

Article

The Institutional Aspects of Water Management Practices in Classical Athens

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Abstract

This paper analyzes the water management practices that were implemented by the Athenian city-state of the Classical period (508–323 BC) from an economics perspective. These were based on the following diptych: investing water management infrastructure and introducing effective relative institutions. Infrastructure included extensive public works such as the building of public wells, aqueducts, fountains, springs and cisterns, as well as the building of underground water supply and sewage networks. Institutions included the introduction of three categories of public magistrates who implemented the city-state's water management policy. By implementing Elinor Ostrom's Institutional Analysis and Development (IAD) framework, this paper examines how rules-in-use and administrative incentives structured the *action arena*, arguing that the success of the Athenian water management policy should be attributed to an institutional matrix that perfectly aligned administrative incentives with environmental realities. Finally, we discuss how the Athenian water management practices, based on a system of motives and disincentives, could be seen as a useful historical paradigm for our modern societies.

Keywords: Classical Athens; water supply infrastructure; water management institutions; economic institutions; E. Ostrom's IAD methodology

1. Introduction

This paper contributes to the ongoing global discussion on sustainable water management, an issue that has become imperative in contemporary times. Increased demand and inefficient usage of water resources globally has led to environmental degradation both quantitatively and qualitatively. This is one of the most important and pending global problems at present, alongside other challenges, including pandemics (such as COVID-19) and energy shortages.

It has been estimated that, by 2050, over 40% of the global population will reside in areas facing water scarcity. The intensification of water shortages will exacerbate both the economic and environmental consequences of climate change. The water crisis, which is a sub-category of the wider global environmental crisis, is largely due to poor water management [1].

To date, environmental scientists, economists, and researchers from other disciplines have addressed water shortages, since this is an interdisciplinary phenomenon. Various studies have tried to find the optimal means of exploitation of water resources by re-

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searching ideal water management techniques and practices [2,3]. More generally, this discussion is related to the consideration of the global depletion of non-renewable resources, including mineral deposits and forests, which has driven demand for regulatory oversight [4–7].

Taking the above into account, this paper attempts to contribute to the global discussion on managing water resources by analyzing a historical case, the city-state of Athens during the Classical period (508–323 BC). We chose this case study for three main reasons.

First, we wish to see how an ancient society dealt with water management problems, and if there are any ideas from the past that could be applied to contemporary challenges. Eminent scholars such as the economist J. Schumpeter believed that to fully comprehend modern economies, we must carefully study past economic systems to leverage historical experience [8]. C.H. Lyttkens, who has extensively studied the economic organization of Classical Athens, adds that, under specific institutional parameters, we can use the ancient Greek experience as a historical laboratory to gain insights of a general nature that could be applicable to contemporary societies [9].

Second, Athens, was not just a typical city-state of the times, but, similarly the position of the USA at present, was the leader of the Delian League, an alliance of more than 300 member city-states. Thus, Athens “exported” its political and economic model of organization, to a larger or a lesser extent, to its more than 300 allies [10,11].

Third, evidence shows that the Greeks pioneered sophisticated infrastructure to effectively manage their limited water supplies as early as the prehistoric era, spanning the Cycladic, the Minoan and the Mycenaean civilizations (3000–1100 BCE) [12–14]. In this paper, we focus on Athens during the Classical period because much more reliable and tangible archeological evidence and ancient written texts are available in comparison to earlier historical case studies, thereby ensuring that our deductions are reliable.

The main finding of this paper is that Classical Athens achieved long-term socio-ecological resilience for its water network by establishing a tightly aligned “infrastructure–institution–performance nexus”. Applying Ostrom’s Institutional Analysis and Development (IAD) framework, this study demonstrates that the physical vulnerabilities of Athens’ arid environment were neutralized by: (i) creating effective infrastructure and water management institutions and (ii) matching specific public administrative roles—technical oversight by the *epimeletes* and behavioral enforcement by the *astynomoi*—with a highly efficient dual-incentive system. This institutional matrix prevented resource degradation by securing permanent daily salaries for magistrates while checking bureaucratic negligence through a strict “cascading penalty rule” that held officials personally liable if they failed to penalize rule-breakers.

The paper is organized as follows: Section 2 provides a brief explanation of the political and economic organization of Classical Athens. This Section is necessary since it helps the reader to understand that behind the infrastructure and institutions that are described in Sections 3 and 4, respectively, there is the economic reasoning derived by the Athenians. Section 3 describes the public works and infrastructure that the Athenians developed so as to efficiently execute a targeted water management policy. Section 4 describes the institutions that were introduced by the Athenian policymakers to support this framework. Section 5 applies Ostrom’s formal Institutional Analysis and Development (IAD) framework to demonstrate how water management infrastructure was systematically linked to and supported by tailored institutional rules, ensuring long-term resilience and socio-ecological durability.

Section 6 concludes by offering insights that could benefit modern environmental governance, based on the experience and the wisdom that the Athenians gained through implementing their own water management institutions and practices.

2. The Athenian Political and Economic Institutions in Brief

Athenian society represented the world's first democracy, where a series of sophisticated political and economic institutions were implemented in practice.

The most important political institutions included the Athenian Assembly of citizens (known as Ecclesia), the Council of the Five Hundred (known as Boule) and the popular courts (known as Heliaia). The Assembly was gathered approximately 40 times a year and was open to all citizens, serving as the primary venue for legislative and policy decisions. The Council organized the topics for the Assembly to discuss and was also the main supervisory institution of the Athenian public administration. The popular courts administered justice to ensure the regime functioned under the rule of law [9,11,15,16].

The Athenians, during the Classical times, established a primitive version of a market economy governed by supply-and-demand dynamics. Various sophisticated institutions were implemented in practice, such as state officials who protected the market against profiteering, known as the *agoranomoi* [11,15,17,18]. In his highly influential book, *Athenian Economy and Society: A Banking Perspective*, E. Cohen thoroughly investigated the highly developed methods through which banking institutions operated in the Classical Athenian period. They performed a plethora of activities such as exchanging coins and foreign currencies, accepting deposits, and providing loans under interest to various business operations. More than 30 bankers are recorded in Athens, such as the famous Pasion [19]. The sophisticated methods of handling various state economic affairs, including the efficient management of state expenses through the shaping of the annual state budget (public revenues and expenditures), have been analyzed by various authors [9,11,15,17,18,20]. Due to such institutions the Athenian state achieved economic development, at least for specific sub-periods during the Classical times, and according to various authors this facilitated the provision of public goods such as defense and police services, education (partially), public health safeguards and, as is further analyzed in Section 3, the development of a robust water management infrastructure.

