydides, The Peloponnesian War, 1.138.

# The end of Pausanias's life

ἔπεμψε δὲ καὶ ἐπιστολὴν τὸν Γόγγυλον φέροντα αὐτῷ: ἐνεγέγραπτο δὲ τάδε ἐν αὐτῇ, ὡς ὕστερον ἀνηυρέθη: 'Παυσανίας ὁ ἡγεμὼν τῆς Σπάρτης τούσδε τέ σοι χαρίζεσθαι βουλόμενος ἀποπέμπει δορὶ ἐλών, καὶ γνώμην ποιοῦμαι, εἰ καὶ σοὶ δοκεῖ, **θυγατέρα τε τὴν σὴν γῆμαι καὶ σοὶ Σπάρτην τε καὶ τὴν ἄλλην Ἑλλάδα ὑποχείριον ποιῆσαι. δυνατὸς δὲ δοκῶ εἶναι ταῦτα πράξαι μετὰ σοῦ βουλευόμενος.** εἰ οὖν τί σε τούτων ἀρέσκει, πέμπε ἄνδρα πιστὸν ἐπὶ θάλασσαν δι' οὗ τὸ λοιπὸν τοὺς λόγους ποιησόμεθα.'

[...] ἀκούσαντες δὲ ἀκριβῶς τότε μὲν ἀπῆλθον οἱ ἔφοροι, βεβαίως δὲ ἤδη εἰδότες ἐν τῇ πόλει **τὴν ξύλληψιν ἐποιοῦντο.** [...] καὶ δηλώσαντος εὐνοία πρὸς τὸ ἱερὸν τῆς Χαλκιοίκου χωρῆσαι δρόμῳ καὶ προκαταφυγεῖν: ἦν δ' ἐγγὺς τὸ τέμενος. καὶ ἐς οἴκημα οὐ μέγα ὃ ἦν τοῦ ἱεροῦ ἐσελθὼν, ἵνα μὴ ὑπαίθριος ταλαιπωροῖη, ἡσύχαζεν. οἱ δὲ τὸ παραυτικά μὲν ὑστέρησαν τῇ διώξει, μετὰ δὲ τοῦτο τοῦ τε οἴκηματος τὸν ὄροφον ἀφεῖλον **καὶ τὰς θύρας ἔνδον ὄντα τηρήσαντες αὐτὸν καὶ ἀπολαβόντες ἔσω ἀπωκοδόμησαν, προσκαθεζόμενοί τε ἐξεπολιόρκησαν λιμῷ.** καὶ μέλλοντος αὐτοῦ ἀποψύχειν ὥσπερ εἶχεν ἐν τῷ οἴκῳ, αἰσθόμενοι ἐξάγουσιν ἐκ τοῦ ἱεροῦ ἔτι ἔμπνουν ὄντα, καὶ ἐξαχθεῖς ἀπέθανε παραχρῆμα.

(He also gave Gongylus a letter for the [Persian] king, the contents of which were as follows, as was afterwards discovered: 'Pausanias, the general of Sparta, anxious to do you a favour, sends you these his prisoners of war. **I propose also, with your approval, to marry your daughter, and to make Sparta and the rest of Hellas subject to you. I may say that I think I am able to do this, with your co-operation.**

Accordingly if any of this please you, send a safe man to the sea through whom we may in future conduct our correspondence.'

[...] The Ephors listened carefully, and then departed, taking no action for the moment, but, having at last attained to certainty, were **preparing to arrest him in the city.** [...] Setting off with a run for the temple of the goddess of the Brazen House, the enclosure of which was near at hand, he succeeded in taking sanctuary before they took him, and entering into a small chamber, which formed part of the temple, to avoid being exposed to the weather, lay still there. The Ephors, for the moment distanced in the pursuit, afterwards took off the roof of the chamber, and having made sure that he was inside, **shut him in, barricaded the doors, and staying before the place, reduced him by starvation.** When they found that he was on the point of expiring, just as he was, in the chamber, they brought him out of the temple, while the breath was still in him, and as soon as he was brought out he died.)

[Thucydides, The Peloponnesian War, 1.128-134]

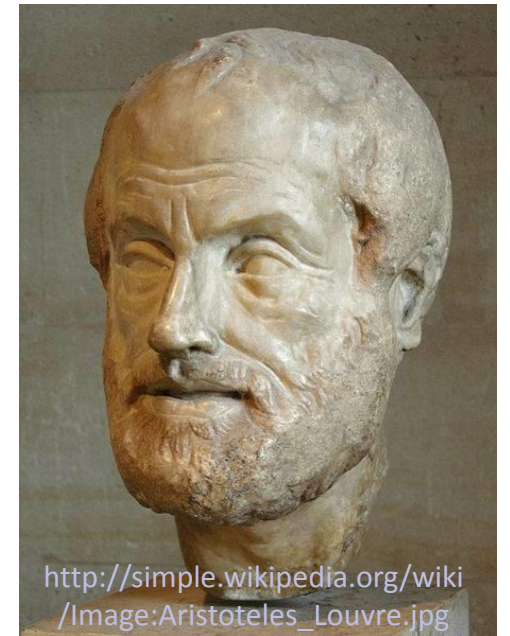
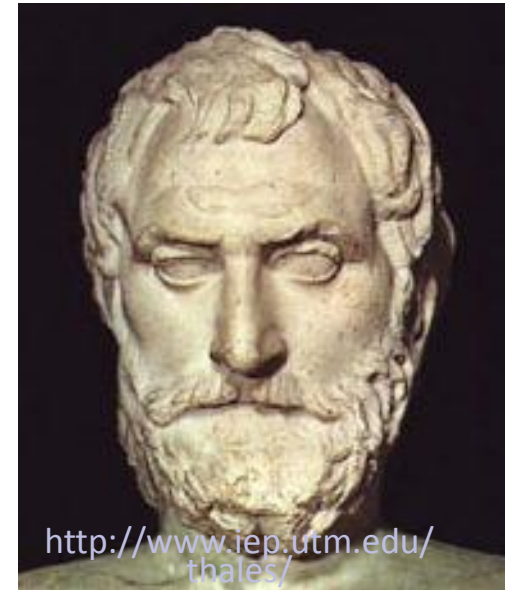


# Most important Greek contribution

It is in this “climate” of war (against Persians and civil) and betrayal, with frequent crises and massacres, that the Greek miracle occurred. The miracle includes, inter alia:

- Creation of philosophy and science, explaining nature and history based on reason (abandoning older hyperphysical explanations).
  - The father of philosophy and of science was (according to many) Thales of Miletus (640-546 BC).
- Conception of the principle of Orthos Logos (Recta Ratio, or Right Reason) in guiding human decisions and actions.
  - Aristotle (384-328 BC) was perhaps the first to formulate this principle:  
*τὸ μὲν οὖν κατὰ τὸν ὀρθὸν λόγον πράττειν κοινὸν καὶ ὑποκείσθω.*  
*(It is a common principle which must be accepted that we must act in accord with orthos logos.)*

Aristotle, Nicomachean Ethics 1103b



# Need is the mother of creativity

ἴθι δὴ, ἦν δ' ἐγώ, τῷ λόγῳ ἐξ ἀρχῆς ποιῶμεν πόλιν: ποιήσει δὲ αὐτήν, ὡς ἔοικεν, ἡ ἡμετέρα χρεία.

*(Come, then, let us create a city from the beginning, in our theory. Its real creator, as it appears, will be our needs.)*

Plato, Republic, 2.369c



Principle also known as “Necessity is the mother of invention.”

# Scarcity and poverty triggers progress in Athens

μάλιστα δὲ τῆς γῆς ἡ ἀρίστη αἰεὶ τὰς μεταβολὰς τῶν οἰκητόρων εἶχεν, ἢ τε νῦν Θεσσαλία καλουμένη καὶ Βοιωτία Πελοποννήσου τε τὰ πολλὰ πλὴν Ἀρκαδίας, τῆς τε ἄλλης ὅσα ἦν κρᾶτιστα. διὰ γὰρ ἀρετὴν γῆς αἶ τε δυνάμεις τισὶ μείζους ἐγγιγνόμεναι στάσεις ἐνεποιοῦν ἐξ ὧν ἐφθειρόντο, καὶ ἅμα ὑπὸ ἀλλοφύλων μᾶλλον ἐπεβουλεύοντο. τὴν γοῦν Ἀττικὴν ἐκ τοῦ ἐπὶ πλεῖστον διὰ τὸ λεπτόγεων ἀστασίαστον οὕσαν ἄνθρωποι ὥκουν οἱ αὐτοὶ αἰεὶ. καὶ παράδειγμα τόδε τοῦ λόγου οὐκ ἐλάχιστόν ἐστι διὰ τὰς μετοικίας ἐς τὰ ἄλλα μὴ ὁμοίως αὐξηθῆναι: ἐκ γὰρ τῆς ἄλλης Ἑλλάδος οἱ πολέμῳ ἢ στάσει ἐκπίπτοντες παρ' Ἀθηναίους οἱ δυνατώτατοι ὡς βέβαιον ὄν ἀνεχώρουν, καὶ πολῖται γιγνόμενοι εὐθύς ἀπὸ παλαιοῦ μείζω ἔτι ἐποίησαν πλήθει ἀνθρώπων τὴν πόλιν, ὥστε καὶ ἐς Ἴωνίαν ὕστερον ὡς οὐχ ἰκανῆς οὔσης τῆς Ἀττικῆς ἀποικίας ἐξέπεμψαν.

