Research Article

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Waterscape and Floods Management of Greek Selinus: The Cottone River Valley

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Abstract: This paper investigates water bodies in the Greek colony of Selinus, Western Sicily-Italy. It focuses especially on one of the two rivers of the city: the Cottone. The investigative strategy adopted in this study consists of an interdisciplinary approach based on the analysis of archaeological evidence, Earth Sciences data, and the study of historical cartography. Results indicate that the Cottone River was not a swampy and unhealthy intermittent stream as it was believed so far; it was instead a fully functional water body featuring an active floodplain. Most importantly, research presented in this article indicates several floods occurred in Selinus from the second or third quarter of the sixth century BC to the end of the fifth century BC. These floods, which occurred at the peak of Selinus' cultural and economic life, were related to severe major events, rather than seasonal floods, as suggested by other scholars. The management of these floods and the waterscape was crucial to the city's prosperity. This article also analyzes the relationship between the Cottone River and the fortification walls located at the Cottone River Valley. Results indicate that the fortification walls functioned not only as a defensive infrastructure, but also as a hydraulic engineering solution for flood retention. A better understanding of the environment in which Selinus was settled is now available, and knowledge on the importance of waterscapes and their management has been enhanced.

Keywords: Sicily, Selinunte, waterscapes, coastal landscape, floods, water management, Greek archaeology

1 Introduction

Archaic and Classical Greek coastal settlements of Sicily, such as Naxos, Syracuse, Agrigento, Megara Hyblaea, Himera, Camarina, and Selinus (Figure 1), are well-known monumental cities that flourished due to a combination of various components, including a favorable environment (De Angelis, 2016, p. 26). Long-term archaeological investigation of these sites has resulted in an overall good understanding of their urban plans, including the location of major temples, necropolises, and public buildings (Boardman, 1999; Pugliese Carratelli, 1996). Yet such a growing knowledge on Greek coastal settlements of Sicily has for the most part excluded a rigorous study of the coast. As a result, our understanding of connectivity and interactions among people in those settlements as well as our knowledge of the relationship between humans and the environment has been lacking. While scholars have increasingly recognized the connectivity enabled by the sea in the ancient world over the last three decades (Blake & Knapp, 2005, pp. 2–6; Brughmans, 2013, p. 652; Dawson, 2016, pp. 234–235; Knappett, 2011, pp. 15–22; Leidwanger & Knappett, 2018, pp. 3–7; Malkin, 2011, p. 17; Purcell, 1990, pp. 29–58; Tartaron, 2013, pp. 139–140; Theodoulou, 2011, p. 62), sufficient attention has not been given to one of the most important nodes of these

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Figure 1: Location map of study sites in the Sicily-Lipari islands (Mazza, 2016c, Figure 1).

connections, the coast, even though it is often the key component of the waterscape for many Greek settlements. It is the quintessential place for the departure and arrival of anyone traveling by sea and encompasses both physical features (e.g., the geography of oceans, lands, rivers, valleys, mountains, etc.) and nonphysical aspects (e.g., sounds, colors, emotions, memories, tales, etc.).

In Greek Sicily, we know that maritime life was imbued with religious meaning, beliefs, and practices, but we do not know how these aspects were connected with the more practical aspects of living on the coast, such as commercial activities, fishing, and the management of the waterfront. The various ways by which the inhabitants of Western Greek colonies of Sicily experienced the shore are still an under-investigated topic. As a result, there are many important questions regarding major ancient towns that are still unanswered. What's more, the physical features of the shore where people met and connected are little understood.

Little is known about the waterscapes of many Archaic and Classical Sicilian settlements. Decades of archaeological investigation into those settlements have too often excluded the shore from any systematic study, while more conventional avenues of research (monumental architecture, artistic production, and material culture) were pursued. As a result, when one looks at city plans of Greek coastal settlements of Sicily, it is common to see that the coast sketched somewhere between two known points: the end of the excavated insulae and the current shore. Rivers had a similar fate; their course was mapped approximately in the vicinity of a modern one.

One might think that such an aprioristic positioning of palaeoshoreline cannot be off by too much. If an error of a few meters did exist, it would not necessarily compromise our understanding of a site. It cannot be denied that the shore is one of the most complex and ever-changing features of our planet. Tectonic uplift (the vertical elevation of the Earth's surface in response to natural causes), submergence (the sinking of an area of land in the water), subsidence (the gradual sinking of an area of land), erosion, and sedimentation are only a few of the factors that contribute to a changing of the shoreline position. As a result of these movements, the paleoshoreline of coastal settlements of antiquity can be located much farther away (inland or offshore) than one expects, and if so, the understanding of a coastal site might change to a

significant degree. The sites of Portus (Keay & Millet, 2005, pp. 297–314; Tormalin, 2000, pp. 85–98), the fifth century AD port of Classe (Augenti & Cirelli, 2004, pp. 59–63), and the shoreline in Kaulonia (Stanley, Bernasconi, Toth, Mariottini, & Iannelli, 2007) are good examples.

Rivers and paleorivers are also complex natural systems and their shape and flow have been also influenced by several geological and geomorphological human and environmental factors.

The uncertainty in investigating the waterscape in coastal settlements of Sicily has been caused in part by the low level of interest that archaeologists who study the island have shown in investigating ports, harbors, rivers, and in general maritime contexts. When compared to the investigation on monumental buildings and temples or the great degree of study on necropolis and their material culture, the gap is substantial. It has to be said, however, that investigating waterscapes and their infrastructures requires a great degree of interdisciplinary competences that classical archaeologist in the past did not have. Holistic investigations on the waterscape of Greek and Roman coastal settlements which include geological and oceanographic aspects are scarce. As a result, the coastal landscape that shaped the cultural life and social interactions in the Western Greek colonies of Sicily is far from being fully understood.

There are a handful of studies from France, Greece, and Italy where a holistic and interdisciplinary approach toward the coastal archaeological landscape has greatly enhanced our knowledge of important coastal settlements. For example, in Marseille it was possible to understand coastal changes to the waterfront for the last 4000 years and both the natural features and the human impact on the port were discovered (Goiran & Morhange, 2001, pp. 665–667; Morhange, Laborel, Hesnard, & Prone, 1996, p. 844). At the Piraeus, investigation on ship sheds and slipways enlightened us on the palaeoshoreline and infrastructures and port facilities of such an important coastal settlement (Loven & Schaldemose, 2011, pp. 60–62). Results of the investigations on the Lion Harbor Miletus were also outstanding and a completely new picture of the city is now available (Brückner, Herda, Müllenhoff, Rabbel, & Stümpel, 2014, pp. 49–103; Brückner, Herda, Kershner, Müllenhoff, & Stock, 2017, pp. 876–877). Interdisciplinary investigation in Kaulonia, Croton, Locri, and Sybaris established the baseline for a better understanding of coastal settlements in Magna Graecia (D'Arrigo, 1959; Stanley, 2010, pp. 17–29; Stanley, Nickerson, Bernasconi, Fischer, & McClure, 2011, pp. 130–132; Tennent, Stanley, Hart, & Bernasconi, 2009, pp. 401–488). In Sicily, studies focused on the shoreline conducted in the Greek coastal settlements of Syracuse, Camarina, and Caucana, for example, suggested interesting interpretations of underwater structures located in those cities as palaeoshoreline indicators (Basile, Di Stefano, & Lena, 1988, pp. 15–33; Gargallo di Castel Lentini, 1970, pp. 199–208; Kapitän, 1970, pp. 43–56; Scerra, 2015, pp. 54–65). More recently, investigations in Catania, Megara Hyblaea, and Lipari, just to name a few, resulted in an enhanced understanding of diachronic and topographic changes to the ancient waterfronts of those cities (Castagnino Berlinghieri & Monaco, 2010, p. 101; Mazza, 2016a, pp. 383–385; Scicchitano, Antonioli, Castagnino Berlinghieri, Dutton, & Monaco, 2008, p. 30). Thanks to these interdisciplinary research efforts, it is now clear, more than ever in the past, that a throughout understanding of Greek coastal settlements cannot be limited to the investigation of the urban settings and the material culture.