3. Public Infrastructure for Establishing a Water Management Policy

Thucydides (*The Peloponnesian War*, 1.2.3-6) informs us that Athens, and the region of Attica in general, was much less fertile in comparison to other areas of Greece, such as the districts of Thessaly and Boeotia (Central Greece) and most of the Peloponnese (South Greece). Plutarch (*Solon*, 23.5) adds that the region of Athens was poorly endowed with water, lacking flowing rivers, lakes or rich springs. In contrast to civilizations like Mesopotamia and Egypt, which relied on the intensive cultivation of major river systems such as the Tigris, Euphrates, and Nile, Greek civilization developed within an environment characterized by severely constrained and often inadequate natural water resources [12–14].

This natural scarcity necessitated that the Athenians optimize the use of available water resources through an effective public management system to guarantee a basic quality of life and civic well-being. To achieve this, they implemented a twofold system based on both infrastructure and institutions. In this Section, we focus on the former, while the latter are analyzed in the next Session.

3.1. Building Wells, Fountains, Springs and Cisterns

Athenians directed significant efforts toward securing the water supply of their arid region. While most inhabitants used private wells, these were insufficient to meet collective demand. To confront this systemic water shortage—which posed an existential threat to the city-state—the Athenian lawmaker Solon, active in the early 6th century BC, instituted a law where public wells were considered as a collective good to which all residents

should have access. However, if their homes were located far from public wells, citizens were required to dig deep wells on their own properties. If they failed to find water on their land, they were legally permitted to draw a 20 L jug of water twice a day from a neighbor's well. This account provides clear evidence of an early, legally enforced water management protocol [21–23]. This historical insight is significant as it documents an early, formalized approach to water management mandated by law.

Furthermore, archeological evidence demonstrates that during the successive reigns of the tyrant Peisistratus and his sons (561, 559–556, and 546–510 BC), Athens developed an extensive public water supply network consisting of wells, fountains, and springs [23–25]. Approximately 400 wells were excavated, stemming from both public and private initiatives. These wells exhibited significant variation in depth, ranging from 2.5 to 37 m, with an average depth of roughly 10 m. This infrastructure was further expanded during the Classical (480–323 BC) and Hellenistic periods (322–31 BC) [13,22].

Beyond the construction of wells and extensive aqueduct systems, the Athenians engineered technologies to harvest rainwater from roofs into underground cisterns. A notable example is the so-called Doric Stoa or Stoa of Abatos, used to supply water to the Athens Asclepieion (a type of ancient hospital). This structure was a covered walkway or colonnade that formed part of a sanctuary dedicated to the God Asclepius.

Regarding cisterns, these were large tanks that stored rainwater for domestic use or for consumption. A large portion of them were constructed below the ground surface and were waterproofed [23,24]. Archeological evidence near the Hephaisteion in the Athenian Agora reveals an intricate network of interconnected cisterns. In many instances, individual structures—such as wells and cisterns—were linked to form complex systems designed for the systematic storage of groundwater and rainwater. As Athens' public water supply network expanded and aqueducts funneled water directly to public fountains, private installations were progressively abandoned. However, because the public network remained highly vulnerable to interruption during times of war, owners were legally required by state decree to ensure the ongoing functionality of their private wells and cisterns [12].

Regarding natural springs, a distinct subcategory existed: sacred springs used exclusively within religious contexts. A prominent example is the Sacred Spring near the Acropolis, which served various ritual functions, including symbolic purifications before religious festivals or temple entry. Pilgrims and worshippers would use the water for ritual cleansing, washing their hands, faces, or sometimes even their entire bodies, to symbolically remove impurities.

To summarize, during the Classical and Hellenistic periods, the city relied on a decentralized, hybrid water supply system composed of public works and private infrastructure. This system included individual wells, which were dug to tap into underground aquifers, and cisterns, which were used to collect and store rainwater. These findings underscore the engineering ingenuity of the Athenians in mitigating their environment's physical constraints. The wells were typically lined to prevent collapse, and cisterns were often coated with waterproof plasters to preserve water quality.

3.2. Building Aqueducts

Beyond natural pools and springs, Aristotle (*Politics*, 7.1330b) explicitly recognized the strategic importance of constructing large-scale aqueducts to maintain an effective urban water supply. He writes:

"...and [the polis] 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."

A highly important public work of this nature was constructed under the Peisistratid tyranny: a massive aqueduct that transported water from Mount Hymettus over a distance of approximately 7.5 km to the urban center near the Acropolis. The greater part of this aqueduct was built as a subterranean tunnel reaching depths of up to 14 m. In other sections, it was constructed as an open channel carved directly into the bedrock or constructed from stone masonry, measuring 1.30–1.50 m in depth and 0.65 m in width. Other aqueducts were constructed in successive phases, forming an intricate pipeline network; one of these, the Hymettus aqueduct, ran parallel to the original Peisistratid route [12,23]. Meton, the celebrated mathematician and engineer, constructed another vital aqueduct to supply the port city of Piraeus.

In general, these ancient water projects demonstrate a sophisticated understanding of structural durability and hydrological functionality. Parts of the Peisistratid aqueduct were uncovered during the modern Athens Metro excavations (1992–2013), proving that segments remain structurally identifiable today.

The building of aqueducts dates back to the Archaic Period (750–508 BCE), a time when various tyrants oversaw their construction, including Periander of Corinth, Theagenes of Megara, Peisistratus of Athens, and Polycrates of Samos, the latter of whom commissioned the renowned Eupalinian Tunnel. Drainage systems within the Greek city-states were equally diverse, ranging from eaves and troughs for private residences and wall-piercing drain pipes to sophisticated neighborhood collector channels, such as those found in Hellenistic Akragas, and the massive public drainage networks of the Argos Agora. Operating and maintaining these large-scale aqueducts ultimately lowered the long-run costs of water distribution while increasing the volume of available water [23].

3.3. Building an Underground Water Supply Network

The Athenians exploited both groundwater (via well-drilling) and storm runoff (via waterproof cisterns). Additionally, water from the two primary rivers of Attica—the Ilissos and Kephisos—whose flows were severely diminished during summer, was primarily allocated for agricultural irrigation [12]. Archeological excavations have confirmed that the urban water distribution network was supported by a sophisticated subterranean conduit and gutter network reaching depths of 14 m [23,24]. This water distribution network was situated beneath the city, comprising an interconnected system of wells that was progressively extended to encompass the urban periphery [12].

The gutter system was built incrementally in several phases. This serves as a reminder of the immense labor and logistical disruption inherent in upgrading modern urban water infrastructure, where aging pipe networks often necessitate the closure of major thoroughfares and entire city districts. Although there are no statistical and construction data available, it is reasonable to infer that the construction of a gutter network by the Athenians represented a significant financial investment in the provision of an essential public good.

3.4. Building a Sewage Underground Network for Wastewater Management

Just as modern public health science emphasizes that access to clean water is fundamental to societal well-being, the Athenians recognized that water safety was central to civic health. Aristotle (*Politics*, 7.1330b) explicitly argued for the strict separation of water sources based on quality:

“...And since we have to consider the health of the inhabitants... and the influence of the water-supply and of the air is of this nature. Hence in wise cities if all the sources of water are not equally pure and there is not an abundance of suitable springs, the water-supplies for drinking must be kept separate from those for other requirements...”

