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## Sustainable tourism in the Tremiti Islands (South Italy)

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An analysis of the pressure factors that influence the sustainable tourism in the Tremiti Islands (TI) has been performed. Tourist's fluxes have been investigated in terms of monthly arrival and presences showing a high value of the territorial exploitation index with high number of arrivals, particularly in August, and low occupancy rate. Effects of climatic change has been analyzed in TI with reference to the increase of average air and sea temperature in the islands. Some measures of contrast to climate change and to favour sustainable tourism have been discussed also. The CO<sub>2</sub> emissions by ferries transport, solid waste and wastewater treatment have been calculated. Environmental taxation for sustainable tourism aimed at CO<sub>2</sub> content reduction is also assessed identifying the value in 1.47 €/capita on the basis of the tourist arrivals and presences considering the environmental cost for CO<sub>2</sub> removal and showing that tourism taxation should be well accepted if funds are destined to environmental purposes.

The Tremiti Islands (TI) are located in Apulia, Southeast of Italy, and consist of five islands: San Domino (the largest), San Nicola, Capraia, Cretaccio (little more than a large rock) and Pianosa (11 miles from Capraia), for a total extension of 3.34 km<sup>2</sup>; it is 12.5 miles from the nearest town in the Gargano (Torre Mileto, a hamlet of Sannicandro Garganico). The emerged surface of the archipelago is part of the Gargano National Park. Tremiti Islands are one of the Marine Protected Areas (MPA) in the Mediterranean Sea.

The Mediterranean Sea is a densely populated region where multiple human activities have placed stress on biodiversity, food webs, and ecosystems for centuries<sup>1-3</sup>. The Mediterranean coastal region is home to more than 150,000,000 people and is by far the largest global tourism destination, attracting almost a third of the world's international tourists annually (343,000,000 out of 980,000,000 worldwide in 2014, with a projection of 500,000,000 by 2030<sup>4</sup>). The demand for marine resources and space is quite high, leading many users to oppose the establishment of MPAs. This is because such conservation measures may limit or displace activities such as local commercial and recreational fishing, boating, and diving. In such situations, it is crucial to understand whether MPAs are actually effective and under what circumstances. This can help raise awareness among the public and decision-makers, and guide decisions about creating, maintaining, expanding, managing, enforcing, and supporting MPAs.

One of the areas most affected by the tourism phenomenon in Puglia is the Tremiti Islands archipelago. The Italian Institute of Statistics, ISTAT, which recently classified the Italian municipalities by tourist areas prevalent concerning tourist density and territorial vocations, has defined the municipality of the Tremiti Islands as a "municipality with a maritime vocation and with a cultural, historical, artistic and maritime, cultural"<sup>5</sup>. The Tremiti Islands municipality boasts a unique blend of natural and man-made heritage. Its natural elements—such as inlets, sea caves, stunning views, and diverse underwater ecosystems—are a sight to behold. The island's archaeological sites, like Greco-Roman tombs, and architectural landmarks, such as the fortified walls and the Abbey of San Nicola, are equally impressive. The monastery, which was home to three different religious orders from 1000 to 1700, is another must-see attraction. Overall, the archipelago's rich heritage makes it a perfect destination for tourism.

The Tremiti islands are now in a delicate balance between the delicacy of their natural beauty and the high pressure of tourist fluxes.

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Human activity, through the emission of greenhouse gases, has caused global warming, resulting in a significant increase in the global surface temperature of the earth and oceans, and coastal areas are particularly vulnerable to the effects of climate change<sup>6–9</sup>.

TI are also subject to the effects of climate change, regarding the rise of the average and maximum temperatures of the air and water which can have consequences in the management of sustainable tourism. In TI, different approaches should be taken to manage the indirect impacts of climate change on tourism, depending on the specific impacts under consideration for sustainable tourism. For example, implementing a program to reduce CO<sub>2</sub> emissions, preserving biodiversity in the TI, optimizing waste collection and disposal, reducing organic and inorganic pollution and managing the increased risk of forest fires in the interior<sup>10,11</sup>. All these climate change adaptation measures should include specific actions for the environmental, social and economic sectors, as well as tailor-made adaptation measures for well-managed and participatory sustainable tourism<sup>12–15</sup>. In TI, sustainable tourism development is closely linked to ecotourism, a form of tourism based on natural resources that preserves environmental sustainability and develops people's well-being. It should be characterized by community participation and conservation for the sustainable development of the MPA as a key strategy for environmental education<sup>11,16–18</sup>.