In Selinus, our overall knowledge of the city and its inhabitants is more extensive than that of many other Greek colonies in Sicily and Southern Italy. Rituals and cultural interactions have been extensively discussed by several scholars such as Collin-Bouffier (2015a, pp. 235–251), Curbera (1999, pp. 159–186), De Vido (2010, p. 605), Iannucci, Muccioli, and Zaccarini, (2015, pp. 2–7), and Kotansky (2015, pp. 127–134). Pottery, sculpture, and architecture were also investigated to a great degree by Dehl-von Kaenel (1995), Greco and Tardo (2009, pp. 677–792), Marconi (1994, 2012, pp. 22–24), and Spatafora (2017, pp. 431–437). Urban plan, sanctuaries, and industrial district were analyzed in detail by several eminent scholars (Albers, Bentz, Müller, & Zuchtriegel, 2011, pp. 45–47; Bentz, Adorno, Albers, Müller, & Zuchtriegel, 2013, p. 69; Bentz, 2015, p. 62; Hannah, Magli, & Orlando, 2016, p. 213; Marconi, 2013, p. 261; Meola, 1998; Mertens & Drummer, 1994, pp. 1479–1480; Mertens, 1989a, pp. 391–393, 1999, pp. 185–193, 2003; Tusa, 1986, pp. 13–16). Yet there are important aspects of Selinus's archaeological heritage that are still enigmatic. Such as, for example, the line of fortifications in the Modione Valley (Mertens, 2003, pls. 9–10) and in the southern sector of the acropolis (Mazza, 2017, p. 67).

One of the most significant lacuna in the archaeological investigation of Selinus remains the lack of knowledge on the city's waterscape. The information pertaining to the shore and the rivers is both sparse and problematic. The location and extent of the coast and its topographical relationship to the residential areas and sanctuaries are unknown. Moreover, documentation on port facilities and submerged archaeological evidence is insufficient to determine the diachronic and topographic development of the harbors (Lentini, 2010a, pp. 191–203; Purpura, 1975, pp. 58–64, 1986, pp. 155–160, 1991, p. 20, 1993, p. 163–184; Tusa, 2010a, pp. 115–211, 2010b, pp. 219–231). Similarly, very little information is available on the two rivers of the city: the Cottone and Modione.

In this paper, a holistic and interdisciplinary approach has been adopted and applied to the study of Selinus' waterscape. Archaeological evidence has been combined with Earth Sciences data along with ancient and modern literature, early cartography, and early photographs (Mazza, 2016a, p. 379, 2016b, pp. 297–315, 2016c, pp. 177–190). Within such an interdisciplinary framework, this article focuses on a specific sector of Selinus's landscape: the Cottone River Valley. The evidence analyzed indicates that the Cottone Valley, which has often been considered a low-energy system featuring a marshy lowland traversed by an intermitted river, was instead a dynamic geographic feature in Selinus's ancient landscape. In fact, as we argue, the palaeoenvironmental history of the Cottone River, and in particular the stratigraphic evidence of the river's flooding activity, suggests a gradual weakening of the city's defenses right before the 409 BC siege occurred.

2 History and Geography of Selinus

In order to provide a framework for this and other results presented in this paper, a brief introduction on Selinus's history, followed by an in-depth analysis of the city's geography and geomorphology, is presented.

2.1 Summary of Selinus's Main Historical Events

Founded by the Greeks from Megara Hyblaea and Megara Nisea, Selinus was one of the most important Greek colonies in Sicily (De Angelis, 2004, pp. 87–110; Strabo, *Geography* 6.2.6. Jones, 1967, p. 83) (Figure 2). The date of its foundation cannot be precisely determined, with historical evidence ranging from 650 BC (De Angelis, 2003, p. 124; Miller, 1970, p. 36; Diodorus Siculus, *Library* 13.59.4. Oldfather, 1933, p. 287) to 628 BC (Thucydides, *History of the Peloponnesian War* 6.4.2). Both dates correspond with significant events that could have been interpreted as years of foundation, and it is commonly agreed that both dates can be considered valid (De Angelis, 2004, p. 90; Marconi, 2013; Miller, 1970, pp. 14, 26, 183–184; Wilson, 1987, p. 101). In 409 BC, Selinus was destroyed by the Carthaginians, led by Hannibal Mago (De Vido, 2010, p. 599). During Roman times, the city was only sparsely populated (Lentini, 2010b, p. 209).

After the Vandal War (ca. 500 CE), a building was constructed on the foundations of Temples O and A on the acropolis (Figure 3). Scholars interpret it as a *castrum* (Lentini, 2010b, p. 212; Maurici, 2003, p. 905, 2005, pp. 200–201, Figure VII.15; Naselli, 1972, pp. 21–22; Trasselli, 1972, pp. 45–48), or perhaps an Arab *ribat* (Mertens, 1989a, p. 391; Molinari, 1995, p. 238, n. 33). Between the fifth and the sixth century AD, a commercial emporium was active at the mouth of the Modione River (Lentini, 2010a, pp. 194–195). During the sixth century AD, the presence of a baptistery at the mouth of the same river indicates the existence of an early Christian community (Lentini, 2010a, pp. 196–197; Maurici, 2005, pp. 193–204; Paoletti, 2006, pp. 634–635). On the former acropolis, there is also evidence of a later occupation related to the Arab period, with a contemporary Islamic cemetery. In 1154 AD, the Arab geographer Idrisi mentions the existence of a small village called Rahl'-al-Asnam. Such name was translated by the historian Amari as "Villaggio dei pilastri," which means Village of Pillars – where pillars allude to the columns of the temples

Figure 2: Selinus general plan (Mertens, 2003, pl. I, with additions by the author).

(Amari, 1854, p. 258; Blandi, 2000, p. 76). Fragments of protomaiolica pottery dated from the end of the thirteenth century to the end of the fourteenth century AD suggest a frequentation of the settlement in the Swabian period. After the fourteenth century AD, the archaeological record suggests that the area was not populated. In the middle of the sixteenth AD century, a coastal tower was then built (Fourmont, 2006, pp. 211–212; Maurici, 2005, 2008, p. 514; Molinari, 1995, pp. 223–239). From that time, Selinus has become the object of antiquarian interest. In fact, the ruins of the settlement were recognized by the historian Fazello as belonging to the former Greek city of Selinus as early as 1558 AD (Fazello, 1558, deca I, L. VI, Chapter IV).

2.2 Overview of the Geography, and Geomorphology of Selinus

Located in the Trapani Province, the site is today the largest archaeological park of Europe. The topography of Greek Selinus develops on three natural hills and the sea (Figure 2), with the East Hill being the location of the monumental temples (Figures 2 and 3). The central hill, which is in fact a double hill, is composed of the acropolis (to the south) and the Manuzza Hill (to the north). The acropolis featured an urban sanctuary with monumental temples and houses, whereas the Manuzza Hill featured the Agora and large residential districts, with industrial quarters for the manufacture of pottery located at the edges of the urban sectors toward the Cottone Valley. Finally, there is the Gagera Hill, which is the westernmost of the three hills (Figure 2). It has a narrow and elongated shape and is oriented N/S. It features sanctuaries and a freshwater spring named “La Gagera” in Italian.

