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The Architecture of Wind: Microclimatic Strategies in Roman *Villae Maritimae* across the Mediterranean (Case Studies from Tripolitania)

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Abstract

This study examines four maritime villas located in the Tripoli area, aiming to highlight how Roman domestic architecture adapted spatially to local climatic conditions. In particular, it hypothesises that the combination of *porticus* and *cryptoporticus* formed an architectural device conceived to exploit the natural direction of the winds in order to ensure the passive cooling of residential spaces. Such interpretations, especially concerning the Tripolitanian villas, were partially advanced by mid-twentieth-century scholars. However, they have never been systematically organised within a comparative, interprovincial framework. The data employed in this study derive from a doctoral project that analyses, through published cartography and relevant scientific literature, the architectural evidence of maritime villas along the coasts of the Roman Mediterranean provinces, with the aim of identifying common architectural typologies. Preliminary findings indicate that these strategies of environmental architecture may represent a regional peculiarity of Tripolitania, rather than a broader pattern within the Roman world.

Keywords: Roman maritime villas, Tripolitania, Passive cooling, Porticus and cryptoporticus, Environmental architecture

Introduction

This study is part of a doctoral project in Sciences for Cultural Heritage and Production (funded by the Cultural Heritage Active Innovation for Sustainable Society PNRR – CHANGES, SPOKE 6, CUP E63C22001960006), which investigates Roman *villae maritimae* within the Mediterranean context[1].

Through a comparative analysis of the architectural layouts from other Roman provinces[2], the villas of Tripolitania stand out for an architectural design that was carefully calibrated to exploit local climatic conditions, with particular attention to the role of the wind. This adaptation also entailed an aesthetic modulation of space and the adoption of architectural solutions designed to regulate environmental conditions.

The synergy between nature and architecture extended beyond mere technical functionality, reflecting a sophisticated environmental awareness among the designers, who transformed natural forces into instruments of prestige and comfort serving both daily life and the optimal preservation of products from the *fundus*. In this sense, the Roman villa may be understood as an integrated climatic device engaging with the landscape and expressing, through architecture, an ideal of harmony between humans and their environment[3].

The study examines how the predominantly regional Mediterranean wind[4] patterns influenced the spatial layout of the villas, hypothesising that design strategies were developed to protect against prevailing winds without compromising sea views. Particular attention is given to the use of the sea

[1] The research project, through a comprehensive survey of all sites corresponding to the definitions of 'villa marittima' and 'coastal villa' (Lafon 2001), aims to define one or more architectural typologies of Roman dwellings in the Mediterranean area and to develop a unified reference system for managing the archaeological data collected. This will be achieved through the creation of a dataset - based on information gathered from scholarly literature - designed to serve as an extensive repository organised according to chronological, topographical, and architectural criteria.

[2] By way of mere exemplification, two cases may be cited: the villa of Torre de Benagalbón, located in the Roman province of *Baetica*, and that of Els Munts, in *Tarraconensis*. In both instances, the arrangement of the *porticus* and *cryptoporticus* does not serve purposes of climatic adaptation but rather appears as an architectural expedient intended to create shaded areas for promenading.

[3] On how the *villae maritimae* represent a paradigmatic example of the "sintesi tra natura e artificio, tra ambiente e opera dell'uomo" (Musso 2024, p. 224), see Filser et al. 2017, pp. 74–84.

[4] For further insight into regional wind systems, see Zecchetto & Cappa 2001, p. 52.

breeze[5] as a resource for the natural cooling of interior spaces, and to the spatial arrangement of the *porticus*[6] and *cryptoporticus*[7].

Methods

Several examples identified during the typological survey of Mediterranean *villae* confirm this careful design approach, with particularly notable recurrence in the villas of North Africa. These villas overlook spectacular coastal landscapes and display complex configurations organised around internal courtyards, colonnades, and windbreak walls-features designed to mitigate the impact of marine currents while shielding against hot winds from the desert hinterland. These measures contribute to the creation of climatically balanced spaces, functional for daily life.

