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Impact of Climate Change on the "Trabocchi Coast" (Italy): The Trabocco Turchino Case Study

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Abstract: The increasing and extreme weather phenomena observed in the Mediterranean basin are only one aspect of the problem which has broader effects on population, structures and infrastructure. Each of these aspects is itself characterized by a wide variety of issues, which are increasingly leading studies toward a multidimensional assessment of impacts (economic, social and environmental). In this study, we focus on the impact related to the increase in extreme weather events in a specific area characterized by typical vernacular architecture: the "trabocchi" of the Italian Adriatic coast, whose identification as cultural heritage is the result of historical events and social dynamics closely linked to the collective imagination and for which inclusion as intangible cultural heritage in the UNESCO World heritage List has been requested. The weather event investigation was performed considering both long-term large-scale (using the ERA5 dataset) analysis and short-term small-scale (models and ground-based sensors) analysis. The results provide an overview of the event dynamics and enhanced understanding of the area's vulnerability factors to extreme weather phenomena, as well as emphasized the need, in order to protect the integrity of the asset, to study environment changes and to plan concrete actions aimed at conservation, including social actions, to mitigate the problem.

Keywords: severe weather; intangible cultural heritage; vulnerability; resilience; safeguarding; heritage perception; heritage uses

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1. Introduction

In recent decades, there has been a significant increase in the intensity of extreme weather events, often resulting in damage and loss. With the goal of better understanding the mitigation and adaptation actions to be taken, a key step is to identify the regions most prone to weather risk. In this regard, many studies have been carried out and the scientific literature offers a significant number of arguments [1–5]. The analyses are available both in terms of specific kind of weather events [6–8] and in terms of forecast improvement [9–12]. If the genesis and analysis of intense phenomena is a sensitive issue, so is the aspect of the impacts that such phenomena may have on the natural environment [13,14], agriculture [15], human-made areas [16] and cultural heritage [17,18]. In this frame, the detailed analysis of the effects of climate change on some historic assets helps to show how this phenomenon has, already today, visible impacts in terms of damage to cultural heritage [19–25]. In this dynamic context, the analysis of what is happening in the Mediterranean basin finds its place, attempting to show, in a concrete way, how climate change has a direct impact and must be taken into account when talking about heritage conservation and when integrating projects that seek to ensure its proper management, stewardship and preservation/conservation, also including the social view, use and perception of heritage as effective tools to understand how to solve this problem. In this study, we focused on the Adriatic side and more precisely on a specific stretch of the Abruzzo coastline, which is affected for much of the year by the marked contrast between tropical air masses and those of polar origin, allowing for the transit of perturbations [26]. The scientific literature points to a potential increase in storm surges in the Adriatic Sea in relation to increasing wind speed; in particular, it has been tested how future storm events can be generated by increasing the wind intensity of the weather pattern [27]. With the aim of understanding how the weather in the Adriatic area changed in recent years, we made large-scale evaluations with ERA5 (Fifth generation of meteorological reanalyses issued by ECMWF (European Centre for Medium-range Weather Forecasts)) data [28], focusing properly on convective precipitation and wind gust. The next step involved identifying the events which mostly hit the area known as "Trabocchi Coast" (Section 2) and, in particular, characterizing a peculiar event which occurred in July 2014 which caused the Trabocco Turchino, famous for being celebrated by the writer Gabriele D'annunzio in their 1894 novel *Il trionfo della Morte* (The Triumph of Death), to collapse. The collapse of the structure, although already damaged by previous storm surges [29], is indeed closely related to a period well limited in time (21–28 July 2014) and featured by intense weather phenomena. To study these occurrences, an analysis on data collected locally by a ground-based sensor belonging to the National Mareographic Network by ISPRA was performed as described below in Section 3. The analysis was carried out both in terms of wind speed and wind trajectory, as described in Sections 3.2 and 3.3. In order to provide an overview of the event, we included the NWP model output, the setup of which is described in Section 3.4.

2. Perception of the Trabocchi Coast as Cultural Heritage

The Trabocchi Coast is the stretch of Middle Adriatic coastline between Ortona and Vasto, in Southern Abruzzo (Italy). The trabocchi are vernacular, evocative and fragile fishing machines [30–32]. They represent a peculiar case of architecture built for productive activities, which has remained practically unchanged over time, except for the small adaptations and improvements that technology has been able to allow [33]. These are ancient wooden buildings that consist of a platform anchored to the rock jutting out into the sea from which the fishing machines protrude. Their use is attested by very ancient traditions [34]. The trabocchi in Abruzzo, which have remained intact until our days, were built over a period time ranging from the 1880s to the 1930s ([33], pp. 38–49). From a landscape point of view, the numerous trabocchi that rise along the protrusions of the Trabocchi Coast (Figure 1) constitute a highly distinctive and identifying element, configuring themselves as an expression of material and immaterial values. The charm of these structures, built between land and sea, is derived from their position as constituent elements of a territorial area: that is, the trabocchi make an important portion of the territory recognizable and attractive [33].