Figure 3: Aerial photograph of Selinus oriented to the east; courtesy of Giovanni Miceli, 2014.

The three hills on which the city was built originate in a horst-and-graben geological setting (Piro & Versino, 1993, pp. 13–14) (Figure 4). The acropolis was established on the higher geological structure in the area of the horst. Two normal (vertical) faults have been postulated at both sides of the acropolis. The two faults stretch NE–SW and NNW–SSE, creating two structural depressions (grabens) in which two river valleys of the Modione and Cottone eventually developed. On the grabens, two monocline structures were documented. The east one (the East Hill) is a monocline fold whose dipping is oriented WSW. The west one, also a monocline fold (the Gaggera Hill and Manicalunga area), is lower.

The lithostratigraphic sequence at Selinus is made up of the following layers from top to bottom: Holocene sand dunes, Pleistocene calcarenites with macrofossil inclusion, clay-sands (on some occasion compacted with calcarenite concretions and macrofossils), and Pleistocene clay. Yellow ochre-colored calcarenites of the Tyrrhenian age can be observed on the shore. They are partially covered by beach rock formations consisting of a yellowish-gray conglomerate crust (Amadori et al., 1992, p. 87; Piro & Versino, 1993, pp. 14–15; Ruggieri & Unti, 1977, p. 803) (Figure 4). The territory on which Selinus was settled is subjected to movement of geomorphological origin. The quaternary layers are affected by subsidence phenomena caused by carsic dissolution of underlying gypsum of the Upper Miocene (Piro & Versino, 1993, pp. 13–14). This phenomenon happened during the Pliocene and the Lower Pleistocene. At the end of the Lower Pleistocene, however, the area underwent moderate uplift (Amadori et al., 1992, p. 89). A fault system is also present in the area near Selinus. It is formed by three faults dated to the Pleistocene which make a sort of a graben system. Underwater faults have also been detected (Piro & Versino, 1995, p. 896). Uplift rate of Tyrrhenian age terraces has been discussed by Antonioli et al. (2006, pp. 3–18), whereas a recent study on the geology of the area by Barreca et al. (2014, pp. 138–140) showed the existence of a new active fault, which can provide fresh insights into the seismic history of the area. The sea shapes the southern margins of the city. The seabed off Selinus is sandy, and it lies in very

Figure 4: Geolithological map of Selinus (Amadori, Feroci, & Versino, 1992, p. 97, Figure 16).

shallow water. There is a shallow band (maximum of 8 m depth) of approximately 220 m width which runs parallel to the shore. After that, the waters are still relatively shallow for several hundred more meters (Brizzolari, Piro, & Versino, 1994, pl. III). In that first band, the seabed is sandy with some scattered *poseidonia oceanica* spots.

Two rivers once flowed in the valleys created by the three hills: the Modione (west of the acropolis) and the Cottone (east of the acropolis) (Figures 2 and 4). Both the Modione and the Cottone rivers have been channeled in modern times. Channeling happened in the late 1980s. Embankments were most likely created; however, no sufficient information on such an operation was found in historical archives. It was reported as personal communication by the inhabitants of the nearby fishing village of Marinella (October 2016). The Modione river features several tributaries that provide the river with water that flows both on the surface and underground. Its hydrological basin has been documented as far as Castelvetro (Barreca et al., 2014, p. 140). It currently flows all year around, and we can suspect that its flow was also relatively consistent in the past. A freshwater spring located at the Gaggera Hill constantly provides, and would have provided, water that eventually flowed into the river. The Cottone River is also known in literature as Gorgo Cottone. *Gorgo* is in fact the poetic word that it is used in Italian to mean river. The Cottone is currently almost silted up. It flows very scarcely, and mostly in winter.

Beachrock formations have been documented, but unfortunately not mapped, in correspondence to the current mouth of the Modione and the Cottone rivers (Hermanns, 2014, pp. 102–104). One beachrock formation is located east of the acropolis. It runs at sea level alongside the current shoreline. Its features indicate that such a beachrock may be currently undergoing formation. However, a detailed geological survey would be needed in order to better understand such beachrock formations in Selinus and their relationship to the paleoshoreline. The other beachrock is located at the Modione's mouth, at an approximately 80–100 m distance from it. It is a 45 m long structure at ca. 3.8 m in-depth (Hermanns, 2014, p. 102). Pottery fragments of different periods of time have been noted inside these formations (e.g., Hellenistic and Roman materials) (Hermanns, 2014, pp. 102–104).

3 The Cottone River and its Valley: Historical Cartography, Travel Narrative, and Hydrological Evidence

The Cottone River Valley is of utmost importance in the urban development of Selinus. It is one of the most critical geographical features of the waterscape of the city and among the most informative coastal landscape features for better understanding the human-environment interactions on site. Literature traditionally locates the Greek period port of the city at the river's mouth (Purpura, 1975, p. 57, 1986, p. 139, 1991, p. 23, 1993; Tusa, 2010a, pp. 200–202, 2010b, pp. 219–231). The river valley could even be the location where the first Greek settlers established. In fact, remains of structures built with mud bricks on a stone socle were documented below the earliest layer of the foundation of the Small Gate. Scholars suggest that this could be evidence of the earlier colonial settlement, which was interpreted as a maritime district located nearby the port (Mertens, 2003, p. 73, 2010, p. 99, Figure 3; Mertens & Schützenberger, 2006).

The location and extent of the Cottone River's flow cannot be precisely estimated, as investigations specifically aiming to locate the exact position of the paleoriver's course during the Greek period have not been performed yet. One seismic profile and coring (unfortunately not supported by C14 results) have been performed at the Cottone by Rabbel et al. (2014, pp. 135–150). Very recently (autumn 2017), Prof. Gilberto Pambianchi of the Department of Geology of the University of Macerata and Camerino investigated the area by employing a thermic camera installed on a drone. Preliminary results suggested that the mouths of the rivers were much wider than previously believed, with brackish water basins getting as inland as the Gaggera spring (for the Modione) and as north to the Large Gate. However, previous studies by Rabbel et al. (2014, p. 146) suggest a different palaeoenvironment in both river valleys.

Catchment hydrology (the study of the hydrology in drainage basins) and hydrogeology (the area of geology that deals with the distribution and movement of groundwater) have not been investigated. Similarly, information on the palaeohydrological and sedimentological contexts is very scarce. Nonetheless, a thorough analysis of excavation reports of the fortification, a detailed study of historical cartography and today's topography of the area, and some knowledge of river hydrology offer a sufficient database to better understand the Cottone River Valley.

In hydrological terms, we can define the Cottone as a straight-line pattern river with floodplain and banks. Since a geological cross section of the river has not been produced yet, it cannot be excluded that the river in its lower course featured a meandric pattern. Satellite photographs do not show traces of meander footprints; nonetheless, historical cartography indicates that since the end of the eighteenth century AD, such a portion of the valley featured small lakes, marshes, and backswamps, which can be found in estuaries, as well as in meander rivers.

We are most likely dealing with an intermittent type of river (Southard, 2007, p. 223). The river originates locally, with historical cartography indicating that a modest spring located ca. 300 m north of Casa Florio (now Baglio Florio; Figure 2) provided the Cottone River Valley with fresh water (Figures 5 and 6). This spring is still active today. Evidence of a Late Roman occupation of this area suggests that the spring was both active in that period of time and appealing for the people who populated the site after the Greeks and Punics.

Water also arrived by the confluence of three streams which are visible in ancient cartography, but whose names are not reported. The two branches to the west seem to originate in the valleys next to Contrada Galera and Contrada Azzaruto, whereas to the east the main branch seems to originate in Contrada Garraffo.