Aristotle raised various issues, as mentioned in the above passage, but two of them are of great importance: water resources are not unlimited, and it is essential that the water consumed in organized cities, such as Athens, is of the highest quality. Similar views are referenced in his *Metaphysics* (1.983b), where Aristotle writes that water is the origin of nature.

Having understood this, the Athenians introduced laws and regulations which protected surface waters from pollution, as will be further analyzed in Section 4. The Athenians went a step further by establishing an underground sewage system to completely separate drinking water from water used for other purposes. Similar pipes to those used for channeling fresh water throughout the city-state were also used for sewers. Sewers were built with a large cross-section. Construction methods for these sewers varied, ranging from meticulously crafted stone walls and tiled ceilings to simple conduits formed by inverted roof tiles, all featuring access points for maintenance and debris removal [12,25].

The earliest recorded wastewater management infrastructure was installed in the Athenian Agora during the 5th century BC, featuring a monumental stone drain [25]. This main channel collected drainage from the southwestern entrance and funneled it north along the western perimeter of the Agora, eventually discharging into the channel of the Eridanos River near the Sacred Gate. Over the centuries, this primary system was enlarged and supplemented by secondary wastewater channels laid below the city streets, complete with clay-cylinder manholes featuring integrated foot holes for worker access. Another exceptional example is the drainage network south of the Acropolis near the Theatre of Dionysus—a high-density hub of cultural, political, and religious activities. Excavations have revealed stone-lined channels that directed rainwater and wastewater away from public assembly areas. This layout highlights the sophisticated way in which ancient engineers capitalized on the natural topography, utilizing gravity to guide waste runoff downhill through a unified network that extended into adjacent civil and religious spaces. Archeological evidence of drainage channels around the theater confirms that measures were taken to manage water flow effectively. The natural slope of the Acropolis provided an advantage for water management. The drainage system took advantage of gravity to guide water downhill through an organized network.

In sum, the Athenian water governance footprint relied on a carefully coordinated equilibrium of large-scale public networks (such as the Peisistratid aqueduct) and small-scale decentralized systems (wells and cisterns) [22]. This dual model was not unique to Athens; similar hydro-engineering infrastructures are well-documented across the wider Greek world, including in Akragas, Argos, Corinth, Delos, Delphi, Byzantium, Syracuse, and Pergamon [24].

4. Establishing the Institutions for Supporting a Water Management Policy

In addition to investing in public infrastructure so as to create a water supply network, the Athenians introduced robust institutional structures to ensure the sustainable execution of their water management policies as part of their broader public policy.

Their approach strongly reflected Douglass North's foundational economic axiom that "institutions matter" [26]. Thus, they took care to secure the effectiveness of their water management policy not only by creating the proper infrastructure, but also through effective institutions, in order to optimize the use of water, seeing it, above all, as a public good. In this section, we focus on these institutions.

4.1. The Superintendent of the Fountains

During the Classical period, the Athenian state established the office of the *epimeletes epi ton ydaton kai ton krunon* (superintendent of fountains). This magistrate was required to possess specialized technical knowledge to oversee the equitable distribution of water and ensure the sanitation of public springs. This magistrate was instituted in the early 5th century BCE, known as *krounon epimeletes*.

It is important to note that, according to Aristotle (*Athenian Constitution*, 43.1) and the orator Aeschines (*Against Ctesiphon*, 3.29), the majority of public offices in the Athenian public administration were filled through election by lot, but there were also a small number of posts for which public officials were appointed by the Athenian *demos* (the people), instead of being elected. According to Aeschines, all these magistrates were subject to a formal auditing process to ensure accountability. Aristotle (*Politics*, 6.1317.b15–1318.a3) adds that some posts required experience and skill; thus, they could not be filled by common people. According to Aristotle (*Athenian Constitution*, 42.2, 43.1), these included special posts such as the ten *stratego*i (ten generals) who led the Athenian armed forces, as well as the superintendent of the fountains, known simply as the *epimeletes*. Suitable candidates for this magistracy would require special skills in order to be successful in overseeing the water supply of the city [11,12,15,22,23].

The requirement that the *epimeletes* be an expert highlights the high priority the state placed on the effective management of its water infrastructure. This is because the Athenians understood that filling this post with the most competent men was directly related to their prosperity as a whole. The high importance of this particular post is also illustrated by three historical facts: Firstly, according to Plutarch (*Themistocles*, 31.1), Themistocles, the great Athenian statesman, served in this post at some point in time. Secondly, according to a surviving Athenian decree (IG I³ 49) regarding the Athenian water supply Pericles had also been assigned to this post. We note that, in principle, water management duties were assigned to capable and highly recognized political figures of Athens, with Themistocles and Pericles being two of the most well-known examples. Third, in 333 BCE, the Athenians publicly honored the *epimeletes* Pytheus with a gold wreath, recognizing his efforts in the restoration and maintenance of the city's fountains and aqueducts [12,23]. Honoring someone publicly in the direct democratic regime of Athens was something special. It was an extraordinary honor from the state and a way of morally rewarding a citizen for his loyal deeds.

4.2. The Guardians of the Water Supply and the *Astynomoi*

The post of *epimeletes* primarily aimed to ensure the technical integrity and sustained functionality of the fountains. Because a single elected *epimeletes* could not personally police every decentralized extraction node across the entire territory, the state deployed a distributed network of local field guards to oversee public fountains and wells. These guards were supervised by a powerful ten-member administrative college known as the *ten astynomoi* [11,15,20,27,28]. Plato (*Laws*, 6.763d) vividly presents their mandate:

“...[the *astynomoi*] shall also have charge of all the water-supplies conveyed and passed on to them by the guards in good condition, to ensure that they shall be both pure and plentiful as they pour into the cisterns, and may thus both beautify and benefit the city. Thus it is needful that these men also should have both the ability and the leisure to attend to public affairs...”

In general, the *astynomoi* had a series of important duties to accomplish, including keeping streets clean, managing the removal of dead bodies, and overseeing road repairs and repairs of the temples of the city-state. Furthermore, they were tasked with ensuring that waste collected by the city's dung collectors was only disposed of beyond the city

walls, at a minimum distance of approximately 1.85 km, and they were also entrusted with broader water management duties. Specifically, they oversaw the supply of water within the city with the duty of ensuring that water was pure and plentiful. This was a primitive water management regulation (Aristotle, *Athenian Constitution*, 50; Plato, *Laws*, 6.759a, 6.763d; [11,15,20,27,28]). The post was filled annually via sortition, with the magistrates partitioned equally into two cohorts: one serving the urban center of Athens and the other stationed in the port of Piraeus.