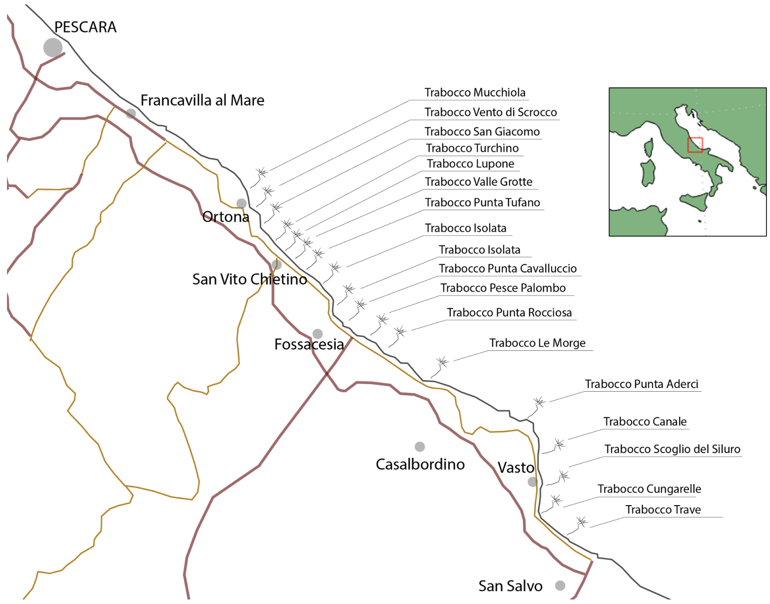

Figure 1. Map of the trabocchi locations of the Trabocchi Coast along the Abruzzo coastline (red box in the small picture on the right).

2.1. Public Engagement and Legislation

After a period of scarce use and oblivion, the recognition of the value of the Trabocchi Coast from an aesthetic, technological and landscape point of view resulted from a long regulatory process by local governments [35], starting with the 1994 regional law [36], which aimed to protect the historical and cultural aspects of these structures. Within this perspective, some trabocchi have been restored and made functional: Tufano, Turchino, Valle Grotte, Cavalluccio and Pesce Palombo are just some of the names of the best-known trabocchi on the coast. Trabocco Turchino (Figure 2), whose good fortune originates, as said before, from the literary suggestions of the writer Gabriele D'Annunzio, is the only one in public property and, following its last restoration, it has become the emblem of the trabocco system ([35], p. 35).

Figure 2. Trabocco Turchino—Trabocchi Coast (photo by Alessandra Mascitelli).

Among the numerous technical and administrative measures, the 2007 regional law should be mentioned, having as its subject: "Urgent provisions for the protection and enhancement of the Trabocchi Coast" [37]. This law intervened with the aim of safeguarding the coastal territory from potential building and speculative aggression following the dismantlement of the Adriatic railway (2005), which affected the coastal stretch from Vasto to Ortona [38,39]. The procedure initiated by the Archaeology, Fine Arts and Landscape Superintendence of Abruzzo for the recognition of the cultural interest of eleven ancient fishing machines on the Trabocchi Coast dates back to 2019, according to the Code of the Cultural and Landscape Heritage [40]. The trabocchi subjected to restriction are selected by reason of their ability to maintain their original function linked to fishing with their local tradition unaltered, and consequently they are considered untouchable [41]. In this operational framework, twenty-two structures were identified and mapped as they were considered elements of regional identity. The immaterial value of the trabocchi and their indissoluble relationship with the coastal landscape in which they are inserted, as pointed out above, is officially recognized. Safeguarding the material culture of the trabocchi requires to not leave their peculiar and attractive environmental situation out of consideration. From this comes the difficulty of reconciling the conservative requests of the government competence with the needs related to their use and their tourist enhancement. This critical issue emerged with the case of the 2019 regional law [42], which defined the criteria and the new surface parameters to be used for catering. However, in a short time, this law was contested by the government for constitutional illegitimacy as it wrongfully intervened in a reserved matter to the exclusive jurisdiction of the state [43]. In the end, it has been established that the trabocchi are protected according to the Code of the Cultural and Landscape Heritage both following the restriction procedure of the superintendence and due to the fact that they are located in the protected areas of the Trabocchi Coast. The resolution of these problems related to the management of the Trabocchi Coast from the point of view of sustainability [44] in a particular, vulnerable and environmental situation [35], could facilitate the process for the UNESCO candidacy for inscription on the list of intangible cultural heritage. Close attention has recently been paid to this issue by the public opinion and institutions.