The middle course of the river features the confluence of the streams into one channel, which then flows at the center of the valley created by the Manuzza and East Hill. Approaching the Large Gate, the Cottone Valley gradually widens, and by the Small Gate, it is already much wider. East of the North Gate of the acropolis, the valley reaches its maximum dimensions, becoming a wide lowland (Figure 4).

According to river hydrology, such a part of the valley would have once featured the lower course of the river and its floodplain. Historical maps of the area indicate that approaching the latitude of the North Gate of the acropolis (Figure 5), the straight-line channel of the river, which can be considered the main course,

Figure 5: Hulot and Fougères' plan of Selinus. In purple, the course of the rivers; in blue, the stagnant areas; in red, the visible structures; in yellow, the parallel walls (Hulot & Fougères, 1910, with additions by the author).

bends to the east and splits in two branches. Those two branches meet again after a few hundred meters. This sector of the Cottone Valley is one of the most interesting to us. Not only is it the area where scholars placed a hypothetical harbor basin, but it is also the location where we can better investigate the relationship between the river and the fortification walls.

The topography of the Cottone Valley drastically changes east of the eastern terrace of the urban sanctuary; it becomes very irregular in correspondence to the today's pine forest, which was planted there around 1973 (Matteini, 2009, p. 157). Parcelling and terracing took place in modern times. Historical aerial photographs and maps show terraces and parcelling of the area, possibly for cultivating purposes. Modifications happened also because of the construction during the WWII of bunkers for military purposes.

Figure 6: 1827 map of Selinuns by Hittorff and Zant (1827, pl. 10).

Another recent modification of the area's topography happened in the mid-1960s, when an elongated artificial terrace oriented NE–SW with a curved shape was created for touristic purposes (Gregorovius, 1968, p. 837).

Such a sector of the valley corresponds to the very low course of the river, which is where fluvial and marine systems meet and it is where the estuary and the mouth were located in historical times (Figure 5). On a general basis, we believe that the Cottone River flowed less abundantly than the Modione River. Not only is the Modione a much longer river, measuring 32 km, but it is also provided with water by several springs and tributaries. It originates from several tributaries and springs. Its source can be found as inland as the town of Santa Ninfa (Contrada Tre Serroni). Water is also provided by a spring close to the “ex Feudo Favara” (the toponym Favara derives from the Arab Fawara which means spring) and Gaggera Spring, which is located within the archaeological park of Selinus, on the east slope of the homonymous hill. (Figure 4).

We suspect that the Cottone flowed more abundantly in antiquity than it does in modern times. Historical cartography dating from 1782 to 1910 is key to this work. As no specific geoenvironmental study is yet available, these historical maps are the only evidence of its flow. They inform us of the tendency of the river to have limited water contribution (discharge), with marshes and ponds forming easily in the valley. The river was represented as a small stream flowing at the center of the valley. For example, in the 1827 map by Hittorff and Zant (1827, p. 10), it is possible to see that several small streams merged into the main course; despite that, the Cottone's flow was much smaller than the Modione (Figure 6). The great majority of

available ancient cartographic representations of the river always featured swamps and marshes, ponds, and typical swamp vegetation (Benndorf, 1873, pp. 13–14; Cavallari, 1872, pl. I; Harris & Angell, 1826; Hittorff & Zant, 1827, pl. 10; Holm, 1896, pl. IV; Hoüel, 1782, pl. XVI; Hulot & Fougères, 1910; Koldewey & Puchstein, 1899, pl. 29; Lo Faso Pietrasanta Duca di Serradifalco, 1834; Reinganum, 1827, pl. I).

In order to better understand why the river water would not flow into the sea but instead create a marshy environment, we should look at the hydrology of the rivers. River mouths are some of the most complex and variable features of coastal landscapes, and river water does not get to a sea or ocean as easily as one would imagine. Estuaries vary according to the coastal part, the hydrological regime, or the character of water mixing (Van der Tuin, 1991, pp. 18–19). This is especially true for Selinus, as many environmental, geographic, and topographic factors might have contributed to making it difficult for the Cottone River to reach the sea.

Water from rivers generally flows into a sea or ocean in a minor part by permeating the ground, whereas the great majority is running water that reaches the sea by the estuary and the mouth. In Selinus, it is extremely difficult for water to permeate through the ground as the lithostratigraphic sequence includes Pleistocene clay layers, as noted above in the previous section (Amadori et al., 1992, p. 87; Lentini & Carbone, 2014, pp. 321–322; Piro & Versino, 1993, pp. 14–15; Ruggieri & Unti, 1977). These layers are impermeable and do not allow water to filter through and eventually reach the sea. This is one of the main reasons Selinus was well-equipped with an efficient rainwater drainage system, which was detected along the city walls and also across the urban plan (Crouch, 2004, p. 75). Such lithostratigraphic setting would have contributed to the creation of a stagnant environment and the formation of marshes and ponds on the outer margins of flood plains.

Clay-sized particles settle out in these areas, and we should expect to find them in the stratigraphic record. In case of floods, the situation would have been aggravated. On those occasions, water would have flooded the floodplain; if not channeled and redirected to the main course of the river, it would have stayed stagnant for several weeks, even months, as it would not have drained into the ground because of the clay subsoil. Natural hollows would have most likely housed semipermanent ponds, shallow lakes, and backswamps (Southard, 2007, p. 216). Semipermanent ponds at the Cottone are documented in drawings included in travel narratives dated 1782–1910. The great majority of water, however, is the running water that gets into the sea by flowing through the estuary and the mouth. And if we look at ancient maps (Figures 5–7) and modern images (Figure 3), we can see that most relevant factor that contributes to making it difficult for the water to reach the sea is the deposit of sediments.

Figure 7: (a) aerial photograph of the Cottone valley from the East hill looking toward southwest; source <https://www.castelvetranoselinunte.it/files/selinunte-vista-aerea-580x351.jpg> accessed December 5, 2018, (b) watercolor painting on the Cottone valley from the East hill looking toward southwest. Author is Charles Gore, who illustrated Richard Payne Knight visit to Selinus in May 1777; cropped from Stumpf (1996, pl. 6), (c) zoom of Gore's illustration on the Cottone Valley, with additions by the author. The light blue area shows the course of the Cottone river, and (d) map of Selinus (Mertens, 2003, pl. I).

In Selinus, there are two types of sediments that deposit in the Cottone Valley: sand from the sea and sediments transported by the river. Sand is transported by the sea and the S-E Sirocco wind, which is the prevalent wind in the area. For the great majority of the year, it deposits on the shore, locking down the mouth of the river, whereas only in winter time and during storms it is washed/blown away, unlocking the mouth of the river and allowing water to get to the sea. Sediments are also transported by the river itself. It is likely that deposit of sediments possibly increased during the human occupation of Selinus as a consequence of the intense agricultural activity of the Greeks. It is known that farming accelerates land degradation and anthropogenic soil erosion (Van Andel, 1994, p. 26) and human activity greatly impact geomorphology of rivers (Anthony, Marriner, & Morhange, 2014, p. 357). We can therefore suggest that impermeability of the subsoil together with a small discharge and sand accumulation were the principal factors that contributed to the creation of Cottone's stagnant water.