The problem of the negative impact of tourism on the environment in TI arises from the growth of mass tourism.

The aim of this paper is to discuss principal aspects affecting sustainable tourism in the Tremiti Islands including tourist' fluxes, climate change, and environmental taxation suggesting measures to promote an environmental awareness in the management of tourism at the Tremiti Islands.

The specific objectives of the paper are:

- To analyze the tourist fluxes during the year at TI
- To illustrate the effects of climate change in TI
- To assess the CO<sub>2</sub> emissions correlated to solid waste, wastewater and ferry transport
- To propose measures to reduce emissions and adapt to climate change
- To determine the value of an environmental tax necessary to facilitate sustainable tourism development.

## Methods

### Dataset and statistics

The tourist arrival and presence data were obtained from “Osservatorio Turistico Regionale 2019,” while the climatic data were sourced from “Protezione Civile Puglia, Annali Idrologici – Parte 1 (2021)” and ERA5 global reanalysis Hersbach<sup>19–21</sup>.

The accuracy of the linear regressions of the climatic data was evaluated by calculating the R-squared values. For the tourist data, a one-way ANOVA was performed to determine significant differences between the values. Correlation tests were also carried out to confirm the trends observed in the regressions.

### Tourists fluxes pressure index

In the Tremiti Islands, there is predominant tourism characterized by high seasonality with short-term stays and a notable density of tourists especially in the months of July and August. The month of August alone accounts for 35% of the annual tourist presences with 20,859 presences as illustrated in Fig. 1.

These data confirm the Apulian seaside tourism vocation. This seasonal tourism is concentrated in July and August and alone covers more than 51% of annual tourist presences (Osservatorio Turistico Regionale, 2021)<sup>19</sup>.

Another critical issue regards the daily arrivals, 73,240 in August, at TI. Every day, in August, as average 20,859 represents the number of the presences, i.e., the number of the tourists that are sleeping in the islands, and 52,381 are the one-day tourists who contribute significantly at the tourism pressure index and to the CO<sub>2</sub> emissions.

The use of Mediterranean islands, including the TI, by both the resident population and tourists is often evaluated using a Territorial Exploitation Index. This index measures the pressure on the environment caused by tourists and the resident population from the demand side. It calculates the impact of tourist arrivals and residents on the total area of the territory. The value of this index can be seen as an indirect measure of the pressure that tourists and residents put on the region's infrastructure<sup>22</sup>, whereby:

$$TEI = (\text{arrivals}/\text{area}(\text{km}^2) + \text{residents}/\text{area}(\text{km}^2))/100.$$