2.2. Local Heritage Perception and Social Use

Alternatively, at times concurrently or at times preceding or following the institutional pathway of heritage declarations of a given property or heritage site, there exist processes of appreciation and social appropriation, which go hand in hand with the perception that local citizens have of these elements and with the use they make of them [45]. In order to gain a comprehensive understanding about the residents of Abruzzo's perception of the trabocchi, whether or not they are included among the local elements they place as part of their identity references and as part of their daily heritage forms a study conducted in 2015 as part of a Master's thesis [46], which served as a point of reference. This study conducted a survey regarding the perception of the territory by children, young people and local authorities in the region. A diverse sample was taken to capture the plurality of the voices present in the area. The population was encouraged to express desires, locate realities and propose solutions to local problems. They were encouraged to envision the future in order to foster a heightened awareness of the present. The first finding of this study was that the sea serves as a significant point of reference for the local inhabitants and the public space plays an important role in their daily lives. In some of the results [46], obtained through interviews, questionnaires and visual representation (such as drawings or photographs), it was observed that the trabocchi were frequently present. Furthermore, the study explored the expression of their fears through the consideration of catastrophic scenarios, as well as their aspirations through the projection of idyllic scenarios. Some of the drawings show the trabocchi as the central part of the representation, depicting them being impacted by gusts of wind. Additionally, photographs showcase the trabocchi as protagonists, while some of the stories highlight the concern of their destruction. These various local perceptions show us that the trabocchi are elements worthy of attention, as they are closely linked to the visual identity of the region, the collective local imaginary and the dynamics within groups and families. In this sense, it is fundamental not to see cultural heritage as a static element or phenomenon, but as something in constant movement, adaptation and transformation. Above all, we should not see it as an isolated element of local social dynamics but as a result of them [47]. Moreover, the different "social uses" that are currently attributed to cultural heritage should be understood as what they are: social phenomena that have been built over time and that have shaped an important part of the cultural property [48,49]. It is important to be clear that "use" can be understood as something that does not necessarily have to always have an economic or material connotation, but rather a personal and emotional meaning. It is essential to know, understand and accept the use that the local population gives to the heritage. Based on this, it is possible to project into the future and, above all, project into the present. The "new uses" of cultural heritage [50] should be elements of analysis and, above all, elements that can be taken into account when institutions make declarations, laws and projects in favor of its conservation. This does not mean approving or supporting "bad practices" that damage cultural heritage [51,52]. It is not about hindering institutional dynamics and processes, but rather proposing that social dynamics be taken into account as a point of reference for understanding heritage and for its proper management and conservation.

Having presented the historical and social importance of the trabocchi in the Abruzzo region, attention will now be placed on one of the problems that currently threatens them: climate change. Proposals will be provided on how to understand the impact that this phenomenon has on these structures of enormous significance and heritage value, both in terms of their material and immaterial aspects.

People do not usually commit themselves to that which seems foreign to them, to that which they do not know, to that which they do not understand. It does not come naturally to them to care for or protect that with which they do not empathize or in which they do not recognize themselves [53]. Therefore, the aspects of perception and current use of cultural heritage play a crucial role when discussing issue of heritage conservation and, above all, when we talk about contemporary problems facing heritage, such as climate change, an issue which is of great urgency to integrate the population into make it an ally.

2.3. Institutional and Social Perception

Cultural properties and active elements undergo constant change and adaptation, following a life path outside the official and institutional dynamics. Often, the experts focus on interpreting them based on their structural and historical origins, overlooking their present significance and evolving nature [54]. The citizen's perception operates through other mechanisms [49] that diverge from those rooted in historical facts, construction techniques or original uses. In many cases, institutional heritage processes succumb to the temptation of attempting to crystallize the passage of time, aiming to activate a mechanism that transport these heritage properties back to their moment of origin in an effort to "return" or "restore" their original value, use or perception and, consequently, "preserve" them [55]. Frequently this tendency aligns with questioning or censoring the contemporary local-level use or social perception, attempting to substitute or complement it with official mechanisms. These actions often disrupt the organic social appropriation achieved over time. Instead of merely criticizing or being astonished by certain "improper" uses of cultural heritage by the population [56], the academic or institutional level should be fully open to exploring and understanding these uses, leveraging them for the preservation of heritage in the present and in the future. If institutions censor, for instance, commercial, touristic or recreational uses [57], as well as emerging social perceptions of certain properties or sites, there is a risk of inadvertently causing their inevitable abandonment, destruction and disappearance, despite the well-intentioned goal of preservation. It is crucial never to underestimate the social intelligence that may have been developed by a particular community, as they will never intend to obliterate their identity references [58]. On the contrary, they will make every effort to preserve them and ensure their survival against the relentless passage of time. It is necessary to complement institutional interpretation with local citizen perception, to complement the formulation of public heritage policies with information and knowledge generated by the population itself. There are numerous cases in which heritage properties, once assimilated into institutional regulations and practices, have faced the emotional abandonment by those who are their inherent users, the citizens. If planners do not recognize the fundamental notion that the future of heritage rests within the hands of the present and the essential role played by citizens in shaping it [59], the realization of the desired future for the cultural heritage in question, exemplified in this specific case study of the trabocchi, will be a challenging task.

3. Weather Event Analysis: Data and Methods

3.1. ERA5 Dataset

To better understand the way weather is changing in the Adriatic Sea, in this study a long-period (1980–2020) analysis was performed using ERA5 (Fifth generation of meteorological reanalyses issued by ECMWF (European Centre for Medium-range Weather Forecasts)) data [28]. The reanalyses combine the Integrated Forecasting System (IFS) model background field with observations to achieve the best estimate of the state of the atmosphere. The ERA5 employed model, covering the whole Earth, uses 137 layers to resolve the atmosphere in the vertical direction and has an horizontal resolution of about 30 km.

The ERA5 dataset includes hourly estimates of a wide range of variables; in the frame of this research, we have employed the following:

- Convective Precipitation (cp), which represents the accumulated precipitation that falls to the Earth's surface which is generated by the convection scheme in the ECMWF-IFS [28];
- Instantaneous 10 m wind gust (i10fg), which represents the maximum wind gust at the specified time, at a height of ten meters above the surface of the Earth [28].