One of the most captivating yet informative images of the waterscape of Selinus in modern times is a watercolor illustration drawn by Thomas Hearne, "Ruins of Selinus, from the South," from a sketch by Charles Gore to illustrate Richard Payne Knight's visit to Sicily in 1777 (Stumpf, 1996, pl. 6) (Figure 7b and c). Even though this illustration is not the earliest one available for Selinus (the first modern traveller who recorded his visit to Selinus was Breval in 1738. He focused on the ruins rather than the landscape; Pumo, 2016, pp. 59–70), it is nonetheless very precious to us, as it is one of the oldest pictorial representations of Selinus where it is possible to see the landscape of the Cottone Valley before human intervention on the archaeological landscape by excavations, landfill, planting of vegetation, and the temple's anastylosis. In this illustration, the Cottone's discharge was relatively low. In this representation, water fills a large depression located at the latitude of the North Gate of the acropolis. Sand and deposits filled the lower part of the Cottone Valley where the estuary of the river was once located. A little water reached the sea by means of a stream running along the bottom of the acropolis's slope. This hydrological scenery agrees with the season in which the travel occurred (May 7–9), when sand was transported from S–E deposits along the shore and locked up a larger part of the lower Cottone Valley.

4 The Cottone River and the Fortifications Walls

In Selinus, the Cottone and the Modione were two fully functional rivers, and their valleys were crucial elements of the coastal landscape. Whenever such rivers were located in the vicinity of city walls, they became crucial waterscape features to elevate the defensive potential of fortifications (Mertens & Schützenberger, 2006, pp. 209–210), making them much more effective in case of a military attack. These elements of the landscape would have added a challenging factor for enemies coming from east and west to reach the urban district located at the acropolis/Manuzza Hill. Such a walls-and-water defensive system has been attested in some of the earliest Greek period walls. We have examples from Naxos in Sicily and Old Smyrna (Tréziny, 2011, pp. 287–296). There is another possible example in Eretria. However, scholars are still debating if those walls were functioning only as a dike, or if they could have also served as fortification (Frederiksen, 2011, p. 74).

Rivers would have constituted an "extra line of defense against approaching enemies" (Frederiksen, 2011, p. 98, n. 187). Theoretically, they would have worked like moats in medieval castles. Within this framework, rivers could be considered not only as a source of water, natural resources, and waterways, but also as part of a combined defensive system. Hence, if we associate the defensive value of Cottone and the Modione in reinforcing Selinus's fortified landscape, it is conceivable that waterscape features influenced colonial urban choices more than has been previously believed.

In Selinus, fortification walls were built as early as the first quarter of the sixth century BC (Figure 2). Reinforcements, in the form of towers, were put in place at the end of the sixth century BC (Mertens & Schützenberger, 2006, p. 175). One of these towers is located south of the Large Gate. Later, refurbishments are dated to the fifth century BC (Mertens, 2003, pp. 71–72, 265–266). Fortification walls were crucial to ensure protection of the city; however, if we think about safety more broadly, it is reasonable to believe that such an important concern for the inhabitants of Selinus was addressed as early as when they decided to colonize the site.

Fortifications at Selinus are known through a combination of geomagnetic surveys and Mertens's trench excavations in the Cottone Valley, which occurred from 1987 to 1994 (Erkul, Rabbel, & Stümpel, 2003, pp. 157–159; Mertens, 1989b, pp. 587–588, 1989c, pp. 132–135, 2003, pp. 67–80, 283–396). Overall, 730 m of wall has been identified. Two gates were fully excavated and documented along the wall. They are the Small Gate (Kleine Osttor or Stadttor T2) and the Large Gate (Große Osttor or Stadttor T1) (Figure 2). These gates were aligned with the street on the Manuzza Hill: the Small Gate was aligned with the street S6–E, whereas the Large Gate was aligned with the street S11–E (Mertens & Drummer, 1994, pp. 1483–1487). Geomagnetic survey north of the Large Gate indicated that the fortification turns to the west to follow the topography of the bottom of the Manuzza Hill's slope (Mertens, 2003, pp. 43–44). Two more gates are known in such a sector (Stadttor T3 and Stadttor T4) 9 Bentz, Albers, Müller, & Zuchtriegel, 2012, p. 105; Mertens, 2003, p. 481). In its southern section, the fortification wall was notably wide. The sector dug at B87 in correspondence to the street S0–E3 was 4.2 to 4.6 m wide (Mertens, 2003, p. 72). Such a thickness was maintained up to the Small Gate. North of the Small Gate, its width reduces to 3.6 m, and to 2.4 m further north (Mertens, 2003, p. 265). As suggests by Mertens (2003, p. 394), such a difference in width could be connected to the fact that in the area south of the Small Gate, the harbor of the city was probably located. Therefore, more protection from water was needed in the area of the probable harbor district.

It has been calculated that fortifications were built with the masonry technique called *emplecton*. It consisted of walls with the outer faces made out of ashlar and internal space was filled with a mixture of stones (including stone flakes from the construction of the wall) and soil. These walls reached a maximum height of 8.5–9.0 m (Ginouvé & Martin, 1985, p. 52). The external face was made by large squared blocks of local stone. The internal face was made of small squared and irregular blocks. The lower part of the external face reached groundwater level, whereas the internal face was up to 2 m shallower compared to the outer face (Mertens, 2003, pp. 102, 265, 968).

There are two sectors of the fortifications that can help us in better understanding the waterscape of Selinus: the Large Gate and the Small Gate. Trenches A 91, A 1 94, A 2 94, C 91, D 91, E 87/90, and F 93 have provided us with the most information for this research.

Figure 8 shows stratification in the trenches D91 (Large Gate, Figure 8b), E 87/90 (Small Gate, Figure 8c), and F 93 (Small Gate, Figure 8d). A very compact and strongly loamy layer has been identified in several trenches dug at the two gates. The layer is located right below the fortifications (Figure 8b, SU 13/26; Figure 8c, SU 35/37; Figure 8d, SU 146).

It has been suggested that this layer can be interpreted as alluvial deposits or natural alluvial subsoils. Such an interpretation underpins the hypothesis that before the Greeks established their defensive system, the Cottone Valley was, at least in its central section, a coastal alluvial plain. Such an alluvial plain was chosen by the Greek urban planners to accommodate fortification walls which ran along its western edge. Geoacoustic survey and coring undertaken in the lower course of the river support the existence of alluvial deposits below the fortifications. They have been interpreted as a possible palaeolagoon undergoing progressive siltation. The possible existence of a lagoon at the mouth of the Cottone before the arrival of the Greek colonists has been postulated for the first time by Rabbel et al. (2014, pp. 142–147). Results are of extraordinary interest; however, additional investigation is required to establish date and extent of the lagoon in relation to the river, its floodplain, and the valley.

Alluvial deposits, even the consolidated ones, are not the best sediments on which to build. Given their nature, they are subjected to ground deformations and groundwater infiltration. This might have been the reason why in several places the natural alluvial subsoil on which the fortifications were built was partially modified by employing pieces of limestone on its top. Such an addition would have worked as a reinforcement of sorts for the foundations of the wall, which, as a result, would have worked better and lasted longer. This natural layer was partially modified during the construction of the gate by including pieces of broken yellow limestones that were interpreted as work waste. It has been suggested that these stones were employed there with the role of consolidating the alluvial subsoil in order to make it firmer for the construction of the fortification (Mertens, 2003, p. 350). Such a building strategy was much needed, as the fortification wall at the Cottone Valley was built in a humid environment given the vicinity of the Cottone river.

Figure 8: (a) Plan of the Cottone valley (Mertens, 2003, pl. I, with additions by the author). (b) Stratigraphic section of the layers detected outside the Large Gate in the trench D 91. The dark blue layer is the alluvial deposit laid down before the construction of the walls. The light blue layers indicate the flood layers. The light orange layer indicates the fortification wall (Mertens, 2003, p. 351, Figure 398, with additions by the author). (c) Stratigraphic section of the layers detected outside the Small Gate in the trench E87/90. The dark blue layer is the alluvial deposit laid down before the construction of the walls. The light blue layers indicate floods. The light orange layer indicates the fortification wall (Mertens, 2003, p. 290, Figure 372, with additions by the author). (d) Stratigraphic section of the layers detected outside the Small Gate in the trench F 93. The dark blue layer is the alluvial deposit laid down before the construction of the walls. The light blue layers indicate the flood that entered the city walls during the second or third quarter of the sixth century BC (Mertens, 2003, p. 333, Figure 392, with additions by the author). (e) Legend (Mertens, 2003, p. 283, Figure 369b).