Some very illuminating information regarding the duties of *astynomoi* is also provided by the so-called ‘Law of Astynomoi’, or ‘Astynomic Law’ of Pergamon found by German archeologists in 1901, in Pergamon in Asia Minor (today’s Western Turkey), in a limestone slab, in a house southeast of Pergamon’s Agora. It describes legislation based on written laws, presenting the responsibilities, the powers and the duties of the *astynomoi*. Their duties were, among others, to monitor the condition and maintenance of the city’s buildings, roads, and water systems [28]. The law further defines who was responsible for the work and costs involved in maintaining infrastructure such as public roads, streets and paths, water cisterns, springs, conduits, sewers, fountains, toilets, rubbish collection, and public and private boundary walls. To ensure the sanitation of these resources, the law strictly prohibited activities such as laundry and the watering of animals at public fountains. Each *astynomos* (singular) was responsible for a particular area within the city-state, in which he was to record and report on the cisterns in private houses and ensure that owners kept them clean and covered. **He imposed fines on trespassers** and then transferred the money either to the state treasurers or to those who suffered damage due to a neighbor’s negligence. **Those *astynomoi* who failed to charge the fine were fined by the state authorities.**

Obviously, the duties of the *astynomoi* of Pergamon are comparable to the standards established in Athens and across many other Greek city-states during this era. Thus, the *astynomoi* had also the power to issue penalties for noncompliance. As documented in Plato’s *Laws* (6.764c, 6.779c), the *astynomoi* were empowered **to impose fines of up to 100 drachmae**, in addition to further punitive measures, against those who failed to comply with municipal regulations [27,28]. The average worker in Athens was paid 1 drachma per day during the 5th century BC and 1.5 drachmae during the 4th century; thus, a 100 drachmae penalty should be seen as **a large sum of money** [29]. The Athenians understood that the heavier the penalty, the better the compliance of the citizens, the *metics* (alien residents, mostly originating from other Greek city-states who relocated to Athens for work purposes) and the slaves who participated in the Athenian economy.

At least 700 of these public servants of the Athenian state (known as *archai*) were receiving 4 *obols* on a daily basis—that is, 2/3 of a drachma—including the *epimeletes* and the *astynomoi* [20]. This means that these two groups were receiving a satisfactory salary on a permanent basis. It is logical to argue that they should have been quite satisfied with this, since, until the completion of their duties, they never faced the threat of unemployment.

4.3. Environmental LAWS and Regulations

This sub-section refers to evidence regarding environmental laws and regulations that supported the success of the overall Athenian water management policy. To start with, we refer to an inscription known as IG I³ 257 of ca. 440 BC, which contains the ‘Law for Tanners,’ which forbade tanners from disposing of their waste in the Ilissos river. In fact, this decree stands as one of the earliest recorded examples of point-source water pollution regulation in human history. It is worthy mentioning that the Athenians introduced many environmental protection laws, such as laws protecting the preservation of trees. For example, Demosthenes, in *Against Macartatus* (43.71), argues that strict legal sanctions

should be imposed upon any citizens or *metics* found guilty of damaging trees throughout the Attic region.

“If anyone shall dig up an olive tree at Athens, except it be for a sanctuary of the Athenian state or of one of its demes (the municipalities of the Athenian state) or for his own use to the number of two olive trees each year, or except it be needful to use it for the service of one who is dead, he shall be fined one hundred drachmae, to be paid into the public treasury, for each tree, and the tenth part of this sum shall belong to the goddess. Furthermore, he shall be obligated to pay to the private individual who prosecutes him one hundred drachmae for each olive tree. And suits concerning these matters shall be brought before the archons, according as they severally have jurisdiction...”

The nine archons were high-ranking officials, mostly either high-income citizens or the nobility, who originated from the aristocratic period of Athens (750–510 BCE), before the advent of democracy. Their duties during the democratic era were limited to judicial matters.

Further evidence is presented by ancient authors such as Lysias (*On the Olive Stump*) and Julius Pollux (*Onomasticon*, 7.146.1–4). Another law, IG I³ 49, is related to the so-called ‘Springhouse Decree’, likely issued no later than 430 BCE and related to Pericles and his family [22].

Furthermore, the close cultural and economic relations between the Greek city-states throughout the Hellenic world at this time (in the East Mediterranean, the Balkans and the Black Sea region), such as mother-cities and their colonies, resulted in the transfer of water management and other techniques and technologies outside mainland Greece [24]. A typical example is the case of the city-state of Corinth and its colony Syracuse in modern South Italy. Due to space limitations, this paper focuses only on the case of Athens during the Classical period. However, it is worth mentioning that laws on water management have survived from many other Greek city-states as well. Legislative efforts to manage scarce resources are well-documented in the 5th-century BCE laws of Gortyn, Crete. One such regulation strictly prohibited the extraction of water from the river Litheos, ensuring levels did not fall below a fixed mark established on the local bridge—a mandate likely directed to farmers reliant on irrigation. Furthermore, additional inscriptions from Gortyn highlight legislative concern regarding agricultural runoff; lawmakers enacted specific provisions to prevent farmers from diverting drainage water into adjacent properties, thereby mitigating structural damage to neighboring infrastructure and protecting local crops (ICret IV 73 A, ICret IV 52A and 52B, 1–6; [22]).

In conclusion, the intersection of robust public works and rigorous institutional governance exerted a profound, sustained impact on Athenian society.

In terms of urban development, the construction of aqueducts, cisterns, and wells facilitated the further development of Athens. These water management systems ensured a reliable water supply, which was crucial for the city’s expansion and the well-being of its inhabitants. In terms of public health, the availability of clean water from public fountains and baths contributed to improved public health and hygiene. This, in turn, helped to reduce the spread of waterborne diseases, leading to a healthier population. Efficient water management supported various economic activities, including agriculture, trade, and craftsmanship. The availability of water for irrigation and other uses boosted agricultural productivity and enabled the growth of industries that relied on water. Furthermore, water management practices also had an indirect but important role in the social and cultural life of Athens. Public fountains and baths were not only functional but also served as social gathering places where people could interact and engage in communal activities.

5. Institutional Analysis of Athenian Water Management: An IAD Framework Approach

To evaluate how Classical Athens successfully managed its scarce water resources, this section applies the Institutional Analysis and Development (IAD) framework pioneered by Elinor Ostrom. Rather than viewing resource sustainability solely as the product of centralized command-and-control, the IAD framework allows us to examine how distinct actors operate under clear institutional rules, boundaries, and incentive structures. To fully appreciate the analytical mechanics of this framework, however, it is necessary to contextualize its intellectual genealogy, which synthesizes foundational breakthroughs in public choice, organizational theory, and behavioral economics.