While rooted in Roman building tradition, this approach is locally enriched by specific solutions emerging from an osmosis between Roman technical expertise and endemic environmental knowledge[8], particularly evident in the region of Tripolitania.

An examination of the floor plans studied thus far-while recognising the preliminary and partial nature of this research[9]-shows that, despite their differing layouts, most of the villas in Tripolitania share certain common features. An exception of the villa at Wadi Zennad, near the former Jewish

[5] For an overview of the impact of sea breeze penetration into the coastal hinterland, see Obermann-Hellhund 2022, pp. 5–6.

[6] For a definition of the *porticus*: "a column-supported roofed space, open or partly closed" (Clarke 1991, p. 377).

[7] As Clarke observes, in the *villa maritima* the arrangement of the *tablinum* and the residential quarters is reversed compared to the prescriptions found in Vitruvius (*De architectura* 6.5.3), precisely in order to provide the inhabitants with an uninterrupted view of the sea (Clarke 1991, p. 19). On the use of the *cryptoporticus* in Roman architecture, see Giuliani 1973, pp. 79–98; for a definition: "underground or partially hidden corridor" (Clarke 1991, p. 374); "A ground-level or semisubterranean vaulted corridor, usually lit by openings in the vault. Its primary function is normally to buttress an adjacent structure, and secondarily it is used as a shady place to walk or store goods" (Sear 2021, p. 284).

[8] A comparative study of built structures and wind channelling in Roman-period architecture (the Roman fort of the Kharga Oasis) may be found in Rossi & Magli 2017, pp. 1–16.

[9] The four villas examined in this contribution were selected based on the available literature, the data derived from the excavations carried out (unfortunately none recent, as is also the case for the reference literature), the state of preservation of the uncovered structures, and similar architectural characteristics, in order to allow for a meaningful comparison between them. The same architectural scheme could also be applied to the so-called Villa del Nilo and that of Gurgi; however, the state of preservation of their structures advises caution, and these two villas have therefore been excluded from the analysis (as already noted in Salza Prina Ricotti 1968–1970, p. 25).

cemetery of Homs[10], which exhibits a typically Roman layout (known as the "tetti a mansarda" type[11]).

This exception, however, further supports the hypothesis that local microclimatic conditions strongly influenced villa design choices[12], prompting a form of climatic adaptation that departs from codified layout schemes and confirms the primacy of environmental factors over architectural orthodoxy. Indeed, as has long been recognised, "a prevailing regional wind changes its pattern as it flows through a built environment"[13].

Results

Planimetric observation of the maritime villas located in other provinces, and of Roman *domus*, reveals that they are typically arranged around one or more *peristylia*. Villas near Tripoli, however, display an elongated west–east layout, with monumental façades featuring porticoes and large-windowed rooms facing north towards the sea, while the rear façade is closed off, almost "blind", to the south. The principal façade's orientation towards the sea is not solely motivated by aesthetic considerations (to enjoy the sea view) or functional ones (some of the Tripolitan villas include a landing stage near the main entrance[14]), but primarily to harness the fresh breeze coming from the sea and to protect the residential areas from the desert winds blowing from south to north, thereby creating a microclimate favourable both to daily life and to the preservation of goods stored in rooms designated as warehouses[15], originating from the *dominus'* agricultural estate (*fundus*).