*The richest soils were always most subject to this change of masters; such as the district now called Thessaly, Boeotia, most of the Peloponnese, Arcadia excepted, and the most fertile parts of the rest of Hellas. The goodness of the land favoured the aggrandizement of particular individuals, and thus created faction which proved a fertile source of ruin. It also invited invasion. Accordingly Attica, from the poverty of its soil enjoying from a very remote period freedom from faction, never changed its inhabitants. And here is no inconsiderable exemplification of my assertion that the migrations were the cause of there being no correspondent growth in other parts. The most powerful victims of war or faction from the rest of Hellas took refuge with the Athenians as a safe retreat; and at an early period, becoming naturalized, swelled the already large population of the city to such a height that Attica became at last too small to hold them, and they had to send out colonies to Ionia.*

Thucydides, The Peloponnesian War, 1.2.3-6



# Reflection from mythology on water scarcity: The competition of Athena and Poseidon

- To choose their patron god, Athenians organized a competition for two candidates: Athena (goddess of wisdom) and Poseidon (god of waters).
- Poseidon offered **abundant** spring **water**.
- Athena offered the olive tree and an explanation why it would be wiser to choose her gift.
- Athenians opted for **wisdom**.
- Scarcity may not be a punishment (as in the biblical story) – but a **choice**.
- **Wisdom** may be more powerful than **abundance**.

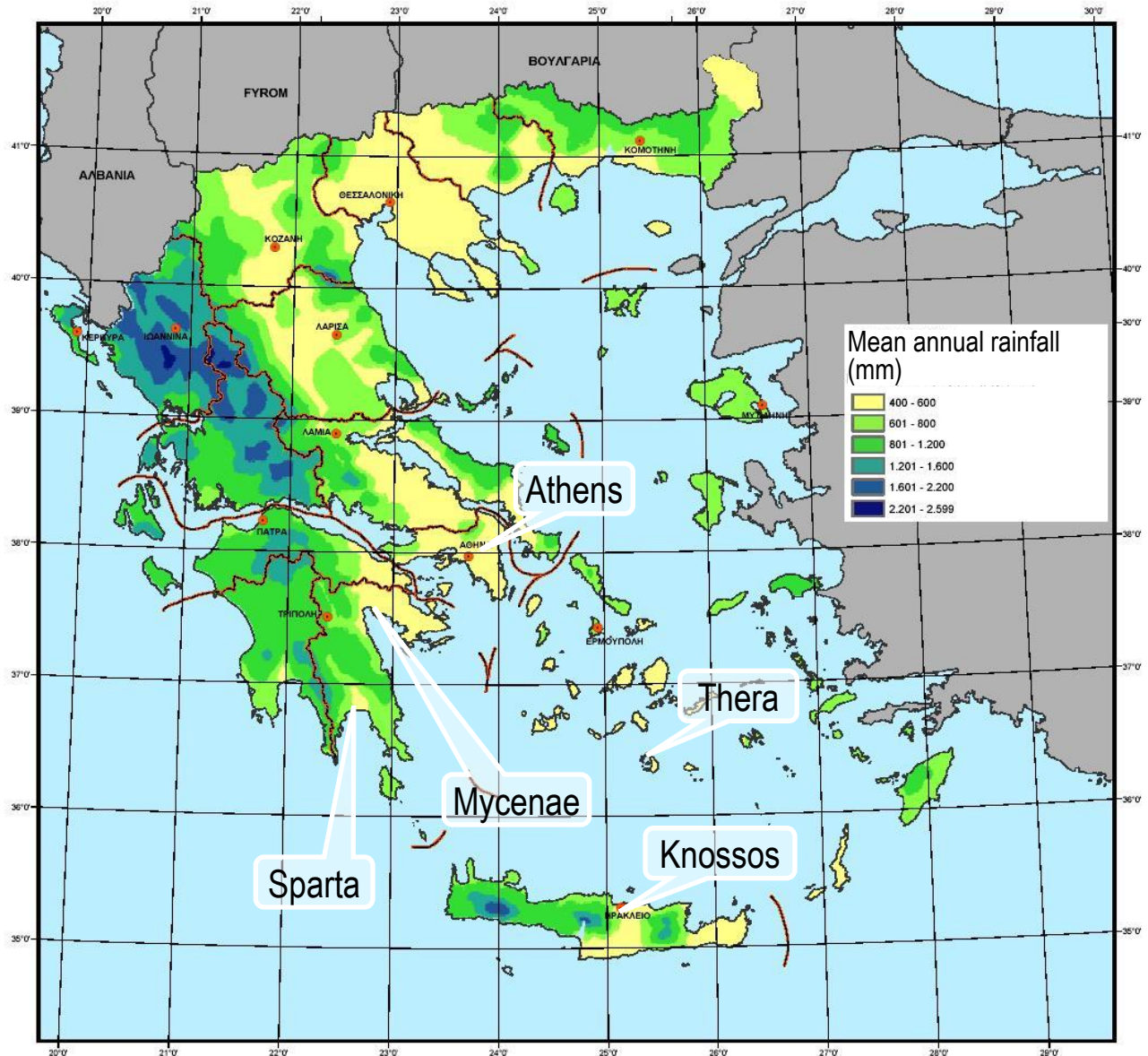


# Climatological conditions and the ancient Greek civilization

- Why ancient Greeks chose the driest places for their cities?

Or

- Why the settlements on driest places were the most flourishing?  
(Life in dry climate is more convenient and healthier?)
- What are the consequences/impacts of water scarcity on cultural progress?  
(Can scarcity trigger progress in technology and management?)



# Wisdom in early water legislation in Athens

- *ἐπεὶ δὲ πρὸς ὕδωρ οὔτε ποταμοῖς ἐστὶν ἀενάοις οὔτε λίμναις τισὶν οὔτ' ἀφθόνοις πηγαῖς ἢ χώρα διαρκῆς, ἀλλ' οἱ πλεῖστοι φρέασι ποιητοῖς ἐχρῶντο, νόμον ἔγραψεν, ὅπου μὲν ἐστὶ δημόσιον φρέαρ ἐντὸς ἵππικοῦ, χρῆσθαι τούτῳ: τὸ δ' ἵππικὸν διάστημα τεσσάρων ἦν σταδίων: ὅπου δὲ πλεῖον ἀπέχει, ζητεῖν ὕδωρ ἴδιον: ἐὰν δὲ ὀρύξαντες ὀργυιῶν δέκα βάθος παρ' ἑαυτοῖς μὴ εὔρωσι, τότε λαμβάνειν παρὰ τοῦ γείτονος ἐξάχουν ὑδρίαν δις ἐκάστης ἡμέρας πληροῦντας: ἀπορία γὰρ ᾧετο δεῖν βοηθεῖν, οὐκ ἀργίαν ἐφοδιάζειν*  
*(Since the area is not sufficiently supplied with water, either from continuous flow rivers, or lakes or rich springs, but most people used artificial wells, Solon made a law, that, where there was a public well within a hippicon, that is, four stadia [710 m], all should use that; but when it was farther off, they should try and procure water of their own; and if they had dug ten fathoms [18.3 m] deep and could find no water, they had liberty to fetch a hydria (pitcher) of six choae [20 L] twice a day from their neighbours; for he thought it prudent to make provision against need, but not to supply laziness.)*

*Plutarch, Solon, 23*

- Important elements of this law are (a) the priority of public wells and their protection; (b) the balance of the public and private interests for the construction and operation of wells; (c) the regulation of relationships among individuals in order to cover water needs of all citizens.