Structurally, the framework's core concept of polycentric governance is deeply rooted in the pioneering work of Vincent Ostrom, who challenged traditional centralized administrative paradigms by demonstrating that overlapping, decentralized jurisdictions could effectively manage public economies without a singular master authority [30,31]. When applied to the Athenian polis, this polycentric lens explains how a complex, non-centralized web of distinct but overlapping civic entities—such as the macro-technical *epimeletes*, the street-level *astynomoi*, and the judicial oversight of the popular courts (*heli-aia*)—could systematically **co-manage water resources without fracturing into bureaucratic chaos or systemic collapse**.

Furthermore, the cognitive profile of the individuals operating within this Athenian “action arena” explicitly rejects neoclassical hyper-rationality. Instead, it should adopt Herbert Simon's paradigm of *bounded rationality*, viewing actors as information-constrained individuals who “*satisfice*” within complex organizational environments rather than perfectly optimize [32,33].

The IAD framework was developed as a direct institutional counterweight to Mancur Olson's pessimistic *zero-contribution thesis* [34]. While Olson argued that rational, self-interested actors are inherently trapped in a free-rider dilemma and will fail to sustain common goods without top-down state coercion or complete privatization, Elinor Ostrom utilized the IAD conceptual framework to model how localized, community-level rules-in-use can dynamically restructure incentives to achieve robust, voluntary cooperation.

By anchoring the study in this rich theoretical pedigree, the Athenian framework closely aligns with the Institutional Economics and common-pool resource (CPR) theories pioneered by E. Ostrom. This alignment exists because the Athenian *polis* did not rely on an all-powerful, coercive state apparatus or strict privatization to safeguard its fragile water network; instead, it perfectly operationalized Ostrom's core tenet that a community of resource-users can successfully achieve sustainable self-governance through robust internal design features. By matching boundedly rational officials with a polycentric administrative infrastructure and high civic social capital (see [35,36]), Athens provided a living empirical proof that localized rules can dynamically defuse free-rider dilemmas. Ultimately, this lineage allows us to frame classical resource governance not as a static bureaucratic mandate, but as an interactive ecosystem where physical realities and human choices are structurally inseparable.

We believe that Athenian state practices resemble aspects of the governance theory of the “commons”, as defined by the seminal works of Elinor Ostrom [37–39]. According to Ostrom's tradition, governance must be analyzed as an interactive ecosystem in which physical realities and human choices are structurally inseparable [40,41].

With the introduction of the *epimeletes* and the *guardians* of the wells and fountains, as well as the *astynomoi* and the *guardians*, it seems that the Athenians probably understood the requirement for efficient water management as a defining factor in shaping the civic and interpersonal relationships within the community. The long-term viability of

Athenian water management institutions was fundamentally contingent upon two pillars: widespread civic compliance by the majority of the residents (citizens, *metics*, and slaves) and high administrative fidelity from the public officials responsible for executing policy. However, in order to support these institutions, they needed to be fair not only in principle, but also in terms of their practical implementation in Athenian daily life.

According to Ostrom, any action in the communal management of a resource is fundamentally constrained by three sets of *contextual variables*: (i) biophysical/material conditions, (ii) the attributes of the community, (iii) and the rules-in-use. Contextual variables (or *exogenous variables*) refer to the fundamental external factors that shape and constrain the so-called *action arena*, that is, the social space where people interact, exchange goods, solve problems and make decisions. When we refer to a contextual value, we mean the specific characteristic or data point that a contextual variable takes on in a specific case study. For example, if the variable is “climate”, the *contextual value* for ancient Athens is “arid/dry”. These variables determine the environment within which the actors (in our case, the *epimeletes*, the *astynomoi* and the guards) make decisions, interact, and enforce rules.

Regarding the first contextual value, as referenced by the ancient authors Thucydides in *The Peloponnesian War* (1.2.3–6) and Plutarch in the *Life of Solon* (23.5), the region of Attica was arid to a great degree, lacking large flowing rivers, deep lakes, or highly productive natural springs. This natural scarcity created various existential physical constraints. Thus, properly managing the area of Attica required sophisticated physical infrastructure (aqueducts, underground networks, cisterns, and sewage management, as mentioned in the previous sections), which could face technical failures during use, suffer contamination, or be exploited unfairly without persistent institutional oversight.

Regarding the second contextual value, these physical realities were embedded within *direct democratic* procedures in decision-making [15,16,20], in a polis characterized by strong civic identity, high levels of social capital (according to the logic of R. Putnam; see [42,43]), and an institutionalized expectation of public accountability (*euthynai*) [15,20]. This created a culture where community members accepted the rule of law and respected formal civic mechanisms, yet still required institutional mechanisms to deter individual opportunistic behavior (for example, rule-breaking). J. Ober and P. Cartledge provide detailed analyses of how strong civic identity and social capital were gradually shaped and practiced in the daily life of the Athenians [15,16,44,45].

In particular, in his 2008 seminal work *Democracy and Knowledge*, Josiah Ober argues that the extraordinary success and wealth of Classical Athens stemmed from its unique capacity to aggregate, organize, and deploy dispersed human knowledge [44]. The Athenian direct democracy lowered transaction costs by creating open-access social networks and face-to-face *deliberative* forums—in James Fishkin’s perspective—building immense social capital [46]. This occurred because citizens from various socioeconomic backgrounds and distinct geographic regions (*demes*) routinely interacted in the popular Assembly of citizens, the Council, and the courts; they developed a shared civic identity and high horizontal trust. When applied to municipal water management, this means that the community possessed common knowledge regarding environmental realities; **individuals complied with rules because they recognized that collective cooperation yielded vastly superior material returns than individual defection**. Thus, Ober’s framework reveals that Athenian social capital directly mitigated the collective action problems inherent in common-pool resources.

While Ober emphasizes knowledge and transaction costs, Paul Cartledge (*Democracy: A Life*, 2018) anchors the community’s attributes in the radical political reality of *kratos* (power) being held directly by the *demos* (the citizen body). Cartledge stresses that Athenian citizenship was uniquely participatory; an ordinary citizen was routinely expected to act as lawmaker, judge, and administrator. The widespread use of sortition (selection

by lot) meant that civic responsibility was normalized rather than professionalized. Crucially, Cartledge observes that this radical dispersion of power was counterbalanced by an absolute, unyielding standard of public accountability. Because the *demos* were highly sensitive to the dangers of tyranny or elite corruption, institutional checks like the *euthynai* (mandatory end-of-year financial audits of public magistrates [15,20,44,45]) were hard-coded into the civic psyche. In the context of the IAD framework, Cartledge's analysis demonstrates that public servants did not operate in a vacuum of bureaucratic opacity; they performed their water management duties conscientiously because the community's political culture treated public betrayal as a severe, existential threat to the polis itself.

Regarding the third contextual value, the Athenian operational landscape was governed by an evolved body of formal statutory laws and written regulations dating from Solon through to the Classical era [11,15,16,44,45]. These included baseline legal rights regarding access to communal wells, environmental restrictions, e.g., the Law for Tanners (see above) protecting the Ilissos river, and strict codes outlining the administrative mandates of public office.