It is evident that the organisation of space, through the creation of buffer zones enclosed between the *porticus* and the *cryptoporticus*[16], reflects

[10] Bartoccini 1927a, pp. 226-232; Bartoccini 1927b, pp. 213-248; Salza Prina Ricotti 1968-1970; Matoug 1995, p. 155; Mattingly 2005, p. 196; Musso 2010, pp. 49-78.
[11] Salza Prina Ricotti 1968-1970, p. 30.
[12] Michael Feige (2022) identifies specific design strategies related to wind dynamics in the constructional choices of certain rural villas in the Roman countryside. According to the scholar, in these sites the arrangement of the rooms intended for the storage of produce is consistently located on the northern side of the structures, so as to make optimal use of the beneficial effect of the cool northern winds and in full accordance with the ancient sources, including Columella (XI, 2, 2-98), Varro (*rust.* I, 57), and Vitruvius (VI, 6, 2 and VI, 6, 4) (Feige 2022, pp. 175-179).
[13] Gao et al. 2012, p. 148. On the subject, see also Patz et al. 2005, pp. 310-317.
[14] A landing stage has been definitively identified for the Villa of the Maritime Odeon (Salza Prina Ricotti 1970-1971, pp. 148-149), while one is hypothesised for the Villa of the Small Circus (Salza Prina Ricotti 1970-1971, pp. 159-160) and for Zliten (Aurigemma 1926, p. 18).
[15] As hypothesised for the Villa of the Race of the Nereids (Salza Prina Ricotti 1968-1970, pp. 31-32).
[16] Recent studies on the configuration of modern buildings confirm that parallel arrangements of a paratactic type (comparable, in fact, to the positioning of the two ancient architectural

a form of ecological intelligence *ante litteram*, in which no orientation is arbitrary but responds to a refined environmental logic.

Discussion

An example [Fig. 1] of the difference observable between the north and south façades of a villa can be seen at the site of Dar Buc Amméra[17] (also known as the Villa of Zliten), which contrasts at the planimetric level with the typical Roman villa in which the extremely elongated north-facing plan becomes the regional paradigm[18]. The principal parts of the complex are not arranged, as usual, around the atrium or peristyle but rather along the hill's ridge on which the villa stands, oriented east-west parallel to the coast. It is likely that the villa had two storeys[19]. In this complex, the residential rooms all overlook a colonnaded portico, later enclosed as a cryptoporticus (equipped with openings[20]), while behind the *pars urbana* (to the south) lies a second cryptoporticus, partially cut into the rock, situated roughly half below the floor level[21].

This lowering of the floor level, besides construction requirements, may also reflect strategies for maintaining coolness, similar to those employed in subterranean domestic spaces and rural storehouses in the premodern period.

elements, the *porticus* and the *cryptoporticus*), produce evident benefits in terms of wind performance (Gao et al. 2012, p. 149).

[17] Aurigemma 1926; Gatti 1957, pp. 298-299; Mansuelli 1958, p. 99; Parrish 1985, pp. 137-158; Mattingly 2005, pp. 256-257; Wilson 2018, p. 274 and p. 293. According to Aurigemma, the villa could be identified as the *statio Seggera* of the Antonine Itinerary, or alternatively, the villa itself may have given its name to the *statio* (Aurigemma 1926, p. 21).

[18] Already noted by Aurigemma 1926, p. 20.

[19] On the basis of certain stylistic comparisons of the mosaics and frescoes on the vault of the southern cryptoporticus, David Parrish suggests that the villa-or at least the date of its embellishment with decorative features-can be dated to between the late 2nd and the mid-3rd centuries AD, specifically to the stylistic current that emerged following Emperor Septimius Severus's visit to Egypt in 199 AD (Parrish 1985, p. 141 and pp. 144-145).

[20] In the portico, the lower parts of the bases of nine columns were found *in situ*. At a later stage, the portico was enclosed with a wall, incorporating the columns within it and creating large windows overlooking the sea (Aurigemma 1926, p. 34).

[21] The cryptoporticus had a beaten-earth floor and a barrel vault frescoed with figures of deities, and was carved into the rock. Approximately halfway along its length, a stone staircase provided access to the upper floor (Aurigemma 1926, p. 34; also see Salza Prina Ricotti 1968-1970, p. 25).