# Legislation for water

- **Water supply safety:** The water supply of classical Athens mainly depended on large-scale public works (aqueducts). However, private installations like wells and cisterns were necessary, particularly in times of war and crisis; it is thus hypothesized that there were regulations forcing people to maintain the wells at a good condition and ready to use, as indicated by the following passage:

*ὕδατων τε καὶ ναμάτων μάλιστα μὲν ὑπάρχειν πλῆθος οἰκεῖον, εἰ δὲ μή, τοῦτό γε εὖρηται διὰ τοῦ κατασκευάζειν ὑποδοχὰς ὀμβρίοις ὕδασιν ἀφθόρους καὶ μεγάλας, ὥστε μηδέποτε ὑπολείπειν εἰργομένους τῆς χώρας διὰ πόλεμον.*

*(...and [the city] must possess if possible a plentiful natural supply of pools and springs, but failing this, a mode has been invented of supplying water by means of constructing an abundance of large reservoirs for rainwater, so that a supply may never fail the citizens when they are debarred from their territory by war.)*

Aristotle, Politics, 7, 1330b

- **Flood damages:** From Demosthenes' speech *Against Kallikles*, which refers to property damage after heavy rain and flooding, we can infer that there was a law penalizing anyone responsible for a man-made obstruction to natural flow of water, which caused damage to someone else's property (penalty 1000 drachmas or else forfeit of the land on which the obstruction stood; MacDowell, 1986; Krasilnikoff, 2002).
- **Protection from pollution:** An epigraph of about 440 or 420 BC contains the "law for tanners", according to which no one 'was to soak skins in the Ilissos above the precinct of Herakles, nor to dress hides, nor to [throw rubbish?] into the river (MacDowell, 1986).

# Institutions

- In Athens a distinguished public administrator, called «κρουνῶν ἐπιμελητής», (Superintendent of Fountains), was appointed to operate and maintain the city's water system, to monitor enforcement of the regulations and to ensure the fair distribution of water.
- From Aristotle we learn that this officer was one of the few that were elected by vote whereas other officers were chosen by lot; an interpretation is that this position was particularly important; the relevant extract is:

*τάς δ' ἀρχάς τὰς περὶ τὴν ἐγκύκλιον διοίκησιν ἀπάσας ποιοῦσι κληρωτάς, πλὴν ταμίου στρατιωτικῶν καὶ τῶν ἐπὶ τὸ θεωρικὸν καὶ τοῦ τῶν κρηνῶν ἐπιμελητοῦ. ταύτας δὲ χειροτονοῦσιν, καὶ οἱ χειροτονηθέντες ἄρχουσιν ἐκ Παναθηναίων εἰς Παναθήναια. χειροτονοῦσι δὲ καὶ τὰς πρὸς τὸν πόλεμον ἀπάσας.*

*(All the officials concerned with the regular administration are appointed by lot, except a Treasurer of Military Funds, the Controllers of the Spectacle Fund, and the Superintendent of Fountains; these officers are elected by show of hands, and their term of office runs from one Panathenaic Festival to the next. All military officers also are elected by show of hands.)*

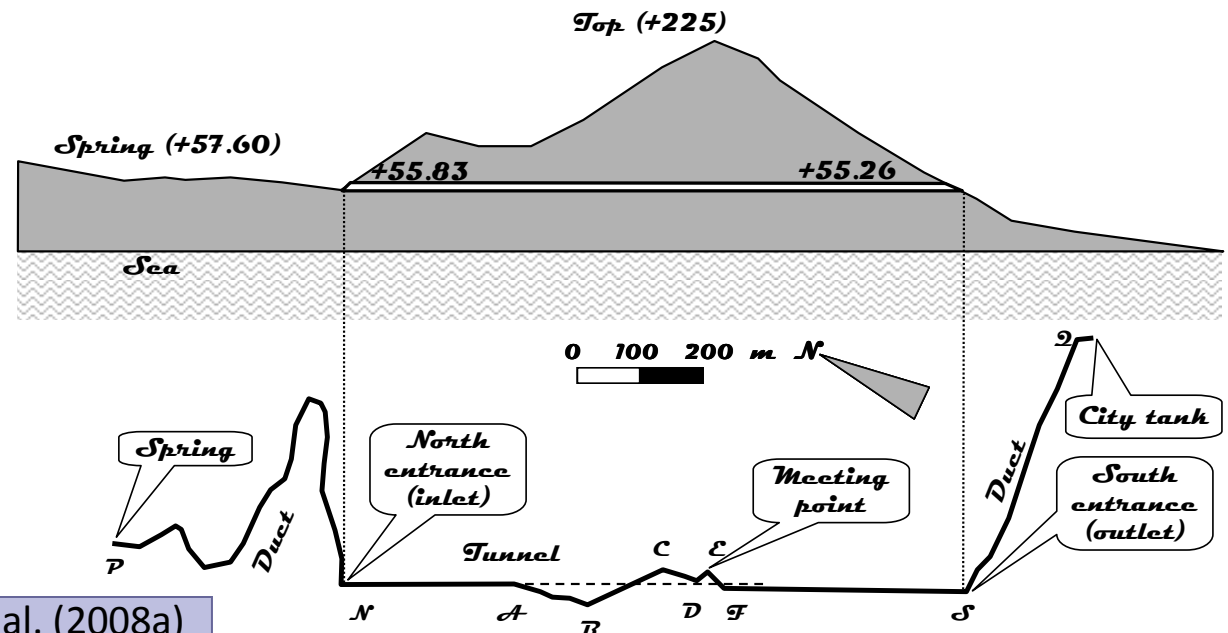
Aristotle, *Athenaion Politeia*, 43.1

- Themistocles himself had served in this position.
- Generally, private sponsoring of public hydraulic systems was encouraged; e.g. in 333 BC the Athenians awarded a gold wreath to the Superintendent of Fountains Pytheus because he restored and maintained several fountains and aqueducts.
- The entire regulatory and management system of water in Athens must have worked very well and approached what today we call sustainable water management.



# Ancient hydraulic technology: The water supply of Samos and the tunnel of Eupalinos

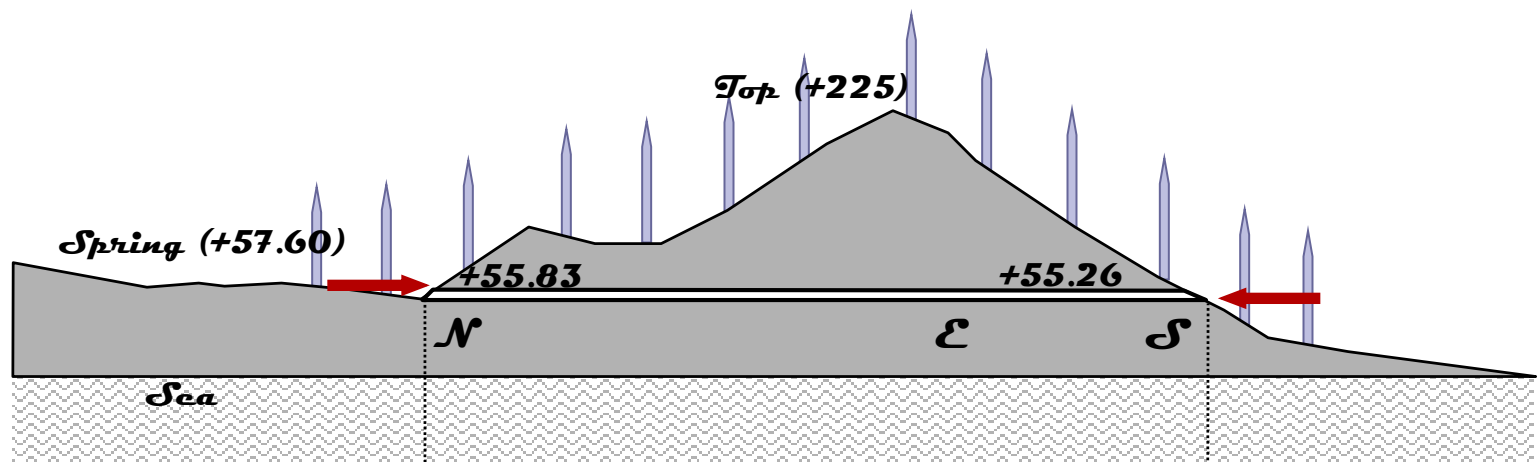
- The most famous hydraulic work of ancient Greece was the aqueduct of ancient Samos, which was admired both in antiquity (e.g. Herodotus) and in modern times.
- The most amazing part of the aqueduct is the «Εὐπαλίνειον ὄρυγμα», or “Eupaninean digging”, after Eupalinos, an engineer from Megara: a 1036 m long tunnel dug from two openings.
- Its construction started in 530 BC, during the tyranny of Polycrates, and took ten years.
- Owing to the text of Herodotus, the entrance of the aqueduct was uncovered in 1856; only ninety years later, between 1971 and 1973, the German Archaeological Institute of Athens uncovered the entire tunnel.