The heart of Ostrom's IAD framework is the *action arena*, where individuals interact, make choices, and jointly produce outcomes. In the Athenian institutional setting, as described above, the action situation revolved around the maintenance of infrastructural integrity, the prevention of resource degradation/pollution, and the equitable enforcement of distribution rules. There were two groups of servants: (i) the *epimeletes epimeletes epi ton ydaton kai ton krunon*—operating primarily at the macro-technical level of the infrastructure network and (ii) the *astynomoi* and water guards—operating primarily at the micro-behavioral level of daily urban consumption, street-level maintenance, and user compliance.

To understand how these public servants performed their duties efficiently and conscientiously, we must compare them along the key operational variables defined by Ostrom's framework: position and boundary rules, information asymmetries, and incentive configurations. Table 1 attempts this information synthesis.

Table 1. Ostrom's IAD framework in the Athenian institutional setting.

Institutional Element (Ostrom)	The <i>Epimeletes</i> (Superintendent of Fountains)	The <i>Astynomoi</i> and Water Guards
Position and boundary rules (selection and tenure)	Selected via direct merit-based election/appointment by the <i>demos</i> due to the required engineering and technical expertise. Tenure was heavily scrutinized, drawing prominent statesmen (e.g., Themistocles).	Selected by lot (annually, with 10 members split between Athens and Piraeus) for general magistracy duties. They supervised a distributed network of local field guards.
Scope and operational focus	Macro-infrastructural: Maintenance and structural integrity of aqueducts, main fountain complexes, and reservoir systems.	Micro-behavioral: Street-level oversight, policing individual compliance, preventing public fountains from misuse, and ensuring private cistern cleanliness.
Information and control	High technical information asymmetry; possessed deep specialized knowledge regarding hydrology, underground pipeline geometry, and structural repairs.	High decentralized, observational information; possessed localized, day-to-day oversight of user actions, localized spills, or illegal domestic sourcing.
Positive incentives	Prominent civic recognition, elite political prestige, and extraordinary moral rewards such as gold wreaths for exceptional public performance.	Steady economic security provided by a permanent daily public salary of 4 <i>obols</i> (2/3 of a drachma), protecting them from market vulnerability.
Negative sanctions and cost cascades	Harsh legal liability, severe financial restitution, potential dismissal, and profound loss of political standing during mandatory democratic auditing (<i>euthynai</i>).	Empowered to issue punitive 100-drachmae fines to rule-breakers. Crucially, <i>astynomoi</i> faced strict personal fines if they failed to charge or report noncompliance.

Three further dimensions must be evaluated based on Ostrom's theoretical framework: (i) selection mechanism and position rules; (ii) information asymmetries and strategic scope; (iii) the dual-incentive structure: rewards vs. cost cascades.

Regarding the first aspect, the boundary rules governing entry into these positions reflect a highly deliberate institutional architecture. The *demos* recognized that macro-level infrastructure management required specialized technical competence that a random lottery could not guarantee. Consequently, the *epimeletes* post was exempt from the standard lottery system and designated an elected/appointed office for experts. Conversely, the *astynomoi* filled a generalized civic oversight role. Because their primary tasks involved behavioral enforcement, community policing, and basic administrative reporting, they were selected by lot annually. This minimized the consolidation of corrupt local networks, while the actual field-level guarding was delegated to a network of localized guards who monitored extraction sites directly.

Regarding the second aspect, the *epimeletes* resolved *information asymmetry* problems (see the seminal analysis of [47–50] regarding such problems, among others) related to the structural health of the network. Because an underground channel at a depth of 14 m is hidden from the public eye, the *epimeletes* acted as the eyes of the state, bridging the information gap between structural infrastructure and public awareness. The *astynomoi* and their guards solved a different information asymmetry problem: user opportunism. Because individuals might clandestinely tend to misuse water resources by acting improperly—for example, using them to launder clothes or allowing animals to drink water at public fountains (which risks of causing infectious diseases in a large portion of the population)—or neglect private cistern maintenance, the *astynomoi* acted as a localized monitoring mechanism, collecting field data on day-to-day resource exploitation.

Regarding the third aspect, Ostrom stresses that for institutional rules to endure, the benefits of compliance and enforcement must outweigh the costs of shirking. The Athenian state achieved this through a bifurcated system of motives and disincentives; on the one hand, the provision of adequate remuneration and rewards for both the *epimeletes* and the guardians and *astynomoi*, providing they were working efficiently, and on the other hand, the imposition of substantial fines and/or removal from public office for any of the aforementioned groups if they provided subpar services.

For the *epimeletes*, who often came from wealthy or politically ambitious strata (such as Pericles' family or Themistocles), the primary positive incentive was moral and reputational capital. In general, public honors, such as the gold wreath awarded to Pytheus in 333 BCE, served as powerful catalysts for efficient performance.

Archeological evidence reveals that a great financial reward was provided to those who performed their duties in a productive way and with zeal: a contemporary decree (IG II2, 338) preserved on stone serves as compelling evidence that efficient water management was a high priority for the state:

"...since Pitheas, having been elected to the superintendence of the fountains, is honourably released from his other duties and has now built a new fountain for the shrine of Ammon and has arranged for bringing water to it, it is agreed to honour Pytheas with a golden crown worth a thousand drachmas so that others elected to the charge of the fountains shall be ambitious on behalf of the people".

Values of 500 or 1000 drachmae were typical for public honors (e.g., gold crowns) [11,20]. Conversely, the same amount was levied as the standard penalty **for serious punishable offenses** committed by public officials that caused harm to the state, including cases of environmental degradation. J. Blok provides an extensive analysis of these cases [51].

This finding connects directly to the vast literature on environmental economics that links resource protection to taxes or fines as a means of limiting environmental degrada-

tion [52–54]. The higher the fines, the higher the compliance of the citizens with the environmental policies. For the *astynomoi*, this institutional architecture relied on an ingenious cascading penalty rule. They were granted authority to levy hefty fines of up to 100 drachmae against citizens or *metics* who violated water laws, while the system checked their potential apathy or corruption by mandating that **any magistrate who failed to enforce or charge a fine would be personally fined by state authorities**. This rule-in-use perfectly aligned the private costs of the bureaucrat with the public utility of resource preservation.

In sum, the interaction between the technical oversight of the *epimeletes* and the enforcement of the *astynomoi* generated **highly stable patterns of collective action**. Rather than competing for jurisdiction, these roles **operated symmetrically**: the *epimeletes* ensured that clean water reached the fountains, while the *astynomoi* and their guards ensured that once the water arrived, it remained pure, abundant, and free from monopolization or contamination.