Figure 1: Villa of Dar Buc Amméra (also Villa of Zliten). The background of the map has been derived from Google Maps (image acquisition date: 25 August 2025; WGS84/EPSG:4326 long. 13.7406; lat. 32.7821)

Figure 2: Villa of the Nereid Race of Tagiura. The background of the map has been derived from Google Maps (image acquisition date: 25 August 2025; WGS84/EPSG:4326 long. 14.1753; lat. 32.6984)

Another example [Fig. 2] of the north façade facing the sea, completely without windows and featuring openings nearly three metres wide, is found in the villa of Tagiura[22], known as the Villa of the Race of the Nereids[23]. Here, the front portico facing north towards the sea is screened by a *viridarium* and enclosed by "transenne," which functioned similarly to the modern mashrabiya, designed to capture the wind and ensure passive cooling of the interior spaces[24]. Furthermore, the arrangement of domestic rooms between the front portico and the rear cryptoporticus created a sort of buffer zone, sheltered and isolated from the outside, where the temperature was naturally cooler. These rooms were partly cut into the rock and accessed by steps, with the floor level situated approximately two metres below the base of the cryptoporticus. Behind them, the cryptoporticus-whose height is presumed to be greater than that of the villa's front section-may have featured a windowed north-facing wall, thereby directly benefiting directly from the sea breeze passing over the roofs of the portico and domestic rooms[25].

Thus, a multi-level system of natural ventilation is configured, whereby air and light are modulated through spatial articulations reflecting a profound empirical understanding of thermal dynamics[26].

A clarification is necessary regarding the presence of the *viridarium* situated between the sea and the front portico, as suggested by Antonino Di Vita[27] (1966): this would be an exception within the context of Tripolitanian villas, since, starting with the Villa of Silin[28], it is more likely that such gardens were located at the rear of the structure, in areas found to be free of building remains[29]. This is consistent with both ancient literary and iconographic sources[30]. Indeed, Pliny the Younger tells his friend Gallus that, at his Laurentine villa, he had to replace the boxwood hedge with simple rosemary,

[22] The walls of one of the *ambulacra* yielded bricks bearing four different stamps, attributable to the Roman workshop of *Domitia Lucilla Minor,* mother of Emperor Marcus Aurelius, and to the *figlina Terentiana*, owned by Domitia Lucilla and later by Marcus Aurelius and Faustina. On this basis, Di Vita (1966) proposes that the construction of the villa dates to a period between 157 and 161 BC. The villa was certainly occupied, at least in part, during the fourth century AD (Di Vita 1966, pp. 18–19).
[23] Di Vita 1966; Mattingly 2005, p. 227; Wilson 2018, pp. 286-287.
[24] Salza Prina Ricotti 1968-1970, p. 25.
[25] Salza Prina Ricotti 1968-1970, pp. 31-32.
[26] Differently, Di Vita 1966, 29: the scholar maintains that this arrangement was intended solely to create a shaded promenade.
[27] Di Vita 1966, p. 14.
[28] Di Vita 1975, pp. 165-187; Al Mahjub 1983, pp. 299-306; Mattingly 2005, p. 257; Bianchi 2002, pp. 1729-1749; Dolciotti 2010, pp. 659-670, tav. LXIII; Wilson 2018, pp. 290-297; Musso 2024, pp. 235-249.
[29] Salza Prina Ricotti 1968-1970, p. 31.
[30] For an overview of the iconography of maritime villas, see Felici 2018, pp. 29–42, with earlier bibliography.

which proved more resistant to the salt-laden sea breeze (*Epistulae* II, 17). Likewise, iconographic sources often depict trees belonging to gardens and *viridaria* to the rear of buildings[31], and never at the front.

Figure 3: Villa of the Maritime Odeon. The background of the map has been derived from Google Maps (image acquisition date: 25 August 2025; WGS84/EPSG:4326 long. 13.4840; lat. 32.8421)

[31] Gatti 1957, pp. 297-298.