In this research, the long-term analysis covers the entire European territory (lat: 33 N–60 N; lon: 11 W–40 E) focusing on the Italian area. For each ERA5 parameter (i.e., cp and i10fg), the value corresponding to the 90th percentile of the sub-period 1980–2000 was calculated and then it was assessed how many times in the entire time period considered (1980–2020) this value was exceeded, in each pixel and in each year. In this way, we obtained the exceedance matrices of each parameter, for each year, over all of Europe. At this step, we cut the dataset, focusing on Italy (lat: 35° N–47° N; lon: 6° E–18° E), and we calculated the trend of the value for each position, normalizing it to obtain values between 0 and 1 in order to facilitate the interpretation (Figure 3).

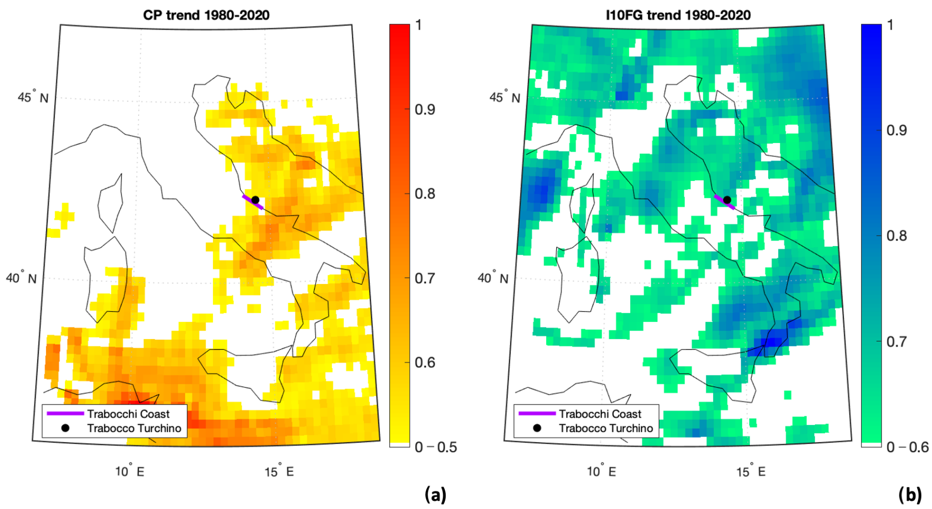

Figure 3. Normalized trend of (**a**) convective precipitation and (**b**) instantaneous 10m wind gust, over the period 1980–2020, identifies the Adriatic area as sensitive to the increased intensity of wind occurrences and convective events.

3.2. Wind Speed Data

Following the long-term analysis and with the goal of focusing more on the coastal stretch of interest, we performed an analysis on wind speed data from the anemometer on the Ortona Mareographic station (about 9 km from the Trabocco Turchino) belonging to the National Mareographic Network (ISPRA [60]). We focused on the year when the

Trabocco Turchino collapsed following a storm surge, in order to characterize the event and assess its specificity. To do this, data from the summer period of 2014 were selected (21 June–23 September 2014). In this dataset, the main statistical indices, such as mean and standard deviation, were calculated. Once these values were obtained, the extreme values for the period under consideration were verified; spanning the values over a rather wide range, an attempt was made to define a threshold equal to the mean plus 3, 4 and 5 times the standard deviation. In the latter case, events referring to two main meteorological occurrences were highlighted, on the first of which we focus in the following analysis.

3.3. Wind Trajectory

To more deeply analyze the wind behavior when the event occurred, we investigated the air mass trajectories over time. We estimated the 24 h back trajectories of the air masses using as starting point the geolocation of the Trabocco Turchino (40°45′36″ N, 73°59′2.4″ E and 5 m a.s.l.). We used the Lagrangian Hysplit model [61] to simulate the trajectories that air masses, reaching the trabocco at different hours of the day during 21 July 2014, followed during the previous 24 h. In this way, we could estimate the wind direction and altitude. We set the isentropic vertical motion method and 25 km as top altitude of the model. The wind dataset, to initialize the Lagrangian model, was retrieved from NCAR/NCEP 2.5-deg global reanalysis archive.

3.4. NWP Model

In this section, the method employed to characterize the synoptic conditions which occurred on 21 and 27 July 2014 is described. The discussion is based on two simulations of the WRF (Weather Research and Forecasting model, Version 4.1.3 [62]) model run at 2 km horizontal resolution. The WRF model is run with 850 by 850 grid points in both NS and WE directions and with 50 vertical levels. The domain is centered over Italy and initial and boundary conditions are taken from the ECMWF operational analysis/forecast cycle issued at 12 UTC on the day before the day of simulation (20 July and 26 July at 12 UTC, respectively). The main physical parameterizations used are the following: the Thompson scheme [63] for microphysics, the Mellor–Yamada–Janjic (Eta) TKE scheme for boundary layer [64], the Dudhia scheme [65] and the Rapid Radiative Transfer Model (RRTM, [66]) for short-wave and long-wave radiation, respectively.

4. Results

As results of the ERA5 long-term analysis, a normalized trend of convective precipitation (Figure 3a) and instantaneous 10 m wind gust (Figure 3b), over the period 1980–2020, identifies the Adriatic area as sensitive to the increased high wind intensity occurrences and convective events; indeed, the normalized trend of convective precipitation shows positive values around the area larger than 0.5–0.6 (Figure 3a) and the wind gusts also show a clear trend (>0.7), showing an increase in potential damaging events for trabocchi.