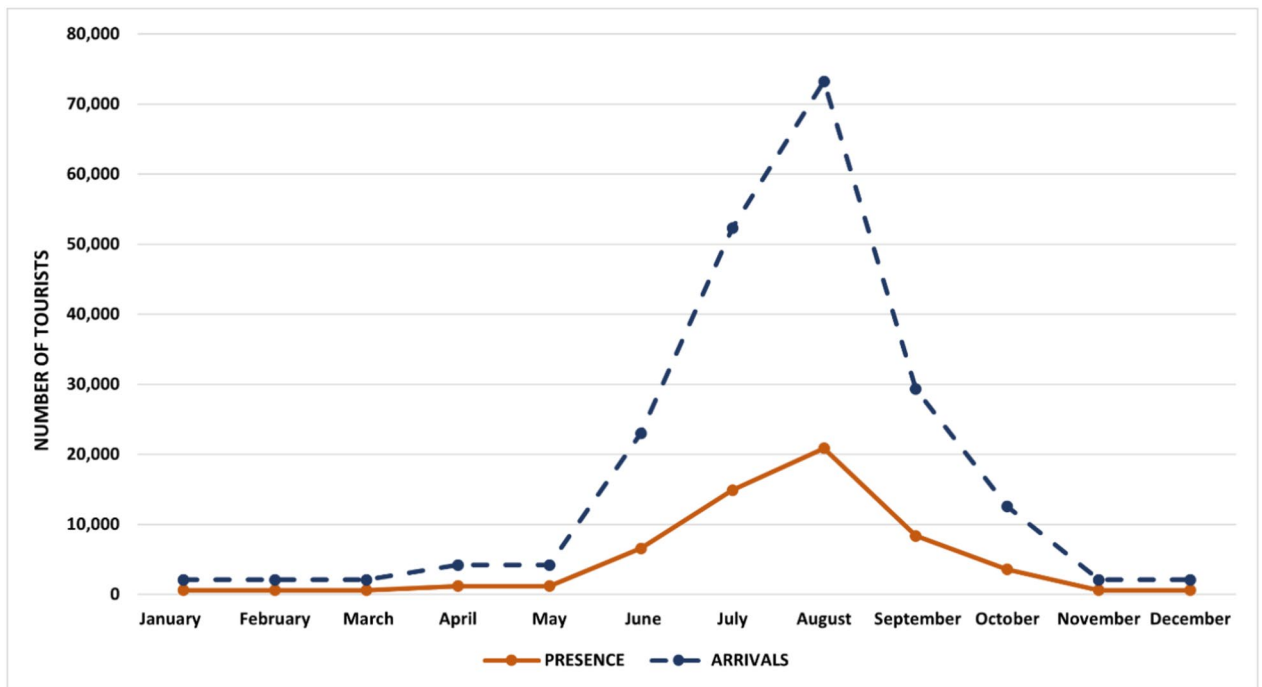
This indicator makes it possible to classify islands according to the degree of exploitation of their territory. The Tremiti Islands Territorial Exploitation Index is equal to 59.8, one of the highest in Mediterranean. This means that TI have a high tourism pressure index, but Tremiti islands have also a low occupancy rate, because the supply of bed spaces is being underutilized, so a design growth strategy is needed<sup>22,23</sup>.

Throughout the Mediterranean, the tourism sector is economically important in terms of job creation, infrastructure development and foreign exchange. Tourism policies aimed at moving towards sustainability should be focused on seasonality reduction, tourism restraint and the upgrading of, but not increasing supply of tourism<sup>22,24</sup>. In these territories, which are often fragile and highly vulnerable to tourist activities, as well as being characterized by developmental backwardness, the strategies to be defined and approaches to be followed must consider the peculiarities of the islands<sup>25</sup>.

## Case study of Tremiti Islands.

### Climate change at TI

A progressive increase of the effects of climate change has been evidenced over the last 40 years throughout the Mediterranean and in the Mediterranean islands<sup>26</sup>. Climate change contributes to the progressive decline of these islands' extraordinarily rich marine biodiversity<sup>27</sup>. Since they are islands, they are more exposed to marine risks



**Figure 1.** Total tourist presences and arrivals at TI during the year.

than mainland locations<sup>28,29</sup>. They share common vulnerabilities to climate change, derived from low economic diversification and capacity for sewage treatment, among other aspects. They are also characterized by having less climate-related data to inform decision-making, compared to the mainland<sup>30</sup>. Climatic conditions have also changed in the Tremiti islands with an increase of the average air temperature and of the average sea temperature over the last 40 years as shown in Figs. 2, 3.

Figure 2 shows a constant trend of increasing air temperature over the last 40 years, which is remarkable for the average maximum temperature.

Figure 3 shows the increase in average seawater temperature in the range of about 1.5 °C in the last 40 years, with serious implications for marine flora and fauna.

### Calculation of CO<sub>2</sub> from the tourist fluxes

CO<sub>2</sub> production has been calculated as the contribution of Ferry Transport, Solid Waste and Wastewater Treatment.