The Villa of the Maritime Odeon[32] [Fig. 3] features a portico in the front section of the complex, designed with a special perspectival illusion so as to appear curved to those approaching the villa from the sea, and a cryptoporticus at the rear, above which the rooms of the *pars urbana*[33] are arranged. In this villa, even if the *porticus*/buffer zone/*cryptoporticus* scheme is not fully realised, one can nonetheless discern the intention to create a form of shelter for the residential area of the complex, which is screened from the south–north winds by the structures positioned behind the villa's front section, which occupies the promontory. The same principle can be applied to the Villa of the Small Circus[34] [Fig. 4], which displays an alternation of *porticus* and rooms in the rear section, while maintaining a west–east spatial distribution in line with the orientation of the coastline. The design of these luxurious residences thus appears to be orchestrated as a functional scenography: optical illusion and architectural order are not merely symbols of *status*[35] but integral elements of environmental control.

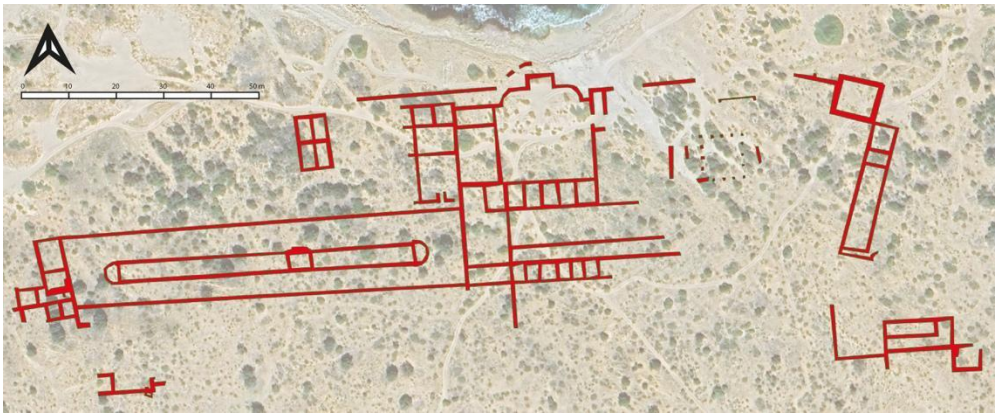

Figure 4: Villa of the Little Circus. The background of the map has been derived from Google Maps (image acquisition date: 25 August 2025; WGS84/EPSG:4326 long. 14.6487; lat. 32.5357)

[32] Salza Prina Ricotti 1968–1970, p. 31; Salza Prina Ricotti 1970–1971, pp. 140–154; Wilson 2018, p. 275 and p. 288. The villa takes its name from a stepped structure (12) with a diameter of 14 metres, cut into the rock of the promontory.

[33] The villa may be dated to a period not earlier than AD 69, when the last invasion by the Garamantes took place (Tacitus, *Hist*. IV, 50; Pliny, *N.H.* V, 5, 38). This hypothesis arises from the presence of limestone thresholds in the *diaetae* of the *porticus*'s projecting sections, where the holes for the central latch bolt are still clearly visible, showing that the French windows could be opened fully towards the sea. Such an arrangement would only have been feasible in areas without particular threats or fear of possible attacks (Salza Prina Ricotti 1970–1971, p. 141).

[34] Salza Prina Ricotti 1970–1971, pp. 154–160; Wilson 2018, pp. 287–289. The villa remained in use over a chronological span from the first to the third century AD (Salza Prina Ricotti 1970–1971, p. 141).

[35] For a discussion of the cultural implications of the *dominus* of Tripolitanian villas, see Musso 2024, pp. 243–246.

It is clear that the architectural and spatial adaptations of the maritime villas of Africa Proconsularis - and particularly those in the Tripolitanian region - were designed to make the most of the cooling potential of the sea breeze blowing from the north, while mitigating the harmful effects of the *Ghibli*, a hot wind that can reach up to 54°C[36]. This dry, dusty wind, also known as the *Khamsin*, comes from the south or south-east and sweeps along the African Mediterranean coast. The Ghibli carries hot tropical air and occurs mainly in spring, but also in autumn, and can provoke intense sandstorms[37].