In this scenario, the Trabocchi Coast appears to be prone to intense weather phenomena and therefore the structures result in being exposed to the arising stresses. For the purpose of focusing attention precisely on the mentioned stretch of coastline, the Trabocchi Coast, a specific case study of an event which took place on 26 July 2014 and characterized by a storm surge was selected. The event was identified through a statistical analysis performed on data from the anemometer on the Ortona Mareographic station (Section 3.2). Summer 2014 wind speed data, from June to September, were analyzed, and the results show a mean value of 2.54 m/s and a standard deviation of 1.56 m/s. In order to find the extreme values and because the values span a rather large range, to find extreme wind values the threshold was set as equal to the mean plus five times the standard deviation (threshold = 10.34 m/s). Applying this threshold value, it appears that exceedance occurred 15 times throughout the summer of 2014. The periods characterized by such exceedance were the week between 21 and 28 July and the first decade of September. It is precisely during the first of these periods that the Trabocco Turchino collapsed. In Figure 4, the wind speed pattern for the week 21–28 July is given.

As can be seen in Figure 4, two storm-surges (i.e., A. and B. over the plot) marked the final collapse of the Trabocco Turchino structure. The first (Figure 4 (A)) occurred on 21 July (Figure 5a) and was characterized by a period of about an hour during which the previously set wind speed threshold (threshold = 10.34 m/s) was exceeded five times, peaking at 13.3 m/s (more than five times the seasonal average for the same year). With this wind speed, it is expected that the sea waves play a significant role for these events, so future works must investigate trends in wave height along the Trabocchi Coast.

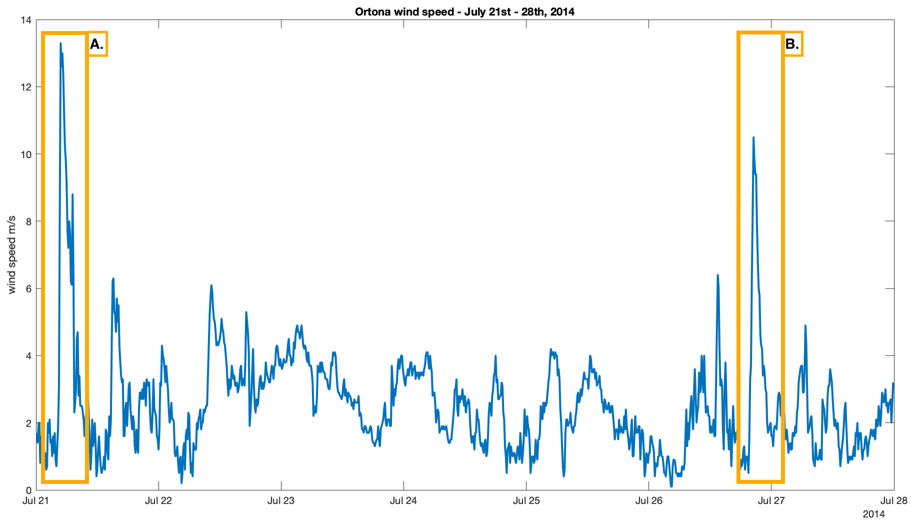

Figure 4. Wind speed pattern for the week 21–28 July 2014. In the figure, the two storm-surges (i.e., A. and B. over the plot) that marked the final collapse of the Trabocco Turchino structure were identified.

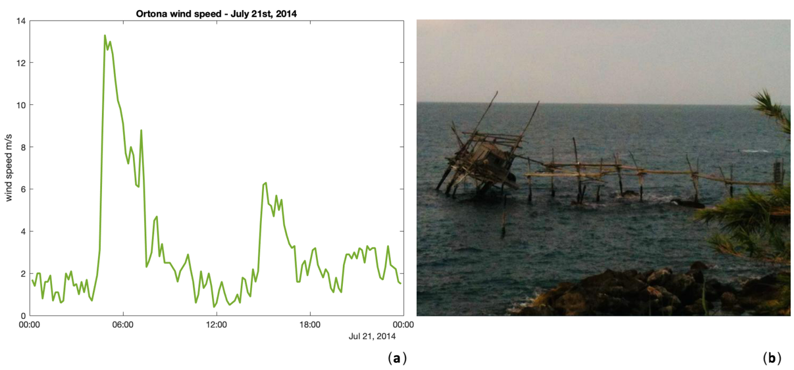

Figure 5. (**a**) Wind speed pattern for the day 21 July 2014 (**b**) Picture of 22 July 2014 in which the damage suffered by the structure as a result of the previous day's storm surge is evident (photo by Fabiano Di Berardino).