Sketch from Koutsoyiannis et al. (2008a)

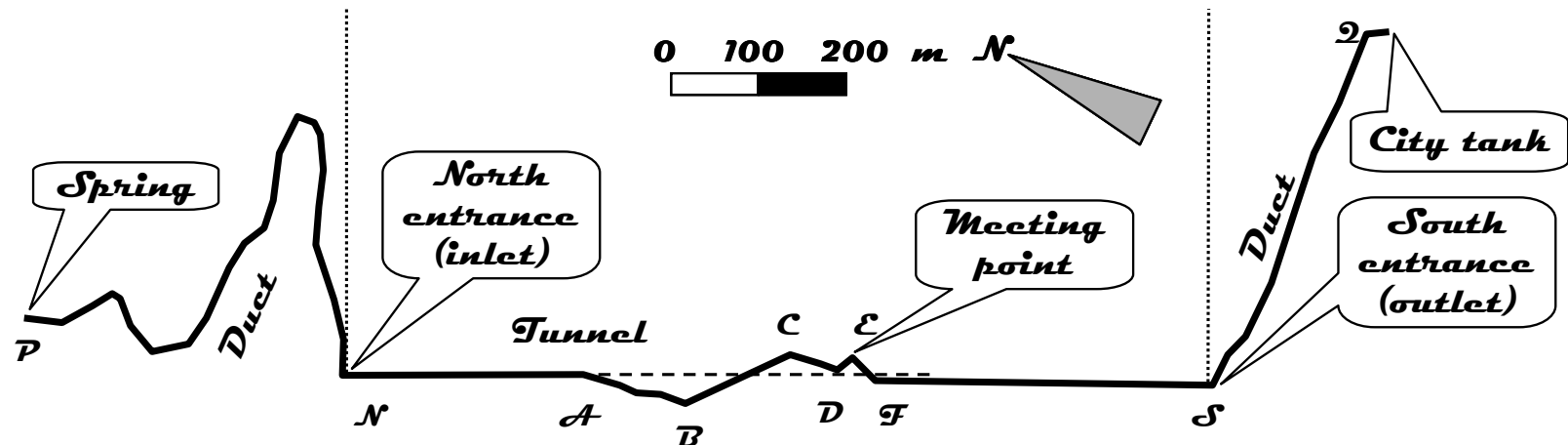
# The great achievements of Eupalinos

- He constructed the first known deep tunnel in history; shallow tunnels are much easier to construct (qanat technology).
- Like in modern construction practice, he started from two openings (N and S); the point E where the two construction lines met is known.
- To carve segments of the same straight line from two openings in a mountainous terrain, he must have had a good working knowledge of geometry and geodesy.
- There is evidence that Eupalinos solved the problem with simple means and in an accurate manner by putting poles up over the mountain along the path in a straight line (a simple method used even today in engineering geodesy, but for simpler problems – not for the construction of tunnels); then he lined up the workers in the tunnel segments with these poles.



## The great achievements of Eupalinos (2)

- He showed that from an engineering point of view a straight line may not necessarily be the best path; thus, at point A he left the straight line NA and followed the direction AB, a plausible explanation for this being that he found a natural fracture or rift and broadening this he was able to proceed faster.
- He found a clever geometrical way to eliminate the impact of uncertainty in position and direction (magnified due to already abandoning of the straight line route) and ensure the intersection of the two construction lines: by deliberately abandoning the straight line routes at points D and F and changing direction to the left and right, respectively, made it mathematically certain that the two lines would intersect.



# The great achievements of Eupalinos (3)

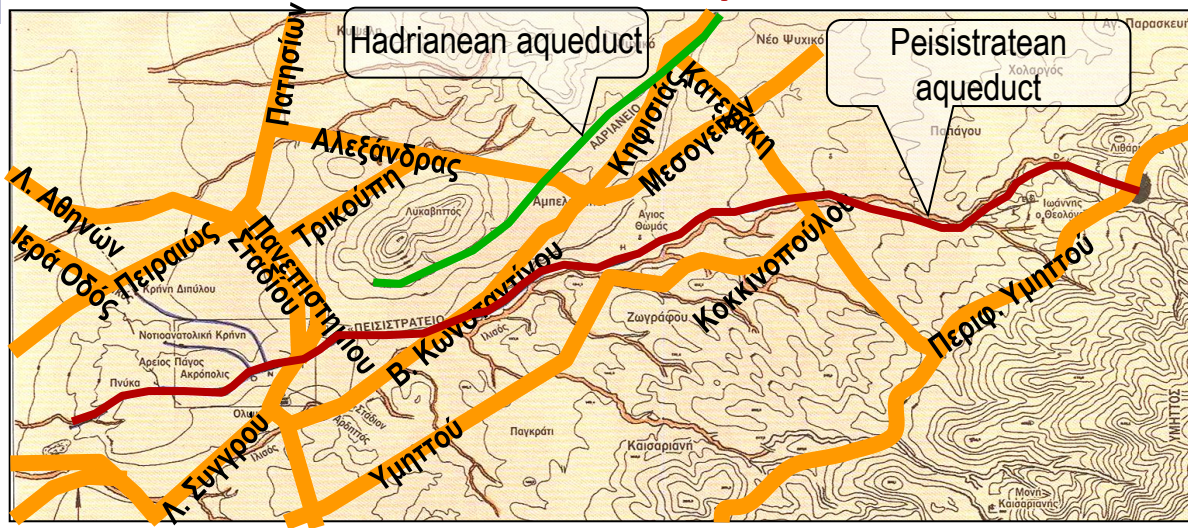
- He devised an especially smart engineering solution to balance the construction needs with the physical properties of water flow.
- On the one hand, the choice of a **horizontal** main tunnel was dictated by the technological means of the time, while a sloping one would be impossible to construct from two sides; note that the accumulation of groundwater in the upper (viz. down-sloping) segment would not allow its construction.
- On the other hand he was aware of the hydraulic principle that water needs a **gradient** to flow.
- In the horizontal tunnel he achieved the necessary gradient by excavating a sloping channel along one side of the floor; in places where due to slope the channel would be very deep, a second small tunnel below the main tunnel was built.



courtesy of G. Papakonstantis



# The Peisistratean aqueduct in Athens



- The first major hydraulic project in Athens was constructed under the tyrant Peisistratos (in power between 546-527 BC) and his sons.
- The largest part of the aqueduct was carved as a tunnel at depth reaching 14 m.
- Other aqueducts were also constructed with similar technologies in several phases forming a network of pipelines; one of them, the Hymettus aqueduct, follows a route parallel to the Peisistratean.
- Greek hydraulic constructions were mostly underground for security reasons (not no be exposed to aliens, e.g. in case of war)



For cleaning and maintenance, in their upper part the pipes had elliptic openings covered by ceramic covers.



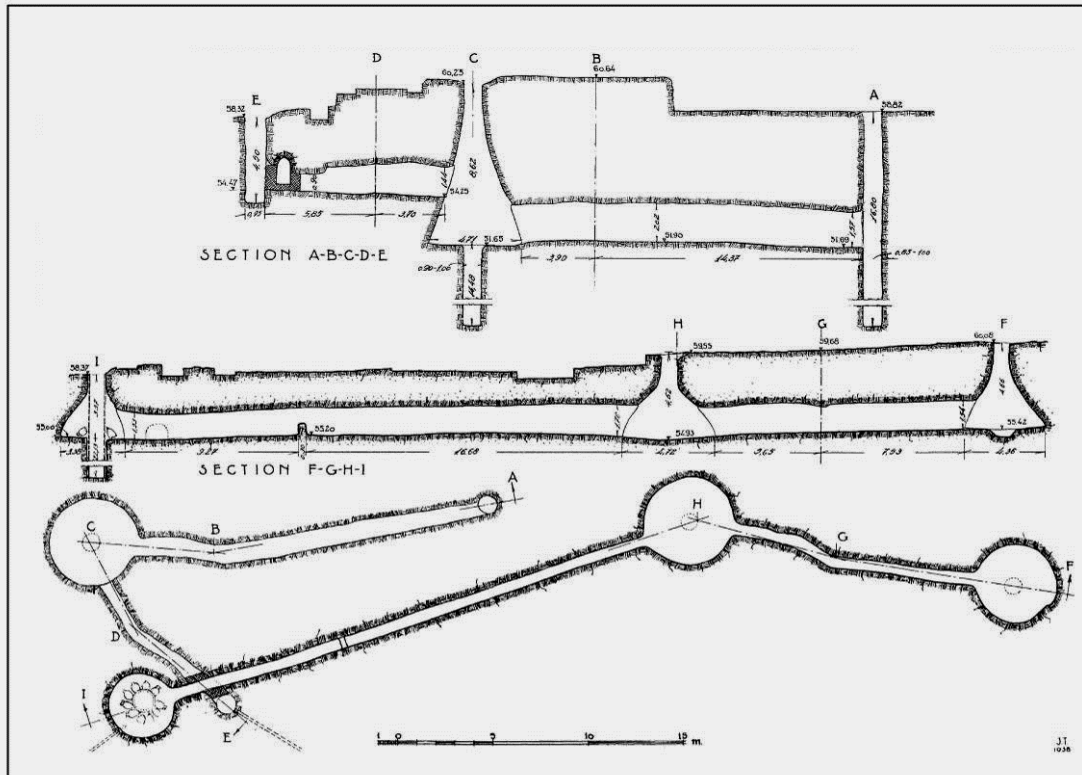
# The Hadrianean aqueduct in Athens

- The last and longest aqueduct of the ancient times, the Hadrianean aqueduct, was constructed in Roman times.
- Its length is 25 km and, as all earlier ones, it was subterranean at typical depths of 20-30 m.