To further investigate and quantify the influence of the *Ghibli* on maritime villas, meteorological data from 21 March 2025, extracted from the Copernicus Climate Change Service Climate Data Store[38], were selected to represent the onset of spring. Although these are modern observations, it is reasonable to assume that similar conditions could have prevailed during the Roman period, given the persistence of seasonal atmospheric circulation patterns in the Mediterranean[39]. Spring was chosen illustratively, as it marks the period when the *Ghibli* begins to blow with greater regularity, thereby allowing a comparison between the orientation and layout of the villas and the direction and intensity of surface wind as reconstructed from the U and V components.

[36] Warner 2004, pp. 90-91.
[37] For the *Ghibli* and *Khamsin*, see Obermann-Hellhund 2022, p. 5.
[38] This dataset is released for use under a CC-BY licence.
[39] It has not been possible to obtain modern climatic data or comparative studies with ancient conditions for the area of Tripolitania under consideration; however, in general, “Die Ergebnisse moderner Klimamessungen können daher auch als Richtwerte für die antiken Bedingungen angewendet werden” (Feige 2022, p. 179, n. 748).

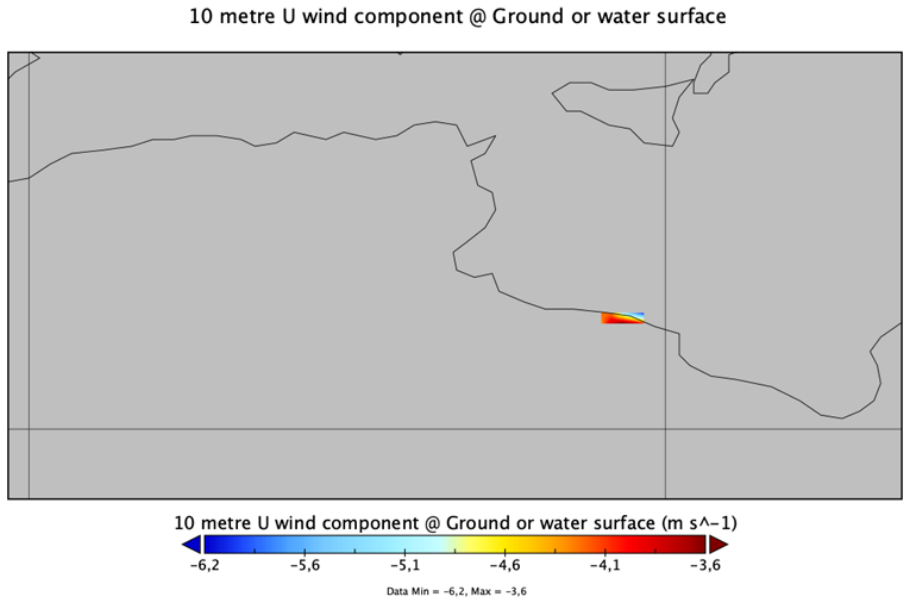

Figure 5: Representation of the U wind component in the studied area. The data were obtained from the Copernicus Climate Change Service Climate Data Store and refer to 21 March 2025 (CDS 2023), and were graphically processed using @Panoply (Version 5.6.2, NASA Goddard Institute for Space Studies [NASA/GISS], 2880 Broadway, New York, NY 10025, USA)