On 21 July 2014, Italy was interested by a low-pressure system deepened on the lee of the western Alps. This synoptic condition is well depicted in Figure 6a showing the scenario at 500 hPa. The low-pressure center was located between the Italian peninsula and Corsica. This position of the main center advects air masses toward central Italy in the SW–NE direction. A similar condition occurs at lower vertical levels (850 hPa, 750 hPa, for example) and the air masses cross central Italy from SW to NE in the lower troposphere. This determines a strong interaction between air masses and Italian orography. This interaction is well represented in Figure 6b, where the sea level pressure and the wind speed are shown. In this map, the wide pressure minimum over northern Italy and air masses crossing central Italy from the SW direction are apparent. The synoptic condition described above favors the development of intense wind speed over central Italy. Furthermore, the interaction between the complex orography of central Italy with the winds generated by the cyclones can reinforce the winds locally. Figure 6c shows the wind speed at 10 m above the surface. More than 10 m/s are simulated over the Adriatic Sea in correspondence to the site of interest. For the specific case study, humid processes could have also played a role for the high wind speed recorded because moderate–intense precipitation (between 10 and 20 mm/3 h, not shown) was simulated over central Italy between 06 and 09 UTC. Humid processes could generate wind gusts at the surface caused by downburst or associated with meso-fronts. Local effects of orography and humid processes are apparent in the high variability of the wind speed over central Italy and over the Adriatic Sea. Figure 6d represents the local wind speed as a function of the wind direction measured at the Mareographic station in Ortona (Italy). The wind with the highest speed reached the Trabocco Turchino blowing from the west, i.e., from the Italian inland, as confirmed by the WRF simulations (Figure 6b).

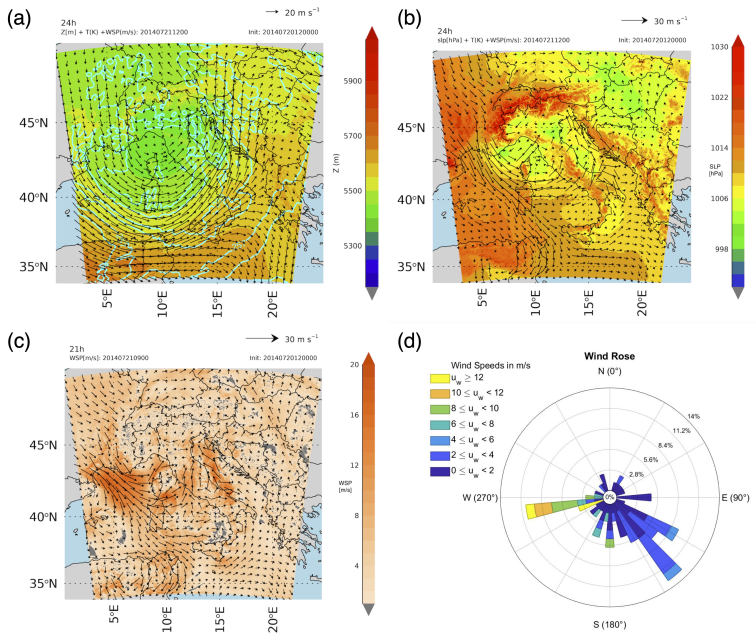

Figure 6. (**a**) Geopotential height (filled contour), temperature (cyan contours) and wind (1 vector every 30 grid points). The reference vector is in the upper-right corner. (**b**) Sea-level surface pressure (filled contour) and wind vectors at the first model level (1 vector every 30 grid points) at 12 UTC on 21 July 2014. The reference vector is in the upper-right corner. (**c**) Wind speed (filled contours) and wind vectors (1 vector every 30 grid points) at 10 m above the surface at 09 UTC on 21 July 2014. The reference vector is in the upper-right corner. (**d**) Wind rose for the wind direction during the high wind speed event registered on 21 July.

To be able to retrieve the position of the air masses during the previous 24 h, simulations of the back-trajectories were carried out by using the Hysplit model. The wind peak registered on 21 July occurred between around 5 A.M. and 7 A.M. (Figure 5a). To fully describe the air masses origin that preceded and during the two events, different starting hours were selected to evaluate the 24 h back-trajectories. Specifically, for the first event, which occurred on 21 July, we ran the back-trajectories starting from 11 P.M. of 20 July and 1, 3, 4, 5, 7 and 9 A.M. of 21 July. The air masses reached the Trabocco Turchino blowing at ground altitude for approximately the last 12 h (Figure 7A) and originating from the Italian inland, turning up to 3 A.M. anticlockwise and then changing to the clockwise direction (Figure 7B). The second event (Figure 4 (B)) occurred on the evening of 26 July 2014 when a peak wind speed of 10.5 m/s was recorded (Figure 8a).

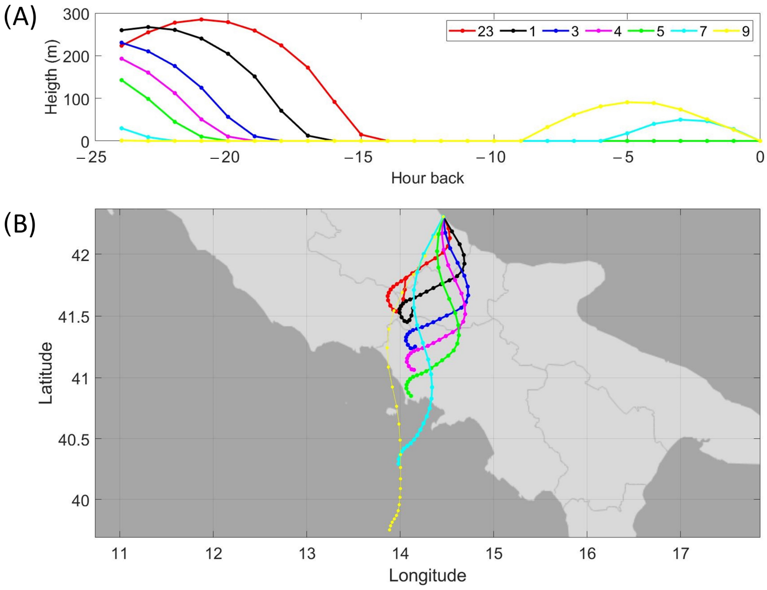

Figure 7. Simulated 24 h back-trajectories starting from the Trabocco Turchino for the event identified during the 21st of July. (**A**) The hourly height of the air masses for the 24 h back-trajectories. (**B**) The geolocation of the air masses for the 24 h back-trajectories.

