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In-Depth Monitoring of Anthropic Activities in the *Puglia* Region: What Is the Acceptable Compromise between Economic Activities and Environmental Protection?

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Abstract: In many countries in the world, the conservation of habitats is at risk mainly due to anthropic pressures on the environment. A study was conducted to assess the extent to which sensitive and high nature-value habitats are damaged by high-impact human activities. Some evaluation methods that are applied may not be entirely appropriate to the characteristics of the investigated areas or may be very accurate but provide results that are delayed with respect to the occurrence of the events that created the loss of their characteristics. The main purpose of this study is to optimise some methodologies for monitoring the impacts of human activities making it possible to obtain better results in less time and with much lower costs. This methodology has been applied in two different areas present in the *Puglia* Region in south-eastern Italy, in the central Mediterranean area. The biotope fragmentation method was applied on coastal dunes, in the province of *Brindisi*, affected by an important tourist influx. The results of the inclusion, in the evaluation methodology, of the remote sensing of the paths indicate a more real situation on the state of fragmentation of the coastal dunes. The second methodology concerns the monitoring, through topographical profiles obtained from Sentinel-1 DEM images, of active and inactive mining sites, allowing to obtain of very detailed information on the progress of mining activities in a very short time. By implementing these methodologies, it is possible to improve the control of the territory allowing a more detailed analysis in order to safeguard the environment from impacting human activities and avoiding, as much as possible, the occurrence of illegal activities. Finally, compensation factors to ensure that human activities are conducted in a sustainable way are also evaluated.

Keywords: anthropogenic pressure; coastal dune; coastal erosion; tourism; quarry; mining activities; biotope fragmentation; naturalistic engineering; satellite imagery; socio-economic development; *Puglia*

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1. Introduction

The expansion of infrastructure and population growth lead to a landscape change and greater environmental resource exploitation. The anthropogenic pressure, such as urbanisation, pollution, and general human influences, are often at odds with the preservation of the fragile ecosystem [1]. Integrated management of environmental and economic components is essential for a successful environmental policy. To make monitoring effective, we need to consider some fundamental habits including: outlining the clear scientific program, adding variation in the design, looking at possible future developments, preserving the quality and coherence of the data, long-term data accessibility and availability, constantly investigating the monitoring data, and multi-faceted approaches [2]. Today, it is increasingly necessary to carry out in-depth analyses and more exhaustive environmental monitoring in order to identify the acceptable compromise between economic activities and safeguarding the ecosystem. There are many possible techniques for the monitoring and characterisation of the environment. Monitoring methodologies may relate to space monitoring and ground-instrumental monitoring [3,4]. The key steps are data collection in the field or remotely. After data acquisition, there is data processing and data analysis [5]. Environmental sensors allow data collection. Distinguish the passive sensors, such as Photographic Cameras, Cross-Track Scanners, Along-Track Scanners, Video Cameras, Microwave Radiometers, and Active Sensors such as Radar, and LIDAR [6]. The new frontier, in the last decade, on the field is represented by unmanned aerial systems (UAS) [7,8]. For the study of an area, the use of UAS is better adaptable in many situations by supplying high spatial detail in a cost-efficient way. Choosing between products from satellite imagery or UAS, there are several aspects to consider as autonomy, accessibility, scalability, legal regulation, weather condition, price, and data processing. For this study, LIDAR and satellite images were chosen due to the presence of high availability of images with high spatial and temporal resolution [9].

The described approach focuses on an area with intense agricultural activity, livestock farming, and fishing, with the presence of some mechanical, iron, and steel industries, mining activities concentrated in some areas, and tourism as the leading sector of the region. All these economic fields impacting on the ecosystems. The Italian Institute for Environmental Protection and Research (ISPRA) drew up the metrics for the determination of anthropic pressure [10,11]. The metrics consider the polluting load, the impact of agricultural activities (plantations and pastures), the impact of transport infrastructure (roads, highways, railways), the built areas (active and abandoned industries, quarries, archaeological sites, population centres), and the presence of protected areas. In this article, we consider first the impact of the road network on endangered habitats and then the economic areas made up of quarrying activities.