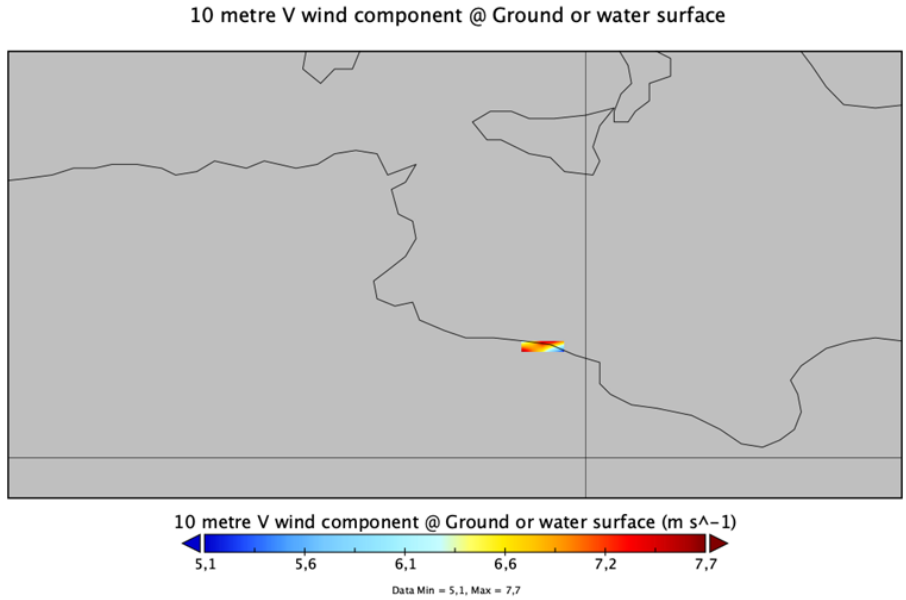

Figure 6: Representation of the Vwind component in the studied area. The data were obtained from the Copernicus Climate Change Service Climate Data Store and refer to 21 March 2025 (CDS 2023), and were graphically processed using @Panoply (Version 5.6.2, NASA Goddard Institute for Space Studies [NASA/GISS], 2880 Broadway, New York, NY 10025, USA)

The U and V parameters represent the two horizontal components of wind at 10 metres above the ground or water surface, which constitutes the international meteorological standard for the measurement of surface wind. The U component describes the east–west direction: positive values indicate wind originating from the west and blowing towards the east, while negative values indicate wind originating from the east and blowing in the opposite direction. The V component describes the north–south direction: positive values correspond to wind blowing towards the north from the south, whereas negative values indicate wind blowing towards the south from the north. Analysis of both components (U and V) allows the reconstruction of the total wind speed and direction.

For the graphical interpretation of the data displayed via Panoply (Figs. 5–6), the component values are represented using a colour scale ranging from blue to light blue, to yellow, orange, and red. This scale allows rapid identification of wind intensity and direction. The geographic data were selected based on a quadrilateral encompassing the area containing the sites of the four analysed villas.

The understanding of the relationship between built forms and wind-induced airflow is important, as it facilitates comprehension of the cooling and ventilating effects, given that built structures create varying resistance to airflow depending on their shapes, sizes, and relative arrangement[40].

The rooms reserved for domestic life or for the storage of agricultural produce, situated between areas delimited by porticoes and cryptoporticoes, were well ventilated thanks to large windows kept wide open during the cool summer nights and closed during the day to prolong the nocturnal freshness as much as possible. Moreover, these rooms were never directly exposed to sunlight, thereby maintaining an ideal microclimate for habitation.

Conclusions

In this way, architecture emerges not only a climatically efficient response but also an instrument of social distinction, where the control of climate also implies control of comfort and self-representation.

It will be of great interest to extend these - still preliminary - observations on spatial adaptation to other maritime contexts of Mediterranean villas in the next stages of my research, in order to assess whether such strategies of ‘environmental architecture’ represent a regional specificity or form part of a broader design practice shared across the Roman world.

[40] Gao et. al. 2012, p. 148.

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Authorship

I declare that I am the author of this contribution, prepared through the reuse and elaboration of data obtained from the literature. All ideas or thoughts originating from other authors have been properly attributed, either by referencing the relevant bibliographic citation or, when quoted verbatim, enclosed in quotation marks and accompanied by the bibliographic reference.

Conflict of Interest: The author reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

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