When measured against Ostrom’s standard evaluative criteria—efficiency, equity, and sustainability—the Athenian institutional system seems to demonstrate exceptional resilience. In terms of the efficiency criterion, internalizing enforcement through the daily 4-*obol* salary and cascading fine mechanisms minimized the state’s transaction costs of monitoring a decentralized network of over 400 wells and extensive aqueducts. In terms to the equity criterion, rules such as Solon’s structural regulations guaranteed a baseline safety net for all residents, ensuring that even if private drilling failed, collective access to neighboring or public water supplies was legally protected. Finally, regarding to the sustainability criterion, by strictly deterring external pollution (such as industrial waste from tanners) and establishing legal mandates to maintain infrastructure even during peace to ensure readiness for war, the institutions preserved a highly vulnerable common-pool resource over centuries.

Ultimately, IAD analysis demonstrates that the success of Athenian water management did not rely only on uncoordinated civic goodwill, nor did it depend entirely on a monolithic state apparatus. Instead, it flourished because of a collaborative institutional matrix that mapped explicit selection processes, information controls, and paired accountability structures to the distinct physical realities of an arid environment.

6. Conclusions

This paper examines how Classical Athens successfully managed its scarce water resources through a strategic combination of robust public infrastructure and structured civic institutions. Physically, the Athenian city-state invested in extensive public works, building underground aqueducts, public wells, fountain houses, rainwater cisterns, and a sophisticated drainage network to isolate and evacuate wastewater. Administratively, the governance of this footprint was split between specialized public officials: technically skilled, elected experts like the *epimeletes* managed macro-level engineering and network maintenance, while public magistrates chosen by lot, such as the *astynomoi* and localized water guards, policed daily urban distribution and enforced strict laws protecting water purity from industrial polluters like tanners. Crouch (p, 30) summarizes our findings in a vivid way [23]:

“This society knew how to find water, to save it or drain it away as circumstances required, to transport it by sophisticated long-distance water supply lines, to make public display in fountains and pools that contributed amenity as well as nourishment, to use it both at home, in the public baths, and in sanctuaries, and to drain it away afterward, cleverly reusing it to maintain other necessary resources such as food, fuel, and building materials, and indeed the water table itself...”

The central takeaway of this study is that the Athenian water management system succeeded because it utilized a carefully balanced matrix of incentives and disincentives to prevent opportunism among the residents of Athens, who were themselves the users of the water infrastructure. To ensure honest and efficient performance, magistrates were granted steady economic security through a daily public salary alongside high civic honors, such as public inscriptions or gold wreaths. On the other hand, citizens, *metics* or slaves who broke water allocation or pollution laws faced massive fines of up to 100 drachmae. Crucially, to eliminate administrative negligence, a rule of cascading liability was established: any magistrate who failed to report or enforce a fine against a rule-breaker was held personally liable and fined by the state during their mandatory end-of-year public audit (*euthynai*).

Although these administrative principles are now foundational to modern environmental policy, their early implementation in the ancient world underscores the enduring necessity of resource management. With the analysis in the previous Sections in mind, it can be argued that the logic of using motives and disincentives for implementing proper water management strategies has an intertemporal character that persists through time and space.

Potential avenues for further research that this paper opens up are, first, to further focus on environmental and economic issues faced by ancient economies (such as Classical Athens as well as other historical cases) through methodological approaches of an interdisciplinary nature, which link an environmental issue, for example, water management, to disciplines such as Institutional Economics, Behavioral Economics and Economic History, as this research does.

A compelling avenue for further analysis is to examine the correlation between environmental policy and the overall efficacy of modern governance. It is well-known that major legislative decisions—ranging from the maintenance of peace to the declaration of war, or building a sewage underground network, etc.—in Classical Athens were decided by the Athenian Assembly of citizens through direct democratic procedures.

Of course, one has to acknowledge that modern environmental decision-making often requires expert input. On the other hand, the Athenian paradigm of direct democracy could inspire modern policymakers regarding environmental issues, for example, through the introduction of referendums on environmental issues at the level of municipalities and regions, or at the state level. For instance, ex ante consultation between local authorities and the community—such as in the deliberative process regarding the development of urban parks and green spaces—could be instrumental in maximizing *positive externalities* (under the definition of Baumol and others [53,54]) and ensuring long-term civic support.

At present, environmental policy issues—most notably climate change—are at the forefront of international interest, requiring effective cross-border collaboration. We believe that the Athenian case of water management can serve as a useful historical paradigm to improve the efficacy of environmental decision-making processes for both current and future global stakeholders.

There are, of course, certain limitations in this paper, the most noticeable being the structural absence of quantitative cliometric data to formally test our hypotheses. However, this data limitation is endemic to the study of ancient economies, requiring researchers to rely on qualitative and archeological proxies evaluated through rigorous theoretical frameworks.

We hope that the above findings will encourage further academic discussions on related issues.

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References

1. Barbier, E.B. *The Water Paradox: Overcoming the Global Crisis in Water Management*; Yale University Press: New Haven, CT, USA; London, UK, 2019.
2. Kroetz, K.; Nøstbakken, L.; Quaas, M. The future of wild-caught fisheries: Expanding the scope of management. *Rev. Environ. Econ. Policy* **2022**, *16*, 241–261.
3. Tang, Q.; Leng, G. (Eds.) *Climate Risk and Sustainable Water Management*; Cambridge University Press: Cambridge, UK, 2022.
4. Solow, R.M. The economics of resources or the resources of economics. *Am. Econ. Rev.* **1974**, *64*, 1–14.
5. Hotelling, H. The economics of exhaustible resources. *J. Political Econ.* **1931**, *39*, 137–175.
6. Dasgupta, P.; Heal, G. The optimal depletion of exhaustible resources. *Rev. Econ. Stud.* **1974**, *41*, 3–28.
7. Dasgupta, P. *Economic Theory and Exhaustible Resources*; Cambridge University Press: Cambridge, UK, 1979.
8. Schumpeter, J.A. *History of Economic Analysis*; Routledge: London, UK, 2006, [1954].
9. Lyttkens, C.H. *Economic Analysis of Institutional Change in Ancient Greece: Politics, Taxation and Rational Behaviour*; Routledge: London, UK; New York, NY, USA, 2013.
10. Figueira, T.J.; Jensen, S.R. *Hegemonic Finances: Funding Athenian Domination in the 5th Centuries BC*; Bloomsbury: London, UK, 2019.
11. Bitros, G.C.; Economou, E.M.L.; Kyriazis, N.C. *Democracy and Money: Lessons for Today from Athens in Classical Times*; Routledge: London, UK; New York, NY, USA, 2020.
12. Angelakis, A.N.; Koutsoyiannis, D. Urban Water Engineering and Management in Ancient Greece. In *The Encyclopedia of Water Science*; Stewart, B.A., Howell, T., Eds.; Marcel Dekker Inc.: New York, NY, USA, 2003; pp. 999–1007.
13. Koutsoyiannis, D.; Zarkadoulas, N.; Angelakis, A.N.; Tchobanoglou, G. Urban water management in Ancient Greece: Legacies and lessons. *J. Water Resour. Plan. Manag. ASCE* **2008**, *134*, 45–54.
14. Angelakis, A.N. Hydro-technologies in Minoan era. *Water Supply* **2017**, *17*, 1106–1120.
15. Economou, E.M.L.; Kyriazis, N.C. *Daily Life in Classical Athens: A Socioeconomic Analysis*; Springer: Cham, Switzerland, 2024.
16. Cartledge, P. *Democracy: A Life*, 2nd ed.; Oxford University Press: Oxford, UK, 2018.
17. Economou, E.M.L.; Kyriazis, N.C.; Kyriazis, N.A. Managing financial risk while performing international commercial transactions. Intertemporal lessons from Athens in Classical times. *J. Risk Financ. Manag.* **2021**, *14*, 509.
18. Halkos, G.; Kyriazis, N.C.; Economou, E.M.L. Plato as a game theorist towards an international trade policy. *J. Risk Financ. Manag.* **2021**, *14*, 115. <https://doi.org/10.3390/jrfm14030115>.
19. Cohen, E.E. *Athenian Economy and Society: A Banking Perspective*; Princeton University Press: Princeton, NJ, USA, 1992.
20. Economou, E.M.L. *The Economy of Classical Athens: Organization, Institutions and Society*; Routledge: London, UK; New York, NY, USA, 2024.
21. Krasilnikoff, J.; Angelakis, A.N. Water management and its judicial contexts in Ancient Greece: A review from the earliest times to the Roman Period. *Water Policy* **2019**, *21*, 245–258.
22. Koutsoyiannis, D.; Mamassis, N. The water supply of Athens through the centuries. In *Cura Aquarium in Greece*; Wellbrock, K., Ed.; Papierflieger Verlag: Siegburg, Germany, 2017; pp. 31–43.