#### CO<sub>2</sub> from ferries transport

The Tremiti Islands can be reached from five ports: Port of Vasto (Abruzzo); Port of Peschici (Apulia); Port of Termoli (Molise); Port of Vieste (Apulia) and Port of Rodi Garganico (Apulia).

The average speed of the ferries is 19 knots per hour (35 km/h) and the average diesel consumption is 2700 l/h (0.0132 km/l). One litre of diesel produces about 2.66 kg of CO<sub>2</sub>, so according to similar calculations, ferry transport produces about 201 kg CO<sub>2</sub>/km<sup>31</sup>.

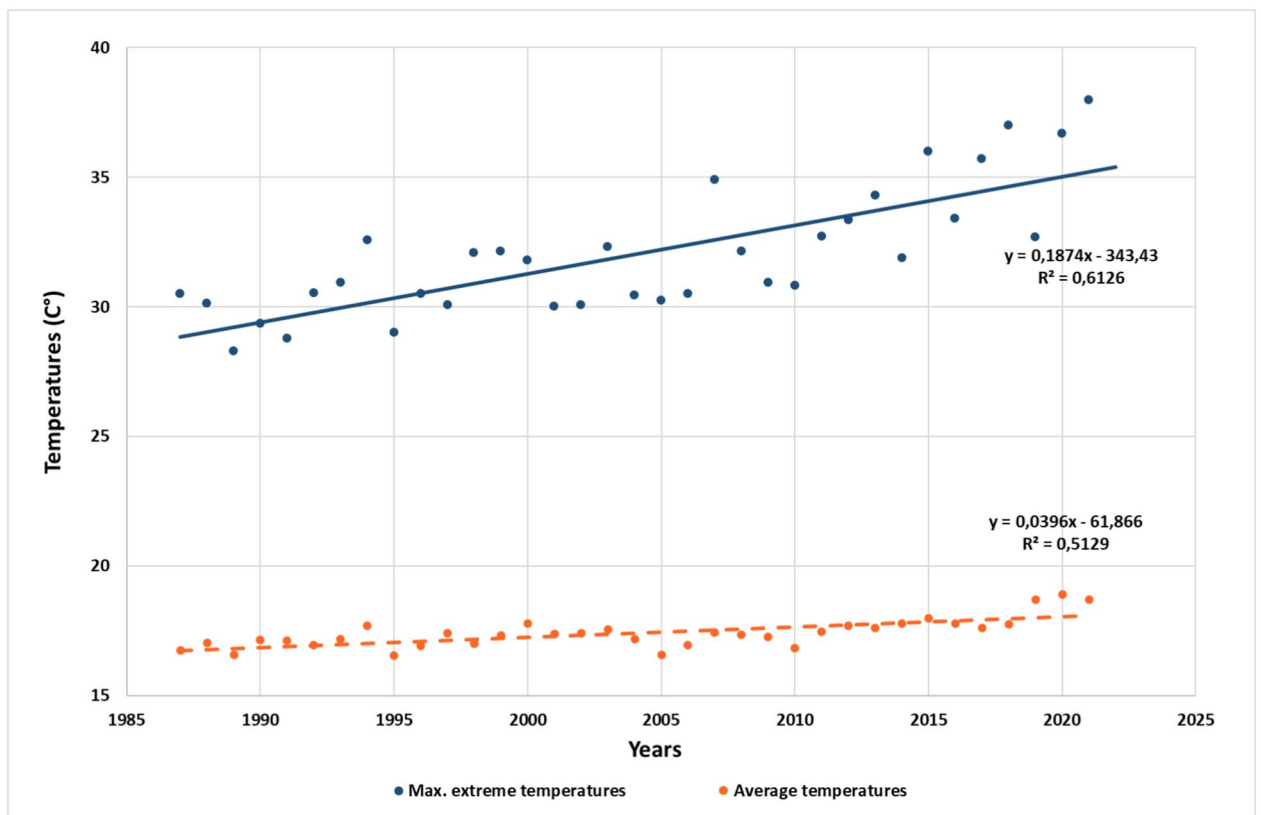
Total Ferries routes are 300 in August and 46 km is the average distance between Italian ports and TI, the total ferries routes cover a distance of 13,800 km.