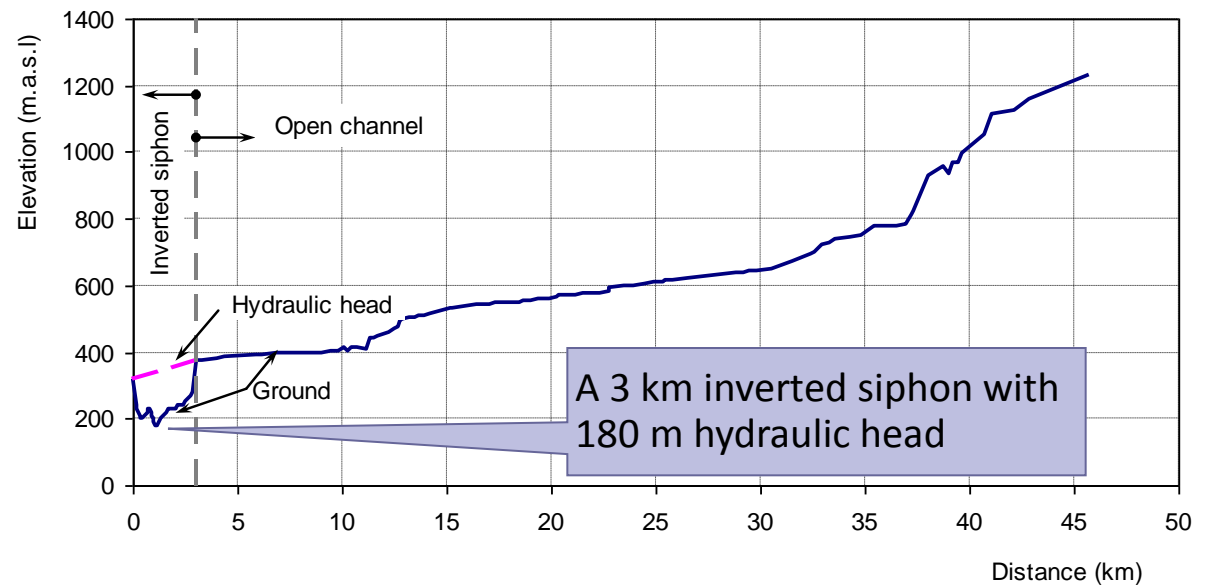
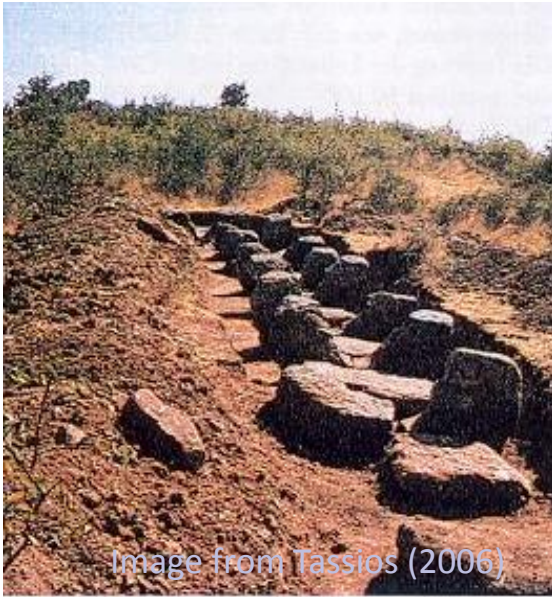
# Small scale water constructions in Athens

- In addition to large-scale aqueducts, Athens had numerous small scale constructions, such as wells for groundwater exploitation and cisterns receiving rainwater from roofs.
- In several cases, such small-scale constructions were interconnected forming complex systems storing groundwater and rainwater.



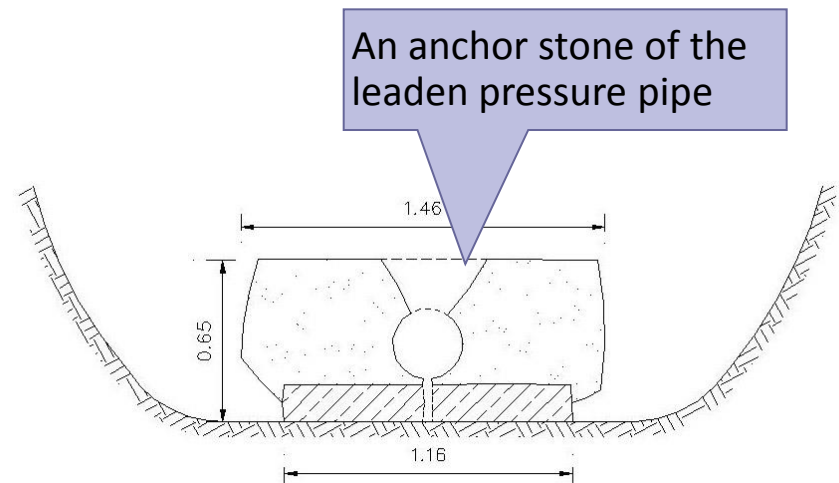
Plan and sections of a system of interconnected cisterns near the Hephaisteion in Athenian Agora (Thompson 1940; Chiotis and Chioti, 2012).

# Pressurized flow and the Pergammon aqueduct



The scientific progress in Hellenistic period allowed, for first time in history, application of the pressurized flow on large technological scale for water conveyance.

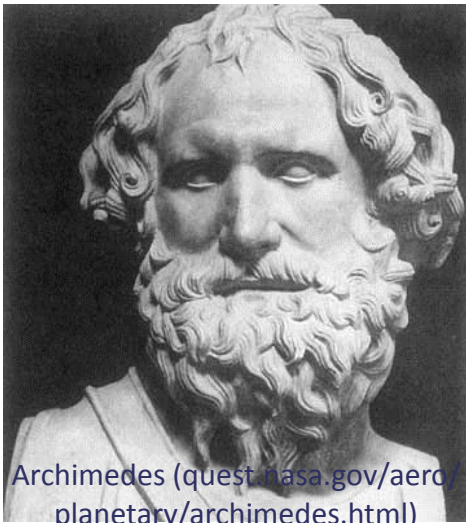
In the city of Pergamon (located on top of a hill, 30 km inland from the Aegean Sea, in Western Anatolia, now Turkey), one aqueduct (Madradag) included an inverted siphon made of metal (lead) and anchored with big stone constructions (Figures from Koutsoyiannis et al., 2008a).



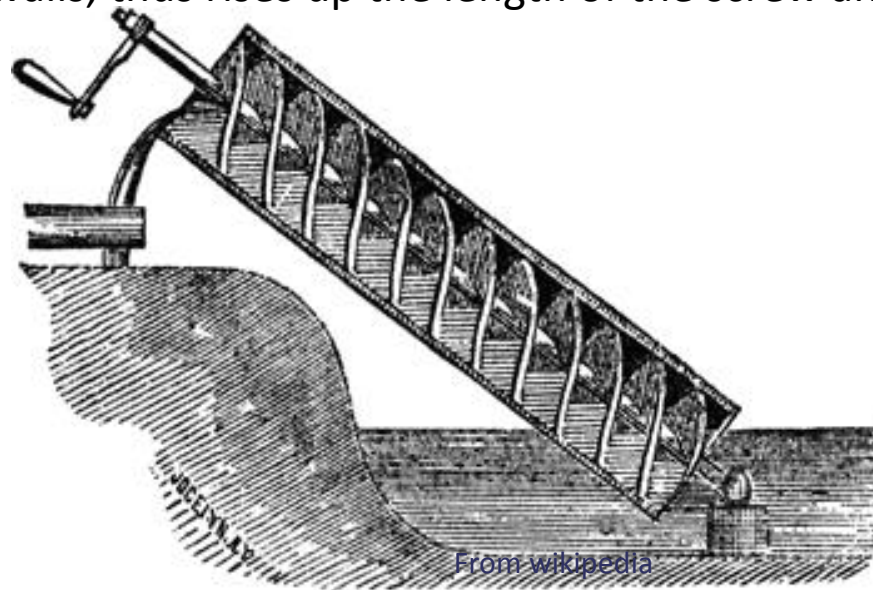


# Hydraulic mechanisms and pumping devices

- Although in antiquity several devices were in use to lift water to a higher elevation, the first pump with the modern meaning is Archimedes's helix or water-screw.
- Archimedes was a Syracusan mathematician and engineer (287-212 BC) considered by many to be the greatest mathematician of antiquity or even of the entire history; the invention of the water screw is tied to the study of the spiral, for which Archimedes wrote a treatise entitled *On Spirals*, in 225 BC.
- This pump is an ingenious device functioning in a simple and elegant manner by rotating an inclined cylinder bearing helical blades around its axis whose bottom is immersed in the water to be pumped; as the screw turns, water is trapped between the helical blades and the walls, thus rises up the length of the screw and drains out at the top.