Above the natural alluvial subsoil, various relatively thin deposits have been detected all along the outer face of the fortifications, as well as in one place inside the walls. Some of these layers, such as SU 23 in trench D 91, SU 140 in trench G 93, and SU 126 in trench F 93 are made of very pure clay. Those last two stratigraphic units might correspond to the same massive flooding event that happened during the second or third quarter of the sixth century BC. Other layers, such as US 10/22, are deposits of almost pure sand, whose origin (natural stratification or brought there as a fill layer) is not clear.

Layers composed by loam and clay soil-based sediments with inclusions were also detected (trench D 91, SU 11, 9/21, 8/20, trench G 93, SU 140) (Mertens, 2003, p. 301, Figure 376).

Common features among these layers suggest an active floodplain environment. These flood layers at the Large Gate and Small Gate originated from the activity of the nearby Cottone River.

A particularly clear overlapping sequence of flood deposits is visible outside the trench E 87/90 at the Small Gate (Figure 8c). In this trench, above the natural alluvial subsoil (SU 35/37), an uninterrupted series of typical flood layers (light-gray or yellow-brown, very compact loamy soil with lens of sand) were detected (SUs 34, 16/33, 15/32, 14/31, 13/30, 11, 12/29, and 10/28). In specific areas, temporary walking surfaces or permanent pavements/street levels made of highly compacted sand mixed with clay-based marl were documented above flood layers. There are three examples of this. Two are located outside the Large Gate: SU 12/24, trench D 91 and US 7/19 in trench D 91. The first is composed by work waste and formed at the time of the construction of the wall, the second is a street layer that was made by a mashed ground of yellow limestone. The third example is located outside the Small Gate. US 27 and 26A in trench E 87/90 are street layers dated end of the sixth century – beginning of the fifth century BC (Mertens, 2003, pp. 350–351, Figure 398).

This evidence indicates that alluvial residues were not cleared up; they were instead let to settle and later covered by walking surfaces.

Toward the end of the fifth century BC, massive traces of a violent destruction are documented across the site. They correspond to the 409 BC. destruction by the Carthaginians. After this date, there is no evidence of later use of the area at the Large Gate. Also, no evidence of later floods has been detected. Similarly, no flood layers have been documented at the Small Gate after 409 BC. At the Small Gate, however, evidence of later activities has been documented. Around the end of the fourth century BC and the first half of the third century BC, the terrain outside the Small Gate was leveled, filled, and paved. It was a massive, planned, and organized work whose magnitude might suggest that the area was needed to be clear and functional for some activities that would have seen people and merchandise entering/exiting the city by the Small Gate.

The environmental history of the Cottone Valley can be summarized as follows. Sometime before the arrival of the Greek people at Selinus, the lower section of the Cottone Valley was a coastal alluvial floodplain. It cannot be excluded that such an alluvial floodplain was partially occupied by a lagoon undergoing progressive siltation. It has not yet been made clear whether the lagoon was active, already silted, or partially silted by the time the Greeks settled on the site. The Cottone River possibly featured a small discharge and would have regularly flooded its floodplain. From the mid sixth century BC to the end of the fifth century BC, flood events reached the fortifications and were stopped by these. On one occasion, during the second or third quarter of the sixth century BC (which means not long after the construction of the fortifications), flood deposits entered through the so-called Small Gate (SU 126, trench F 93, SU 140, trench G 93) (Mertens, 2003, p. 319). No floods were documented at the fortifications after the end of the fifth century BC.

5 Discussion. Flood-Related Implication of the Cottone River

In Selinus, we are dealing with primary evidence of river palaeofloods for Sicily during the Greek period. Floods and stagnant water have also been suggested in Syracuse (Collin-Bouffier, 2000, pp. 37–43, 2020, pp. 157–178; Fucas, 2016, pp. 289–294). River palaeofloods in Greek coastal settlements of Sicily have been documented by means of secondary evidence. For example, a wall located near Gate 8 in Akragas (that could have functioned as a flood control facility) underpins the occurrence of floods in that area (Crouch, 2004, p. 32, Figure 3.4). Also, manmade holes cut in the porous rock leading to Colymbethra (an artificial lake of ca. 1,300 m in circumference and 15 m deep) suggest that they may have been used for drainage during floods. They have been also interpreted as generic channels (Crouch, 2004, p. 93). Moreover, even though there are a number of studies on palaeofloods in Sicily based on stratigraphic evidence, they only deal with flood layers related to palaeotsunamis (De Martini et al., 2010, pp. 2569–2580; De Martini, Barbano, Pantosti, Smedile, & Pirrotta, 2012, pp. 42–57; Pantosti, Barbano, Smedile, De Martini, & Tigano, 2008, pp. 1–6). As a result, there is little comparative studies area available for Sicily in order to better understand river paleofloods.

It seems that the Greek urban planners of Selinus were aware of waterscape-related implications of setting fortification walls in a coastal floodplain type of scenario. The alluvial floodplain on which they established their defensive system was an active waterscape featuring floods of the Cottone River. Within this framework, then, we can surmise that fortifications in Selinus also had the role of preventing floods from entering the city.

If we take as an example the stratigraphic sequence at the Small Gate (trench E 87/90), it is possible to see that seven overlapping layers of floods (SUs 34–28) are documented from the mid sixth century BC to the end of the fifth century BC (Mertens, 2003, p. 284). It is known in river hydrology that floods usually happen once every one or two years during the season with the highest rate of rainfall (Bridge, 2003, p. 11). Therefore, we would expect the stratification at the Cottone River to show evidence of several dozens of floods.

This was not the case in Selinus, however. It has to be said that rainfall in Western Sicily is not abundant. Less than 500 mm of rain occur in Western Sicily in one year, and 95% of it occur in autumn (Milone, 1959, p. 47, pl. 3) and seasonal floods, which usually occur every year or two, might not have been consistent. Nonetheless, we suspect that seven floods in 150 years are too scarce even for an intermittent river like the Cottone. Evidence so far analyzed indicates that the number of documented floods in Selinus is much smaller than expected.

Without a doubt, flood frequency is a complex topic of investigation within the field of hydrologic engineering (Bonaccorso, Brigandì, & Tito Aronica, 2017, pp. 15–22; Cannarozzo, D'asaro, & Ferro, 1993, 1995, pp. 19–42; Ferro & Porto, 2006, pp. 110–115) and its explanation goes beyond the topic of this paper. However, on a general basis, we can say that river floods occur when melting snow or excessive rainfall creates more water than a river can hold in its channel or the terrain can absorb floods (Bridge, 2003, p. 11). Excluding the events related to snow (rain-on-snow floods and snowmelt floods), as they are not applicable for Selinus, flooding events that could have happened in Selinus during the time span of one year are long-rain floods, short-rain floods, and flash floods (Fischer, Schumann, & Schulte, 2016, p. 39).

From a stratigraphic aspect, as floods occur regularly, already deposited layers of alluvium are constantly reworked. For example, fine-ponded backwaters and oxbow lakes sediments may cover sand sediments. Also, meandering channels can erode already deposited floodplain sediments. All these scenarios create interbedding layers. As a result, a floodplain's stratigraphy can be complicated, especially when dealing with river palaeofloods.