The total number of tourists transported, arrivals and presences, in the Tremiti Islands in August is 73,240. A total of 13,800 \* 201 = 2773.8 t of CO<sub>2</sub>/August is produced by the ferries and 2,773.8:73,240 = 0.038 t of CO<sub>2</sub>/tourist\*day is produced by each tourist in August including the one-day tourists.

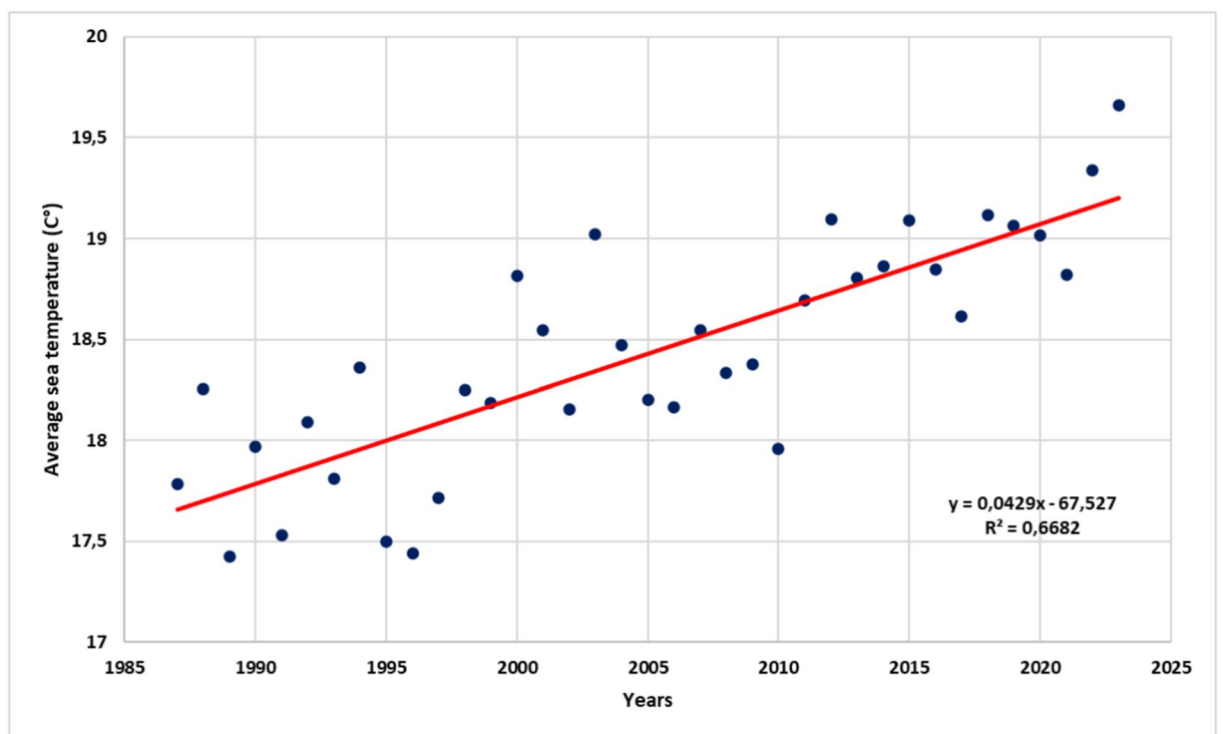
#### CO<sub>2</sub> from solid waste

The seasonal nature of tourism also requires additional efforts from local authorities to provide services such as policing, traffic control, water management and waste management. The seasonality of tourism greatly amplifies the impact of tourism on waste management. It also shows that this additional impact comes through scale effects, with seasonality making it harder to manage solid waste at optimal scale. Therefore, relating to the size of touristic seasonal flow of presences, it should be preferred a lower number of tourists who stay longer over a larger number of short stays<sup>32–36</sup>. It is assumed that 1 kg of Municipal Solid Waste (MSW) produces 1.11 kg CO<sub>2</sub>, mainly due to CH<sub>4</sub> content and emission, and collection and transport<sup>37–41</sup>.