Archimedes ([quest.nasa.gov/aero/planetary/archimedes.html](http://quest.nasa.gov/aero/planetary/archimedes.html))



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# **Water problems in modern societies**

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# Continuity of small-scale technologies up to present date

These pictures are from a 300-year old country house in the Cephalonia island, which still implements a traditional water supply system (for drinking water and garden irrigation) comprising a couple of cisterns; the only modern adaptation is the replacement of the bucket with a pump (photos by author).



# Ancient Greek inheritance to the modern Athens water system

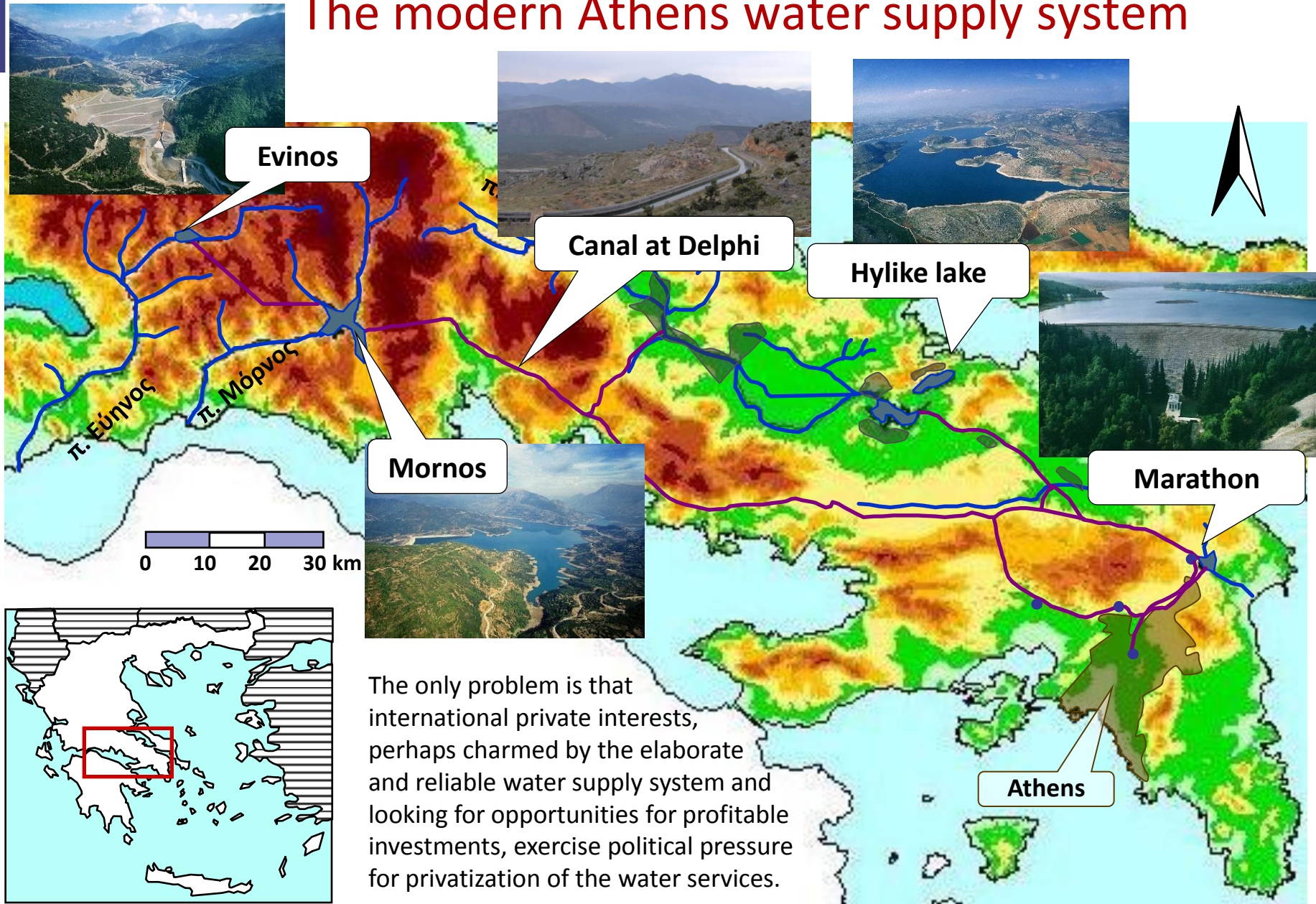
- One aqueduct (Peisistratian or Hymettus?) is still in operation providing irrigation water to the National Garden.
- The Hadrianean aqueduct used to provide drinking water up to the mid-twentieth century.
  - Currently research is under way investigating the possibility of rehabilitating it and putting it again into operation.
- Ancient technologies are still in use in several cases.



Archimedes's water screw in its modern form, as implemented in the wastewater treatment plant of Athens (1 of 5 screws that pump 1 million m<sup>3</sup> per day).



# The modern Athens water supply system

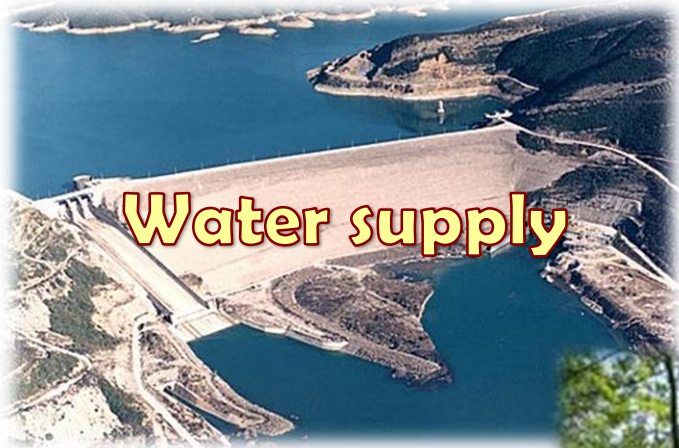


# Why companies want to “invest” in the Athens water system? Aren't there other water problems worldwide?

- 18% of the world population (~1 billion) do not have “reasonable access to water” (Howard & Bartram, 2003).
- “Reasonable access to water” is meant to be 20 L/d per capita at a distance of less than 1 km; this is too low as a target, and even if it were achieved, again it would indicate regression if compared to what the ancients had achieved.
- Half of the urban population in Africa, Asia, and Latin America suffers from diseases associated with inadequate water and sanitation (Vörösmarty *et al.*, 2005).
- Every year, thousands of people die due to floods, the most severe among all natural hazards. The situation may have worsened recently in several areas of the world, in which urbanization was not combined with urban water infrastructure.
- All these problems, including water scarcity, are mostly caused by lack of technological infrastructure for water and, eventually, lack of investment in water (not e.g. by climate change which is often used as a scapegoat).



# Major *real* challenges of the 21<sup>st</sup> century



# Obscuring of real problems by current ideological currents

- From ancient times up to the 20th century, **engineering solutions to real world problems** had a prominent position: By modifying the natural environment using **engineering means**, societies in the developed countries benefited substantially.
- This allowed increase of the **population and its wealth**, better **quality of life**, more **hygienic life style** and, most importantly, **spectacularly increased life expectation**.
- Toward the end of the 20th century, as the infrastructures were completed to a large extent in the developed world, engineering started to lose importance and engineering solutions were replaced by virtual reality games.
- **Environmentalism**, the now dominant ideological current and social movement, focusing on environmental conservation and improvement, and emphasizing a duty to **save the planet from diverse threats**, has also determined the social views of water related problems and solutions.
- This current fully harmonizes with dominant political agendas and thus has been as powerful as to dictate where research funding is directed (e.g. in studying hypothetical climate-related threats and impacts).
- Most of these developments indicate a departure from the Aristotelian principle of “orthos logos” (cf. Gross et al., *The Flight From Science and Reason*, New York Academy of Sciences, 1996).