23. Crouch, D.P. *Water Management in Ancient Greek Cities*; Oxford University Press: Oxford, UK, 1993.
24. Stroszeck, J. Water and Water Management. In *The Cambridge Companion to Ancient Athens*; Neils, J., Rogers, D., Eds.; Cambridge Companions to the Ancient World; Cambridge University Press: Cambridge, UK, 2021; pp. 110–123.
25. Angelakis, A.N.; Capodaglio, A.G.; Dialynas, E.G. Wastewater management: From Ancient Greece to modern times and future. *Water* **2023**, *15*, 43. <https://doi.org/10.3390/w15010043>.
26. North, D.C. *Institutions, Institutional Change and Economic Performance*; Cambridge University Press: Cambridge, UK, 1990.
27. Cox, C.A. The ‘Astynomoi’, private wills and street activity. *Class. Q. New Ser.* **2007**, *57*, 769–775.
28. Saba, S. *The Astynomoi Law from Pergamon: A New Commentary*; Verlag Antike: Mainz, Germany, 2012.
29. Loomis, W.T. *Wages, Welfare Costs and Inflation in Classical Athens*; Michigan University Press: Ann Arbor, MI, USA, 1998.
30. Ostrom, V.; Tiebout, C.M.; Warren, R. The organization of government in metropolitan areas: A theoretical inquiry. *Am. Political Sci. Rev.* **1961**, *55*, 831–842.
31. Ostrom, V. *The Intellectual Crisis in American Public Administration*; University of Alabama Press: Tuscaloosa, AL, USA, 1973.
32. Simon, H. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*; Macmillan: New York, NY, USA, 1947.
33. Simon, H. *Models of Bounded Rationality*; MIT Press: Cambridge, MA, USA, 1982; Volume 1–2.
34. Olson, M. *The Logic of Collective Action: Public Goods and the Theory of Groups*; Harvard University Press: Cambridge, MA, USA, 1965.
35. Kyriazis, N.; Economou, E.M.L. Macroculture, sports and democracy in Classical Greece, *Eur. J. Law Econ.* **2015**, *40*, 431–455.
36. Economou, E.M.L.; Kyriazis, N.C. The emergence of democracy: A behavioural perspective. In *Democracy and Salamis: 2500 Years After the Battle that Saved Greece and the Western World*; Economou, E.M.L., Kyriazis, N.C., Platias, A., Eds.; Springer Verlag: Cham, Switzerland, 2022; pp. 237–268.
37. Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; Political Economy of Institutions and Decisions; Cambridge University Press: Cambridge, UK, 1990.
38. Ostrom, E. Coping with tragedies of the commons. *Annu. Rev. Political Sci.* **1999**, *2*, 493–535.
39. Ostrom, E.; Gardner, R.; Walker, J. *Rules, Games, and Common-Pool Resources*; University of Michigan Press: Ann Arbor, MI, USA, 1994.
40. Ostrom, E. A diagnostic approach for going beyond panaceas. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 15181–15187.
41. Ostrom, E. A general framework for analyzing sustainability of social-ecological systems. *Science* **2009**, *325*, 419–422.
42. Putnam, R.D. *Bowling Alone: The Collapse and Revival of American Community*; Simon & Schuster: New York, NY, USA, 2000.
43. Putnam, R.D.; Leonardi, R.; Nanetti, R.Y. *Making Democracy Work: Civic Traditions in Modern Italy*; Princeton University Press: Princeton, NJ, USA, 1993.
44. Ober, J. *Democracy and Knowledge: Innovation and Learning in Classical Athens*; Princeton University Press: Princeton, NJ, USA, 2008.
45. Ober, J. *Demopolis: Democracy Before Liberalism in Theory and Practice*; Cambridge University Press: Cambridge, UK, 2017.
46. Fishkin, J.S. *Democracy and Deliberation: New Directions for Democratic Reform*; Yale University Press: New Haven, CT, USA, 1991.
47. Coase, R.H. The problem of social cost. *J. Law Econ.* **1960**, *3*, 837–877.
48. Akerlof, G.A. The market for “lemons”: Quality uncertainty and the market mechanism. *Q. J. Econ.* **1970**, *84*, 488–500.
49. Williamson, O.E. *The Economic Institutions of Capitalism*; Free Press: New York, NY, USA, 1985.
50. Stiglitz, J.E. Information and the change in the paradigm in economics. *Am. Econ. Rev.* **2002**, *92*, 460–501.
51. Blok, J. Ten Thousand: Fines, numbers and institutional change in Fifth-century Athens. In *Numbers and Numeracy in the Greek Polis*; Sing, R., van Berkel, T.A., Osborne, R., Eds.; Brill: Leiden, The Netherlands; Boston, MA, USA, 2021; pp. 96–130.
52. Pigou, A.C. *The Economics of Welfare*; Macmillan: London, UK, 1920.
53. Baumol, W.J. On taxation and the control of externalities. *Am. Econ. Rev.* **1972**, *62*, 307–322.
54. Baumol, W.J.; Oates, W.E. *The Theory of Environmental Policy*, 2nd ed.; Cambridge University Press: Cambridge, UK, 1988.

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