101,740 kg of USW are produced by tourists in August (Apulian Osservatorio Regionale Rifiuti, 2021) so an amount of 101,740 \* 1.11 kg CO<sub>2</sub>/kg MSW = 112,931.5 kg CO<sub>2</sub> is expected in the month of August by tourists wastes. 112,931.5 kg CO<sub>2</sub>: 73,240 = 1.54 kg CO<sub>2</sub>/tourist\*day are produced in the month of August per capita.



**Figure 2.** Tremiti Islands—Average and max. extreme air temperature in the last 40 years.



**Figure 3.** Tremiti Islands—Average Sea temperature in the last 40 years.

Therefore, 112.93 t CO<sub>2</sub> are estimated to be produced by tourists as total in August for the disposal of Municipal Solid Wastes.

#### *CO<sub>2</sub> from wastewater treatment*

Wastewater treatment is primary source of CO<sub>2</sub> due to CO<sub>2</sub> biogenic direct emission and to fossil CO<sub>2</sub> correlated to electric energy consumption in wastewater treatment plants<sup>42–50</sup>. According to Ranieri et al. (2023b)<sup>44</sup>, a tourist produces 125 kg/year\*capita and therefore 0.342 kg CO<sub>2</sub>/capita per day is produced by a tourist in wastewater treatment, mainly due to electrical energy and the sludge treatment line<sup>14</sup>.

Considering that the total number of arrivals of tourists in the Tremiti Islands in August is 73,240, calculated in 31 days of August, a quantity of 25.08 t of CO<sub>2</sub> is produced by tourists in August through wastewater treatment.

#### *Total CO<sub>2</sub> Contributes*

Taking into account the three sources of CO<sub>2</sub> sources – ferries, waste and wastewaters—(2,773.8 tCO<sub>2</sub> /month, 112.93 tCO<sub>2</sub>/month, 25.08 tCO<sub>2</sub>/month) produced by tourists in August in the Tremiti Islands, a quantity of 2,911.81 tCO<sub>2</sub>/August is expected and a quantity of 0.04 tCO<sub>2</sub>/day\*capita produced by a tourist as average in one day based on the August arrivals.

## Results and discussion

Climatological data collected at TI showed a clear tendency to the increase of the average temperature of the sea water and air temperature. Meanwhile a positive effect should regard the extension of the touristic season and bathing period due to warmer air and sea water temperature. This trend can result in a serious modification of the sea marine habitat with negative effects for a lot of vegetal and animal species of the Adriatic Sea. So, some measures to contrast the climate change have been outlined at TI.

### Measures for GHGs reduction and to contrast to climate change at TI

In order to face the effects of climate change at local and global level some contrast measures are suggested for their implementation in TI.

These measures of contrast to climate change should be addressed for achieving the Ecological Management Effectiveness (EME) of MPAs and to favor sustainable tourism that is the degree to which TI-MPA reaches his ecological goals<sup>51</sup>.

EME refers to the achievement of ecological goals and is the most frequently assessed aspect of MPA management effectiveness<sup>51,52</sup>. It is usually assessed by comparing one or more biological descriptors -e.g., density, size and biomass of species, species richness- or assemblages' patterns inside and outside protected areas<sup>53–58</sup>.

The contrast measures may include:

- Incentive for tourists out of the season; this is facilitated by the average increase in temperatures and the lengthening of the bathing season observed at TI;
- Energy: development and dissemination of interventions and practices aimed at reducing energy consumption
- Water: rationalization of the use of water
- Wastewater: implementation of affination and reuse of wastewater for irrigation of agriculture or green areas<sup>59–62</sup>
- Trees and green areas: plantation of endemic specie to contrast land degradation and CO<sub>2</sub> emissions
- Solid Waste: reduction separate collection and sustainable management of waste
- Food and products: rationalization, promotion of the short chain
- Awareness raising: training and promotion of practices with reduced environmental impact
- Plastics: reducing the use of plastics on all the islands. In this regard, the local municipality has already banned all plastic plates, cups and utensils on the Tremiti Islands from 1 May 2018.