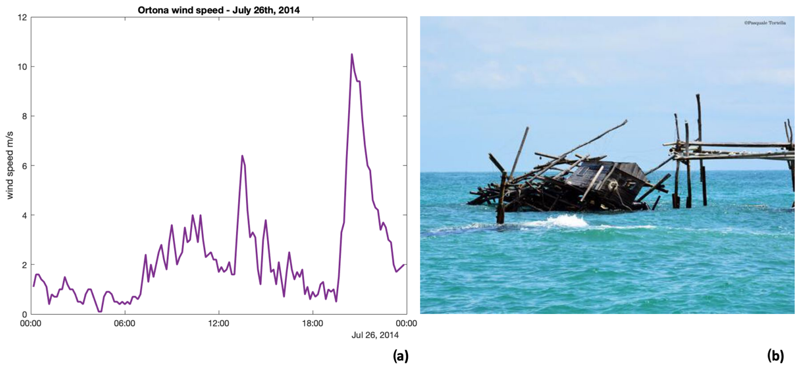

Figure 8. (**a**) Wind speed pattern for the day 26 July 2014; (**b**) Picture of 27 July 2014 in which the structure collapses as a result of the previous evening storm surge (photo by Pasquale Tortella [29]).

After this occurrence, the structure definitively collapsed (Figure 8b). Furthermore, for this case study, the WRF model was able to simulate the synoptic characteristics of the event; nevertheless, there was a delay between the simulated evolution of the storm and the observations. The largest wind speed over the Adriatic Sea, in correspondence of the site of interest, occurred during the late evening on 26 July 2014, while the WRF simulation shows the maximum wind speed in the night and morning of the 27 July 2014. For this reason, the comment of the synoptic conditions for this case study refers to the night and morning of the 27. The case study also shows the presence of a synoptic low pressure pattern over Italy. Compared to the previous case, however, the minimum is shifted toward the SE. This is apparent from Figure 9a, which shows the geopotential height, the temperature and the wind speed at 500 hPa. The geopotential height minimum is positioned over central Italy. At the surface, as can be seen in Figure 9b, a wide low (1006 hPa) extends over Italy. The interaction between air masses and the orography of southern Italy, in particular of the Calabria peninsula, generates a minimum over the Ionian and southern Adriatic Sea that, in the following hours, travels form the SW to the NE direction. The action of the surface minimum advects air masses toward the north of Italy, along the Adriatic Sea, as shown in Figure 9b. As the pressure minimum in southern Italy travel from the SW to the NE, air masses are moved from the Balkans toward the Adriatic Sea, interacting with the atmospheric current coming from the south. This generates convergence at low levels and, possibly, precipitation over the sea. In these conditions, turbulence can be generated in different ways as humid processes, interaction with orography or convergence of different air masses over the Adriatic Sea. These interactions and the fact that wind speed can become locally intense are shown by the wind at 10 m in Figure 9c. Here, the airflow coming from the Balkans toward the Adriatic Sea meets the atmospheric currents from the south, generating convergence. In the Central Adriatic Sea, the winds are intense and turbulent as they change direction and/or intensity in a short distance. This irregular and intense wind pattern was also caused by humid processes as the precipitation between 06 and 09 UTC on 27 July shows intense rainfall in the central Adriatic Sea. Figure 9d shows the wind rose measured at the Mareographic station in Ortona (Italy). In this case, the wind with the highest speed reached the Trabocco Turchino blowing from north to west. However, the wind speed and the wind direction varied substantially during the day, showing a turbulent behavior. This high variability in wind speed and direction confirms the WRF model analysis, wherein both the interaction of the wind with the complex orography and the diabatic humid processes cause the high intensity and high variability of the wind speed (Figure 9c).