Flood evidence found around Selinus's fortifications refers to the very margins of the alluvial floodplain. Thus, it is possible that even if the river flooded regularly, only large floods would have had the magnitude to inundate the terrain as far as the walls. On the occasion of those extreme events, floods inundated a much larger portion of the alluvial floodplain than during seasonal events. This might support the evidence for only seven flood events documented near the fortifications. In Selinus, therefore, one explanation would be that fortifications stopped severe floods from getting into the city; in fact, there is evidence that only one flood entered the city gates. It was the event dated to the second or third quarter of the sixth century BC, which must have been a major flood event. The magnitude of this event was so devastating that flood layer was documented even inside the fortifications (Figure 8d). After this occurrence, other extreme floods did reach the fortifications (six events in ca. 150 years), but none entered the gates, at least not any that were not cleared up.

Stratigraphic evidence at the fortifications shows that no extreme floods reached the walls after the end of the fifth century BC. There could be several possible reasons for this. On a purely speculative level, it cannot be excluded that people living in Selinus after 409 BC. were able to better manage the flooding activity of the Cottone even in case of severe floods (Mertens, 2003, p. 301). However, in order to support this or other possible hypotheses, additional investigation is needed, especially because there are many aspects that are not fully understood. For example, there is not a clear understanding of the hydrography of the Cottone after 409 BC.

On a general basis, we could suggest that continuous accumulation of sediments and little maintenance of the coastal floodplain might have contributed to the progressive siltation of the river. Archaeological evidence shows that after 409 BC, farming activities continued in the territory of Selinus (Greco, Lentini, & Cancemi, 2012, p. 201; Lentini, 2010a, pp. 205–207, 2010b, pp. 199–200). Therefore, even if farming was not as intensive as

during the Greek period, it produced sediments that contributed, together with sand deposit, to the drying up of the Cottone River.

Stratigraphic evidence indicates that flood layers were kept in place, and in some area they were covered by pavements. One would expect, however, that alluvial layers were removed for three main reasons. First, when flood layers covered walking surfaces, they made them unusable. Therefore, in order for merchandise to arrive to the city and for people to commute, it was of primary importance to clear streets and make them usable again. Second, stagnant water does not smell good, and it offers a breeding environment for bacteria and larvae, while contributing to the creation of an overall unhealthy environment. Third, the repeated stratification, accumulation of unremoved flood layers and new pavements above these layers, causes the ground level outside the fortifications to rise gradually. This, if not associated with the rising of the wall itself, would have made the fortification system weaker, as it was much easier for enemies to breach it. In some cases, later flood layers (SUs 11, 12/29 and 10/28) contained large yellow limestone fragments whose presence might suggest that construction works were performed at the walls. This is the first signal of using the space outside the city walls, which was previously kept as an open alluvium terrain. Construction works at the wall continued until the beginning of the fifth century BC. These can be interpreted as maintenance works, such as fixing or repairing (Mertens, 2003, pp. 289–291).

One might argue that agriculture served as a reason for keeping floods in place. In antiquity, floods were considered beneficial to agriculture. In fact, organic matter, nitrogen, and phosphorus were transported and deposited along with sediment on occasion of floods. These materials created very fertile land to cultivate. This is very well-known not only thanks to evidence from Egypt and Mesopotamia, but also from Greece where evidence of floods controlled and managed for agricultural purposes has been documented (Koutsoyiannis, Mamassis, Efstratiadis, Zarkadoulas, & Markonis, 2012, pp. 238–256).

Yet we do not have archaeological evidence in Selinus of any agriculture practice located in the lower course of the Cottone during these times, which instead featured fortification walls, embankments, and possibly streets (Adorno et al., 2016, p. 22; Mertens, 2003, p. 285).

We suggest that in the urbanized area of Selinus, flood sediments were not kept in place. We need to look for other reasons that the inhabitants had to allow flood layers to build up along the outer face of the fortification walls.

Perhaps, the removal of extensive flood layers caused by extreme events was considered too costly, and they were simply covered by streets/pavements in order to make the area usable again. It can be suggested that this would have happened relatively soon after the extreme event, since making the area suitable again for people to travel and goods to be transported was a priority for the economy of the city. If that was the case, Selinuntinians seem to have underestimated the consequence of their actions. To leave flood layers in place, and to allow them to build up one above the other or being covered by new pavements, increased the level of the terrain outside the fortifications. As a consequence, in the time span of ca. 150 years the terrain outside the walls was much higher than it was at the time of their construction. Walls would have looked smaller, and their defensive potential weaker.

In order to maintain their defensive function, walls would have needed to be raised. Work waste associated with fixing and repairing the fortification wall has been found in the stratification. However, it would be conjectural to link this evidence with a rising of the masonry. It was most likely connected to repairing of the wall after floods (Mertens, 2003, p. 350). The Cottone River and the fortifications together were an excellent combined defensive system, but it needed to be efficiently maintained for such a system to work. Whether the 409 BC conquest of the city might have been facilitated by a less efficient defensive system is a topic that needs additional investigation. Nonetheless, it is now clear that the accumulation of sediments of extreme flood reduced the defensive potential of fortifications in this portion of the city.

The Cottone was first and foremost a river. Therefore, we would expect that not only extreme floods occurred, but also regular floods. In a highly urbanized settlement as it was in Selinus during the Archaic and Classical period, it was necessary to manage the regular floods of the Cottone. Moreover, with the Cottone Valley being a major passage for commuting to and from the urban district, we would expect that traveling across it was possible all year around, even during seasonal floods. On those occasions, we cannot exclude that people had to make a detour inland.

As anticipated in the previous section, seasonal floods partially covered the floodplain and deposit. If the water of regular floods is not drained through the terrain (and this did not happen in Selinus) or channeled and redirected to the main course of the river, it creates marshes and unhealthy stagnant waters.

According to Diog. Laert. (8.69–71), stagnant waters were the cause of Empedocles' intervention in Selinus. The account, which is the most discussed ancient literary passage on Selinus, describes the ancient philosopher sanitizing the water of the river as it created a very unhealthy environment that caused disease and death to women (Collin-Bouffier, 2015b, pp. 235–251). It is highly possible that stagnant waters created a marshy and unhealthy environment that was favorable to the spread of water-borne diseases (such as cholera) and most likely vector-borne diseases (such as malaria) (Collin-Bouffier, 1994, pp. 321–336). Therefore, it was crucial for the inhabitants of Selinus to have had a system to manage the regular flood of the Cottone River.

Greek period evidence of structures for channeling floods of the Cottone has not yet been found. However, given the needs for a city such as Selinus to maintain a healthy environment, it is highly possible that a flood-managing mechanism at the Cottone was in place. We do not exclude that channels or other forms of flood-management systems were once in place; however, the *in-situ* archaeological evidence of these has yet to be found. If made with stone, they could have been dismantled, and the stones reused somewhere else or are not yet discovered. Another possibility is that these could have been made by organic material, which can be hardly found in the archaeological record of Selinus.

Even if clear evidence of flood management (other than the fortifications functioning as a flood retaining system) has not yet been found elsewhere at the Cottone, there is evidence, unfortunately scattered and uncertain, that is nonetheless worth mentioning.

An interesting piece of evidence possibly connected to a drainage of water at the Cottone was detected outside the Small Gate. It is a linear structure oriented E–W, slightly offset toward the north. It was interpreted as a dam or embankment. The presence of a dam close to the location of the harbor was initially indicated by Ferdinand Gregorovius in 1886 which referred to this construction as *Dämme des Hafens*, dam of the port (Gregorovius, 1968, p. 842). Its date is contemporary to the fortifications (Mertens, 2003, p. 395). It has been suggested that such a dam/embankment was somehow edging the southern area of the Cottone Valley, which was perhaps more humid, and the northern part, where a more extensively drained environment was possibly attested.