### Environmental taxation for sustainable tourism

These environmental measures can be financed by application tourism/environment taxes. In the recent years tourism taxes have been largely used in Italy but principally as method to store funds aimed at supporting tourist services<sup>63</sup>.

The use of the tourism taxation has proved its general acceptability, contrary to the opinion of many tourism facility managers who frequently complain about the negative impact that this fiscal policy could have on the number of tourists and on the length of their stays<sup>64</sup>.

Environmental purposes are also well accepted as a destination for tourism tax funds.

Some authors (Rotaris and Carrozzo, 2019)<sup>65</sup> demonstrate also that the Willingness To Pay (WTP) for the tourism tax depends not only on the vacation and the tourist type but also on how the tax revenue is used. Thus, if no mention is made of the use of the tax revenues, the WTP can be as low as € 0.85 per person per night. If the tax revenues are used to improve and to protect the environment, the WTP can be as high as € 3.96<sup>65</sup>. This environmental contribution is an environmental tax for tourism purposes in the wrong sense, because the protection of the environment is not included in the taxable case, but the revenue from the contribution is intended to repair the damage caused by tourists in the marine reserve of the Tremiti Islands<sup>66</sup>. Similarly, the Government of the Autonomous Community of the Balearic Islands has proposed the introduction of an environmental tax on visitors in order to internalize external environmental costs<sup>67</sup> in the sense of a Pigouvian tax.

## Social cost of carbon at Tremiti Islands

Environmental measures are very fundamental to promote the sustainable tourism but can be also quantified using economical method that can prove their financial sustainability.

According to Visintin et al. (2022)<sup>64</sup>, a Social Cost of Carbon (SCC) can be adopted as monetary conversion factor. The SCC is the marginal cost of damage caused by carbon emissions or the marginal benefit resulting from reduced greenhouse gas emissions<sup>64</sup>. In our analysis, the SCC damage cost was assumed to be 36.92 €/tCO<sub>2</sub>. So,  $36.92 * 0.04 = 1.47 \text{ €/capita*day}$ , it is the cost necessary to compensate the quantity of CO<sub>2</sub> produced by a tourist in one day, and this value should be the environmental tax to be considered. Considering the low occupancy rate for the bed occupancy and to limiting the phenomena of one day tourism the tax should be applied “*un tantum*” just for the arrivals and then equal to 1.47 €/capita\*day.

Finally, it is fundamental to create and maintain a network among all stakeholder in the MPA and Tremiti Islands in particular management to support the economic growth and sustainable tourism.

## Conclusions

The touristic fluxes have been analyzed in the Tremiti Islands showing that the territorial exploitation index:  $(\text{arrivals/area} + \text{population/area})/100$  is very high in comparison with other Mediterranean islands and the tourist pressure index –  $(\text{overnight stays} + \text{population})/\text{area}$  – reveals that the tourism and population pressure is high in proportion to the island area but there is a low occupancy rate in the Tremiti archipelago.

The climatic conditions of the Tremiti islands are varied at with an increase in the average sea temperature and in the average air temperature during last decade.

Several measures of contrast for the climatic changes regarding the tourism and the existing infrastructures have been outlined.

These measures have also a positive return in terms of environmental balance considering the value for the greenhouse gases reduction.

Finally, these measures may be financed by environmental taxes estimated in 1.47 €/person\*day that have been showed that are well perceived by tourists if they have consciousness that they are visiting a well-managed area with respect to the territory and to all the environments.

The sustainable tourism policy should be implemented in the Tremiti Islands, but it needs to be strengthened by adopting specific measures<sup>16</sup>, especially regarding the reduction of CO<sub>2</sub> emissions and all the environmental issues illustrated.

## Data availability

All data analysed during this study are included in this published article.

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### Author contributions

F.R. and E.R. wrote the main manuscript text. F.R. has coordinated all the revisions and additions to this article. G.D. has suggested the ecological informations related to tremiti Islands. A.C.R. reviewed the manuscript. L.L. prepared Figs. 1–3. A.F.U. made the scientific supervision of the manuscript.

### Competing interests

The authors declare no competing interests.

### Additional information

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