# The “soft path”

- In water affairs, the departure from orthos logos has been epitomized in the so-called “**soft path**” for water (Gleick, 2002, 2003), which,  
*“by investing in decentralized facilities, efficient technologies and policies, and human capital [...] will seek to improve overall productivity rather than to find new sources of supply [and] will deliver water services that are matched to the needs of end users, on both local and community scales.”*
- This has been promoted as a contrasting alternative to engineering solutions that rely on infrastructure development, which Gleick (2002) calls the “hard path” and criticizes for:  
*“spawning ecologically damaging, socially intrusive and capital-intensive projects that fail to deliver their promised benefits.”*
- In one of the rare instances that the concept was criticized, Stakhiv (2011) found it wholly inadequate for the needs of most of the developing world.
- Interestingly, the groups that project threats like bigger floods and droughts of greater duration due to climate change, and highlight the need for adaptation to climate change, are the same groups that discourage building new water projects and promote their “soft path” for developing nations.
- The promotion of the related ideas has been largely based on **hype**.

# Most typical hype: Hydroelectric energy is not renewable and not sustainable

- Business lobbying and “green” ideological influences have imposed laws or regulations that define “small hydro” as renewable and sustainable, whereas “large hydro” is labelled as **not** renewable/sustainable (Frey and Linke, 2002).
- An example from Greek legislation “*The hydraulic power generated by hydroelectric plants, which have a total installed capacity more than 15 MW, is excluded from the provisions of this Act*” (Act 3468/2006, Art. 27, par. 4, [www.rae.gr/downloads/sub2/129\(27-6-06\)\\_3468.pdf](http://www.rae.gr/downloads/sub2/129(27-6-06)_3468.pdf)).
- Related grey literature abounds (e.g. “*Hydro power is not renewable. Hydroelectric power depends on dams, and dams have a limited life [...] because the reservoir fills with silt*”; [http://web.archive.org/web/20090711160342/http://letters.salon.com/tech/htww/2009/07/07/wild\\_salmon\\_cause\\_global\\_warming/view/](http://web.archive.org/web/20090711160342/http://letters.salon.com/tech/htww/2009/07/07/wild_salmon_cause_global_warming/view/)).
- Such developments indicate total misunderstanding of what renewable energy is as well as ignorance of the characteristics of hydropower.
- In particular they are in full contradiction with the fact that **without hydropower there can be no large-scale renewable energy at all.**



# Who is the target of the hype about hydroelectric development?

Continent	Economically feasible hydro potential (% of world)	Exploitation percentage (%)
Europe	10	75
North & Central America	13	75
South America	20	30
Asia	45	25
Africa	12	8

Source: Leckscheidt and Tjaroko (2003).

# An encouraging brand new development

- In July 2013 the World Bank (2013) decided to re-engage in large-scale hydropower infrastructure after having withdrawn from it for the past two decades.
- The report of the World Bank (2013) highlights the fact that nearly 3/4 of potential hydropower resources in the developing world are yet to be realized, including more than 90% in Sub-Saharan Africa and about 70% in South Asia.
- The report now recognizes that for many countries, hydropower is the largest source of affordable renewable energy and that reservoir hydropower can pave the way for the later introduction of other forms of renewable energy.
- Furthermore it recognizes the unique ability of hydropower to instantly offset variability of other parts of the electric power system, as well as the potential for pumped storage to store, for example, wind energy during periods of surplus.
- It is very positive that these unique abilities of hydropower (Koutsoyiannis *et al.*, 2008b, 2009; Koutsoyiannis, 2011) are now understood by the World Bank and this creates hopes that it may be understood by others too.
- While this strategic change of World Bank has been carefully assessed and reported by some groups (Appleyard, 2013), naturally it disappointed other groups (Bosshard, 2013).

# Greece vs. Europe in hydroelectric development

Country*	Economically feasible hydro potential (TWh/year)	Production from hydro plants (TWh/year)	Exploitation percentage (%)
Germany	25	25	100
France	72	70	97
Italy	55	52	95
Switzerland	36	34	94
Spain	40	35	88
Sweden	85	68	80
Norway**	180	120	67
...			
Greece	15	4.7	31

The most developed countries have already developed almost all economically feasible hydro potential. No country has put its hydropower stations into question as being “non-sustainable”.

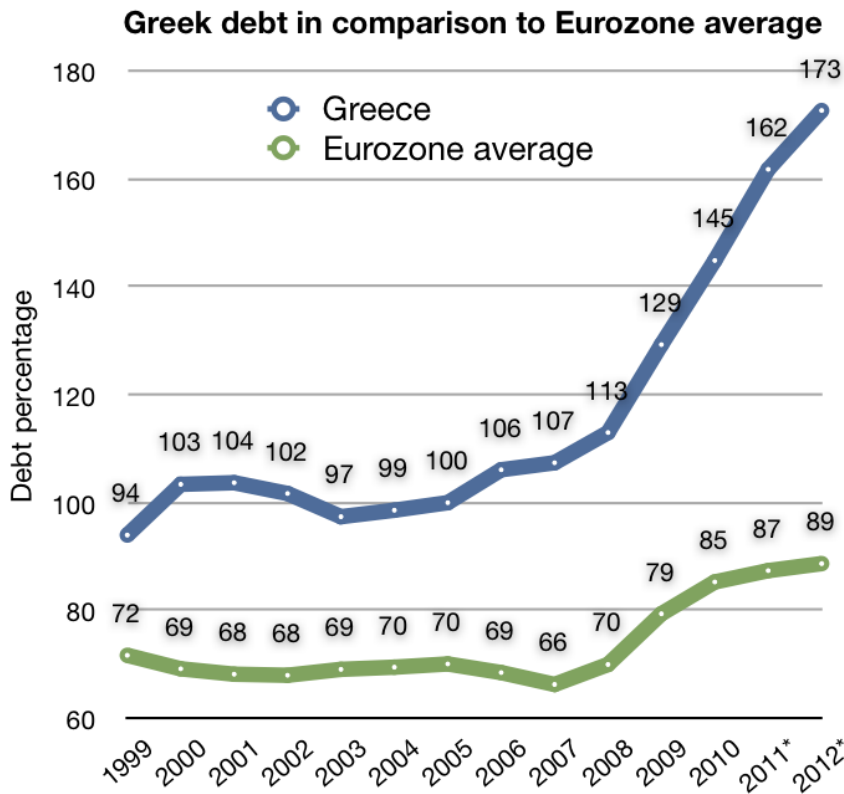
Greece is a dreary exception.

\* Data from Leckscheidt and Tjaroko (2003) in general and Stefanakos (2008) for Greece.

\*\* Norway’s hydroelectricity production is about ~99% of its total electricity (data from [www.bp.com/productlanding.do?categoryId=6929&contentId=7044622](http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622)).



# Greece preferred loans over developing its resources



\*estimate

Source: Eurostat

Sources:

<http://www.bbc.co.uk/news/business-13798000>

<http://www.dailymail.co.uk/news/article-2007949/The-Big-Fat-Greek-Gravy.html>

[http://upload.wikimedia.org/wikipedia/commons/2/29/Greece\\_public\\_debt\\_1999-2010.svg](http://upload.wikimedia.org/wikipedia/commons/2/29/Greece_public_debt_1999-2010.svg)

## The Big Fat Greek Gravy Train: A special investigation into the EU-funded culture of greed, tax evasion and scandalous waste

BBC Mobile

### NEWS BUSINESS

What went wrong in Greece?

Greece went on a big, debt-funded spending spree, including paying for high-profile projects such as the 2004 Athens Olympics, which went well over its budget.

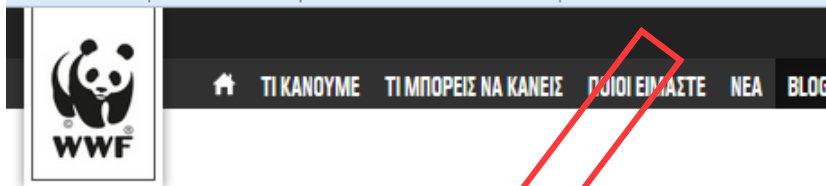
# Greece preferred to import virtual water over developing its resources and its production

**Table 4** Virtual water trade balance of Greece (hm<sup>3</sup>/year; Source: Roson & Sartori, 2010).

Trading country	Exports	Imports	Balance
Albania	83.4	4.7	+78.7
Croatia	16.7	3.0	+13.7
Cyprus	52.0	5.3	+46.7
Egypt	5.4	91.4	-86.0
France	45.0	541.9	-496.9
Italy	242.3	171.3	+71.0
Morocco	0.9	4.9	-4.0
Spain	36.1	121.6	-85.5
Tunisia	1.1	4.2	-3.1
Turkey	30.9	143.1	-112.2
Rest Europe	1662.3	890.5	+771.8
Rest MENA	49.5	42.7	+6.8
Rest World	165.3	2337.5	-2172.2
Total	2390.9	4362.0	-1971.1

Source:  
Koutsoyiannis  
(2011).