Other linear structures have been discovered at the Cottone that might possibly be connected to the management of the floodplain and/or to port infrastructures. They are the so-called *mura parallele* (parallel walls) and some linear anomalies detected thanks to recent geomagnetic investigations (Adorno et al., 2016, p. 22). Unfortunately, both features have not yet been excavated. Thus, only speculations based on their position and function can be made. In brief, evidence known in the literature as parallel walls refers to the vestiges of two elongated elements, parallel to each other and perpendicular to the coast. Harris and Angell in 1826 were the first who mapped parallel ruins at the Cottone Valley (Harris & Angell, 1826, pp. 27–28; Mertens, 2003, p. 3, Figure 4). The vestiges of those walls were visible on the surface during nineteenth and twentieth century explorations and excavations, as so many travelers after Harris and Angell mapped parallel linear features at the Cottone Valley (Figure 5), but they were never fully excavated. A geoelectric survey aiming to relocate them has been performed in recent years, unfortunately without success as the presence of thick vegetation, water table, and the saline environment made survey not effective (Hermanns, 2014, pp. 119–122).

Literature also suggests that parallel walls had the function of shaping the port basin of Greek Selinus, functioning both as a fortification and as the delimitation of a port basin that would have once existed between the acropolis and the East Hill.

Regardless of their link to port infrastructures at the Cottone River's mouth, the parallel walls are major constructions located in the alluvial floodplain of a river. Therefore, when detected, measured, and excavated, they will provide useful information on the management of the waterscapes in Selinus, including any port infrastructures that would have once shaped the waterfront of the city.

Literature indicates that Selinus' waterfront featured two major harbor basins. One was located at the mouth of the Modione River, the other at the mouth of the Cottone River (Purpura, 1975, p. 57, 1986, p. 139, 1991, p. 23, 1993; Tusa, 2010a, pp. 200–202, 2010b, pp. 219–231).

A dock dated to the late Roman period and other port-related infrastructures have been documented at the mouth of the Modione River (Lentini, 2010a). However, no substantial evidence dated to the Greek period was found. Port-related evidence at the Cottone River valley consists of dock-featuring infrastructures located at the bottom right of the Acropolis. These were documented as early as 1879 by Cavallari and later by Salinas in 1885 (Purpura, 1991). Excavations by Salinas in 1902 and Bovio Marconi in 1950–1951 confirmed the interpretation as port-related infrastructures, possibly docks (Purpura, 1986). The date of the evidence is, however, controversial (Mazza, 2017).

Recent geomagnetic surveys at the Cottone Valley detected several buried linear anomalies that have been interpreted as structures (Adorno et al., 2016, pp. 80–83), possibly belonging to the ancient port of Selinus. In August 2019 and 2020, a team directed by Jon Albers (the University of Bonn and Ruhr-University Bochum) excavated those anomalies. Results of these investigations are not yet published. It would be interesting to understand whether or not these walls should be related to the parallel walls known in the literature, to port structures, or to the channeling of the overflow of the Cottone.

6 Final Considerations

This article focused on the waterscape of Selinus and especially on the relationship between the Cottone River and the fortifications at the Cottone River valley. Thanks to an interdisciplinary research strategy, which encompassed the analysis of archaeological evidence, historical cartography, travel narrative, and hydrological evidence, a more exhaustive picture of the Cottone River Valley in Selinus was provided. Moreover, a better understanding of waterscapes and their role in shaping Selinus' life was obtained.

First, we argued that Cottone River, which in modern times features a small intermittent stream with ponds and marshes, looked completely different during the Greek period. Archaeological evidence suggests that the Cottone was a proper fully functional river featuring a floodplain and a regular flow. Its flow, as well as its importance in the overall waterscape of Selinus, was of course secondary to Modione River, whose waters were abundant as several springs and underground channels flowed into it.

Second, we indicated that maintenance of the river and its floodplain was essential for the city's optimal functioning and well-being. We suggest that the Cottone River featured seasonal floods, whose water would have been possibly channeled and redirected to the main stream. By doing so, the environment was maintained relatively healthy. As a result, floodplain's resources such as reeds, brackish water fishes, and mollusks were available to supplement the city's resources (Benecke, in press). We also argued that maintenance of the rivers included keeping gates and streets clear from flood waste. This was key to Selinus's well-being. It is well-known that in order for people to move across the city and for merchandise to arrive and depart, the most direct commute was across the river valleys. Therefore, a sustainable management of the river would have had positive outcomes on commercial activities and on the quality of life more generally. In a few occasions, however, flood wastes were not removed as large flooding layers were documented in the archaeological stratification of the Cottone River Valley.

In one occasion, a major flood extended beyond the gates and inundated the urban area. The event is dated to the second or third quarter of the sixth century BC. After this event, several other floods occurred in Selinus, but they did not reach inside the fortifications. They were documented at the Large Gate, as well as at the Small Gate. Evidence analyzed in this article suggests that those floods occurred between the mid sixth century BC and the end of the fifth century BC. We suggest these floods might relate to severe major events, rather than seasonal floods, as suggested by other scholars (Crouch, 2004, p. 87). Not only is their number smaller than that we would expect for annual floods (seven floods in ca. 150 years), but also their extent, location, and stratigraphic relationship with other layers might indicate that they could be the results of extreme flooding events of the Cottone River. In those occasions, the river broke its banks and inundated the surrounding areas but not entered the city walls (Mertens & Drummer, 1994, p. 1486). In these occasions, the fortification walls functioned as perfect hydraulic engineering facility for flood retention. No more flood layers were detected in the stratification outside the fortification after the end of the fifth

century BC. We do not know whether the later absence of flood evidence in the stratification should be connected to a change in the hydrology of the river (no more extreme floods, or perhaps no more floods) or to hydraulic engineering solutions put in place as part of the extended works that are documented in the area during the Punic period (Mertens, 2003, p. 301).

Ultimately, we suggest that despite the Cottone River was secondary to the Modione, it also played a critical role in Selinus' overall defensive system. Safety was a priority for the people who settled in Selinus. The city was in fact founded in a sector of Sicily which was culturally and politically complex, i.e., among the Phoenicio-Punic and Elymian area of influence (De Angelis, 2003, pp. 124–125; Spatafora, 2012, pp. 105–107). Given its geographical position, providing the city with an efficient defensive system was crucial. For this reason, fortification walls were built as early as the mid sixth century BC. We argued that the city's protection was granted not exclusively by walls alone. The Cottone River, and its valley, shaped a substantial role in strengthening the defensive potential of fortifications. Both the walls and the Cottone River itself together constituted a combined defensive system. It has to be said, however, that maintenance was also crucial for keeping such a combined defensive system fully effective. We suggested that the progressive accumulation of sediments of the above-mentioned extreme flood outside the fortifications reduced the defensive potential of the city's walls. Investigating the Modione palaeohydrology and the relationship between this river and the fortifications in the western sector of the city is now necessary in order to explore this concept more broadly and possibly provide a more solid ground on which to frame the 409 siege and destruction of the city.

In conclusion, this article reinforced the role waterscape plays in establishing and maintaining a functioning Greeks city in Sicily (Danner, 1997, pp. 155–156). Greeks who established in Selinus understood to a great degree both the geography and geomorphological of the area. They made sure to have fertile land to cultivate, good quality stone at a short distance from the city, plenty of clay and firewood for a pottery industry, and fresh water from springs. Rivers granted easy access to the hinterland as well as shaped the physical landscape, social spaces, and the architecture (Chiarenza, 2020, pp. 51–68). In Selinus, the westernmost of the Greek colonies of Sicily, water and its management, was a key component of people's life.

Abbreviations

BC	before christ
AD	annus domini

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