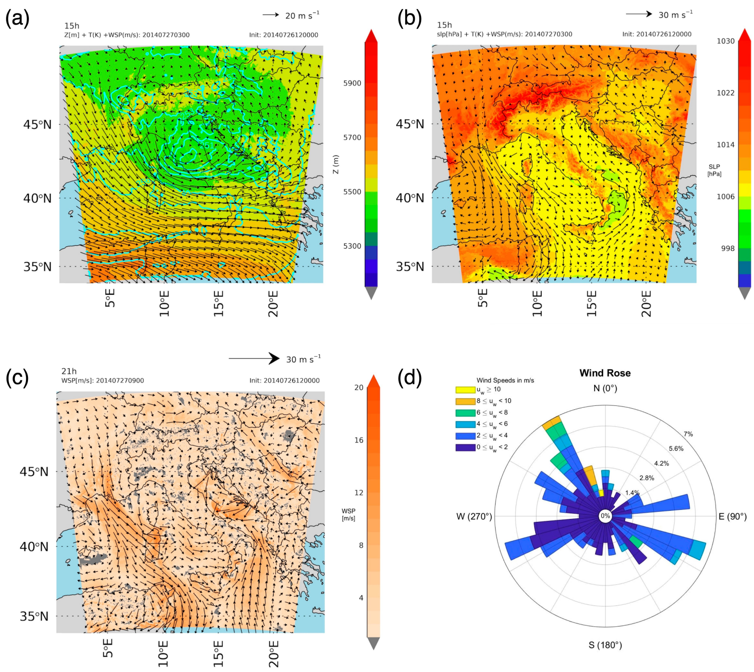

Figure 9. (**a**) Geopotential height (filled contour), temperature (cyan contours) and wind (1 vector every 30 grid points) at 03 UTC on 27 July 2014. The reference vector is in the upper6right corner. (**b**) Sea-level surface pressure (filled contour) and wind vectors at the first model level (1 vector every 30 grid points) at 03 UTC on 27 July 2014. The reference vector is in the upper-right corner. (**c**) Wind speed (filled contours) and wind vectors (1 vector every 30 grid points) at 10 m above the surface at 09 UTC on 27 July 2014. The reference vector is in the upper-right corner. (**d**) Wind rose for the wind direction during the high wind speed event registered on July 26th.

5. Discussion

Following the findings in Section 2, the driving motivation behind this study appears evident. The historical analysis of the trabocchi is crucial because, by understanding the institutional process of recognition of the asset and the social motivations behind it, it becomes possible to better understand the needs for conservation and, consequently, the importance to study the causes that challenge it. In this specific case, one of the risk factors is climate change and, specifically, the resulting extreme weather events which increasingly affect the Adriatic coast. The analytical results offer an overview on a targeted event which hit the Trabocchi Coast on July 2014. The long-term analysis justified the choice of the area where the study focused, highlighting the exposure of that stretch of coastline to increasing convective and wind-storm events. A ground-based analysis of wind speed helped to better understand the storm surges which affected the area on 21 and 26 July 2014, facilitating their identification and their study. A comprehensive analysis of both the synoptic condition at the two events and the wind trajectories allowed us to characterize the conditions that led to the collapse of the structure called Trabocco Turchino. Indeed, the wind load arrived at the trabocco with heights and directions such as to stress the structure in a manner compatible with the fall that occurred. In addition to this, a social analysis was carried out, generating some key questions: nothing is static, everything changes, everything is transformed, and the meaning of cultural heritage is no exception, so what does a given cultural property mean to a group of inhabitants who are, in principle, the "owners" of it? What does this heritage property communicate to the local population, who should naturally feel responsible for its conservation? What link has this cultural property built with the local population? What is the perception of the inhabitants of the Abruzzo region of the trabocchi; are they or are they not inserted among the local elements that they place as part of their identity references and as part of their daily heritage? The answer to this question is found in the role of trabocchi; they are of enormous importance in the history of local fishing techniques; they have an enormous connotation in terms of group and family dynamics, as they are referents in terms of social gatherings; and they are essential to understand the know-how in terms of construction techniques of fishing instruments. When we talk about conservation projects, programs or strategies and when we refer to our duty to take care of our heritage in order to be able to pass it on to future generations, we must at all times think that it is immensely difficult to pretend that it will reach future generations if we do not give the opportunity to those who live there today to give it a "use", to consider it "functional". It is fundamental to know, understand and accept the use that the local population gives to the heritage, and based on this, to project into the future and, above all, with this to project into the present. If cultural heritage does not cover a determined function in the present, it is complex to think that it can see the light in a tomorrow. It is the use itself that allows it to have the capacity to survive the passage of time, it is the "use" that gives us the possibility of fulfilling our desire as professionals: the conservation of cultural heritage. In agreement with what has been reported so far, results pinpoint the need to monitor environment changes and to plan concrete actions aimed at the conservation of the cultural heritage.

6. Conclusions

Today, the trabocchi, having fulfilled their function as a fishing machine, represent a landscape and tourist attraction that unites the land and sea of Abruzzo, becoming elements of regional identity. Trabocchi are not a stable architectural element, but a dynamic one, in constant relationship with the forces of nature, with which their ethereal structures continually interact, as they lose more or less important pieces with each storm, and, after each storm, need adjustments and repairs. As highlighted in this study, the coastal area of Abruzzo is characterized by an extremely dynamic and rather complex climate subject to the increase in intense phenomena. In particular, it was verified that thunderstorm events are characterized by an increase in frequency of occurrence and intensity. Forecasting the intensification of these weather phenomena provides sufficient motivation to prepare for future risk scenarios and it is fundamental to think of a system of actions that mitigates various risk factors. The hazard of coastal erosion has storm surges as its major cause. In order to prevent damage to the coastline and the cultural heritage of the Trabocchi Coast, point design solutions that can operate an organic function should be provided, examples of which are groins, piers at sea and submerged breakwaters that can be placed at the most constrained areas of the coastal stretch [67,68]. These solutions can interact properly with the trabocchi that adorn the area. Important are the accesses to the sea, for which rational restoration may be appropriate. It is also important to underline how all the proposals have to adapt to the problem and not go against it. The main keyword is adaptation; adapting affected areas, making them resilient, switching and adapting to environmental changes.

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