# Greenery and political parties celebrate a recent victory against water development in Greece



An ancient myth turned into a modern victory for nature

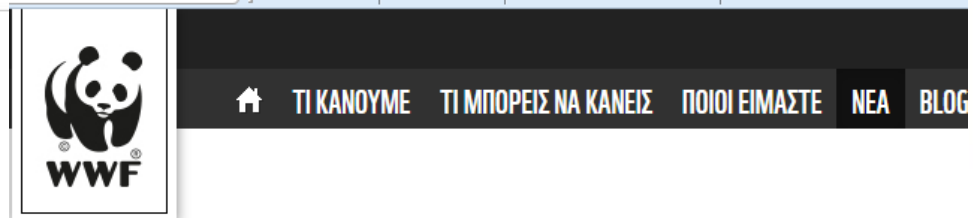


Αρχική > ΠΕΡΙΒΑΛΛΟΝ > ΠΕΡΙΒΑΛΛΟΝΤΙΚΗ ΠΟΛΙΤΙΚΗ > Χαιρετίζει ο ΣΥΡΙΖΑ την απόφαση κατά της "μεγάλης ιδέας" της εκτροπής του Αχελώου

## Χαιρετίζει ο ΣΥΡΙΖΑ την απόφαση κατά της "μεγάλης ιδέας" της εκτροπής του Αχελώου

Σταυρογιάννη Δούλη | 15.01.2014

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εκτροπή του Αχελώου. Δικαιώνει έτσι έναν συνεπή και  
ποταμός από ένα παράλογο και κακοσχεδιασμένο έργ

# The meaning of the ancient myth of Heracles vs. Acheloos



[http://www.britishmuseum.org/research/collection\\_online/collection\\_object\\_details/collection\\_image\\_gallery.aspx?partid=1&assetid=909709&objectid=461907](http://www.britishmuseum.org/research/collection_online/collection_object_details/collection_image_gallery.aspx?partid=1&assetid=909709&objectid=461907)

Attic red figure vase, 6th century BC depicting the battle of Hercules against Acheloos, in which Hercules won (image from British Museum)

ὡς Ἡρακλέους καταπολεμήσαντος τὸν Ἀχελῷον καὶ ἐνεγκαμένου τῆς νίκης ἄθλον τὸν Δηιανείρας γάμον τῆς Οἰνέως θυγατρὸς, ἣν πεποίηκε Σοφοκλῆς τοιαῦτα λέγουσαν“ μνηστήρ γὰρ ἦν μοι ποταμός, Ἀχελῷον λέγω, ὃς μ’ ἐν τρισὶν μορφαῖσιν ἐξήτει πατρός, φοιτῶν ἐναργῆς ταῦρος, ἄλλοτ’ αἰόλος δράκων λικτός, ἄλλοτ’ ἀνδρείω κύτει βούπρωρος. προστιθέασι δ’ ἐνιοὶ καὶ τὸ τῆς Ἀμαλθείας τοῦτ’ εἶναι λέγοντες κέρασ, ὃ ἀπέκλασεν ὁ Ἡρακλῆς τοῦ Ἀχελῷου καὶ ἔδωκεν Οἰνεῖ τῶν γάμων ἔδνον: οἱ δ’ εἰκάζοντες ἐξ αὐτῶν τάληθές ταύρω μὲν εἰκότα λέγεσθαι τὸν Ἀχελῷόν φασι, καθάπερ καὶ τοὺς ἄλλους ποταμούς, ἀπὸ τε τῶν ἤχων καὶ τῶν κατὰ τὰ ρεῖθρα καμπῶν, ἃς καλοῦσι κέρατα, δράκοντι δὲ διὰ τὸ μῆκος καὶ τὴν σκολιότητα, βούπρωρον δὲ διὰ τὴν αὐτὴν αἰτίαν δι’ ἣν καὶ ταυρωπόν: τὸν Ἡρακλέα δὲ καὶ ἄλλως εὐεργετικὸν ὄντα καὶ τῷ Οἰνεῖ κηδεύσοντα **παραχώμασί τε καὶ διοχετείας βιάσασθαι τὸν ποταμὸν πλημμελῶς ῥέοντα καὶ πολλὴν τῆς Παραχελωίτιδος ἀναψύξαι χαριζόμενον τῷ Οἰνεῖ: καὶ τοῦτ’ εἶναι τὸ τῆς Ἀμαλθείας κέρασ.**

*(And this is the cause of the fabrication of a certain myth, telling how Heracles defeated Acheloos and, as the prize of his victory, won the hand of Deianeira, the daughter of Oeneus, whom Sophocles represents as speaking as follows: “For my suitor was a river-god, I mean Acheloos, who would demand me of my father in three shapes, coming now as a bull in bodily form, now as a gleaming serpent in coils, now with trunk of man and front of ox.” Some writers add to the myth, saying that this was the horn of Amaltheia, which Heracles broke off from Acheloos and gave to Oeneus as a wedding gift. Others, conjecturing the truth from the myths, say that the Acheloos, like the other rivers, was called "like a bull" from the roaring of its waters, and also from the the bendings of its streams, which were called Horns, and "like a serpent" because of its length and windings, and "with front of ox" for the same reason that he was called "bull-faced"; and that Heracles, who in general was inclined to deeds of kindness, but especially for Oeneus, since he was to ally himself with him by marriage, **regulated the irregular flow of the river by means of embankments and channels, and thus rendered a considerable part of Paracheloitis dry, all to please Oeneus; and that this was the horn of Amaltheia.**)*

Strabo (ca. 64 BC-24 AD), Geography, 10.2



# A Greek technological breakthrough: The empty Mesochora reservoir

- Part of the Upper Acheloos project is the Mesochora dam, reservoir and hydropower station.
- The power plant in the Upper Acheloos River with installed capacity 170 MW and energy potential of 340 GWh/year.
- The dam and the hydropower plant have been constructed (an investment of 500 M€) and have been ready for use since 2001.
- However, they have not been put into operation, thus causing a loss of 25 M€/year to the national economy (see Koutsoyiannis, 2011).
- This totally irrational situation has been the most representative example of a course that led Greece to the current financial crisis.



# Water transfer projects: Greece vs. India

- Several trials in the Greek Supreme Court thwarted several times the Acheloos interbasin water transfer plans, which had to repeatedly change to comply with the court directives.
- It may be didactic for Greeks to compare this story with that of a much bigger plan in the rapidly developing India, the National River Linking Project (Saleth, 2011).
- When completed, this will be the largest water infrastructure project ever undertaken in the world. It will connect 37 Himalayan and Peninsular rivers through 30 links, involving 3000 storage dams and 12 500 km of water conveyance networks, and handling 178 km<sup>3</sup> of inter-basin water transfers.
- Lacking governmental initiative to start implementing the project, the Supreme Court of India, acting on public interest litigation, directed the central government in 2002 to constitute a task force and complete the project by 2012.
- That is, the pressures from the public and the Supreme Court in India are in exactly the opposite direction from those in Greece—and, evidently, the results in terms of economic development are also in opposite directions.

## Concluding remarks

- Let the “green” saviours of the planet enjoy their ever-falsifying prophecies of doom.
- Let the rest of us who feel not as strong as to save the planet:
  - Try to save ourselves from the saviours.
  - Try to minimize the greenery impacts on our countries, our economy and our civilization.
  - Study history as a good advisor for problem solving.
  - Work for annulling the stereotypes and doctrines related to the environmentalist ideology, which have obstructed progress during recent decades.
  - Work to re-establish orthos logos, logic and rational inquiry in science and society.
  - Work to restore common sense as the necessary foundation of scientific knowledge, technology and social organization.

# Epilogue

Heraclitus  
ca. 540-480 BC



- *Τὸ ἀντίξουν συμφέρον  
καὶ ἐκ τῶν διαφερόντων καλλίστην ἄρμονίαν  
καὶ πάντα κατ' ἔριν γίνεσθαι.*

(Opposition unites, the finest harmony springs from difference, and all comes about by strife; Heraclitus, Fragment B 8).

- *Γίνεσθαί τε πάντα κατ' ἐναντιότητα καὶ ῥεῖν τὰ ὅλα ποταμοῦ  
δίκην, πεπεράνθαι τε τὸ πᾶν καὶ ἓνα εἶναι κόσμον [...] καὶ τὴν  
μεταβολὴν ὁδὸν ἄνω κάτω, τὸν τε κόσμον γίνεσθαι κατ' αὐτήν.*



(All things come into being by conflict of opposites, and the sum of things flows like a river. Further, all that is limited and forms one world. [...] Change [is] a pathway up and down, and this determines the evolution of the world; Heraclitus quoted by Diogenes Laertius IX.8).



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