Coastal tourism, with the related sector as urban infrastructure development, agriculture, aquaculture, and transport (marine, land, and air), often invades the environment and causes countless damage. The Sustainable Tourism Community was established in 2016, acts in the Mediterranean region, and works to develop environmental administration and organisation, raising consciousness, safeguarding and preservation, and legislative measures [12,13]. Coastal tourism is the leading sector for many areas and in the summer mass tourism affects sandy beaches, low rocky coasts, and high cliffs to endure habitat loss, hydrology and sedimentology alteration, and pollution hence erosion speedup and saline intrusion [14,15]. Specifically, the biotope of the coastal dune on a sandy coastline performs countless functions such as specific ecological community habitat, and coastal defence (barrier against wind and waves, limit the effects of storms, obstacle flooding of internal areas, are natural sand storage points) [16]. Greater attention must be paid to safeguarding these fragile but essential environments. The anthropic pressure (through tourism infrastructures, driving, parking, walking paths, and abandoned waste) leads to adverse effects on land use, shape alteration, fractioning, and biotope fragmenting processes [17]. Long-term temporal studies, in the Mediterranean dune ecosystem, recorded in dune grasslands habitat an important decline in species richness and cover and less in shifting dunes [18]. Moreover, the erosion, most notably remarkable on foredunes, caused an alteration of the eco-morphodynamical processes of dune ecosystems [19].

In the *Puglia* region, the mining activity represents about 10% of the national one (4168 authorised quarries are in Italy of which 388 are in *Puglia*; 14,141 are abandoned in Italy and 2522 in *Puglia* [20]). On the territory, there are three main extractive basins: Apricena-Poggio Imperiale, in the north-western sector of the region characterised, Trani-Bisceglie-Ruvo-Fasano in the central sector, and Lecce in the southwestern sector. Extraction activities have permanent and documented impacts on regional ecosystems. Uncontrolled quarry activity harms biodiversity and exhausts ecosystem services. The effects are the removal of original flora and fauna, increment of sediment and water discharge, production of potentially toxic elements, speeding up erosion processes, destruction of available arable lands, noise, and dust [21,22]. In karst terrains the impacts even concern water quality deterioration caused by increased environmental susceptibility and the perhaps generation of sinkhole collapse [23]. Areas subject to uncontrolled development of mining can become abandoned places in conditions of collapse, illegal landfills for the disposal of waste, and places of illegal extraction of stone material. Such actions can lead to harmful effects on the environment, the population and public health, therefore need control and a garrison of the territory. The innovative strategies of quarry rehabilitation are numerous for instance public parks, botanic gardens, infrastructures, cemeteries, and many other recreation areas [24]. Variant approaches, among others spontaneous succession, avoid high-priced rehabilitation practices. Spontaneous succession promotes the self-sustainability of the system by restoring the ecosystem [25,26]. Furthermore, waste-free production is possible with an integrated mineral resource development approach for the sustainable reuse of materials [27,28]. To protect the environment, a type of cyclical production involving industrial waste in recycling should be created [29]. The mere development of human processes in unison with the environment has the potential to reduce human influence on the ecosystem.

Analyzing the above, it can be noted that the monitoring of anthropogenic processes on the territory is a very topical issue. In this article, we thought to consider two economic activities that impact the territory such as coastal tourism and mining activities. Therefore, the purpose of this study is to improve existing monitoring techniques, and to achieve this, it is necessary to solve the following tasks:

(1) to revise the calculation of biotope fragmentation by the road network, applied to coastal dunes;
(2) to determine the elevation profile of the quarries from Sentinel-1 satellite images through Digital Elevation Model (DEM) generation.

2. Materials and Methods

2.1. Description of Study Areas

Two different test areas were considered, each with specific characteristics. The first study area considered the coastal area between the city Ostuni and Fasano (Municipality of Brindisi). In the coastal area, there are various types of characteristic habitats (Figure 1a). In this area, coastal dunes prevail with a prevalence of the species *Juniperus* spp. They are heterogeneous habitats represented by woody vegetation dominated by junipers and other Mediterranean sclerophylls, present along the sandy coasts of the Mediterranean. The representative species are *Juniperus macrocarpa*, *J. phoenicea* subsp. *turbinate* and *J. communis* [30]. The vulnerability of these areas is due to tourist exploitation, involving alterations of the dune micro-morphology, and to the urbanisation of the sandy coasts. Other threat factors that can cause further fragmentation and/or degradation of coastal juniper stands are represented by fires, overgrazing, and expansion of agricultural areas. In addition to this main habitat, those with sclerophyllous vegetation dunes belonging to the *Cisto-lavanduletalia*, formations of sclerophyllous maquis and garrigue settled on the innermost dune cordons, where there is a consistent stabilisation of the substrate. The habitats of coastal lagoons are also partially affected, which are coastal aquatic environments with lentic, salty, or brackish, shallow waters, characterised by significant seasonal variations in salinity and depth. These habitats can be in direct or indirect contact with the sea, from which they are generally separated by sand or pebble strips and less frequently by low rocky coasts. In these environments, the excessive presence of tourism causes an excessive accumulation of organic matter and nutrients in the water and sediments and the triggering of fermentation processes which determine the establishment of chemical-physical conditions favourable to the proliferation of algal species. The latter condition the presence of indicator species such as phanerogams, whose survival is incompatible if we also consider an excessive mechanical disturbance of the seabed.

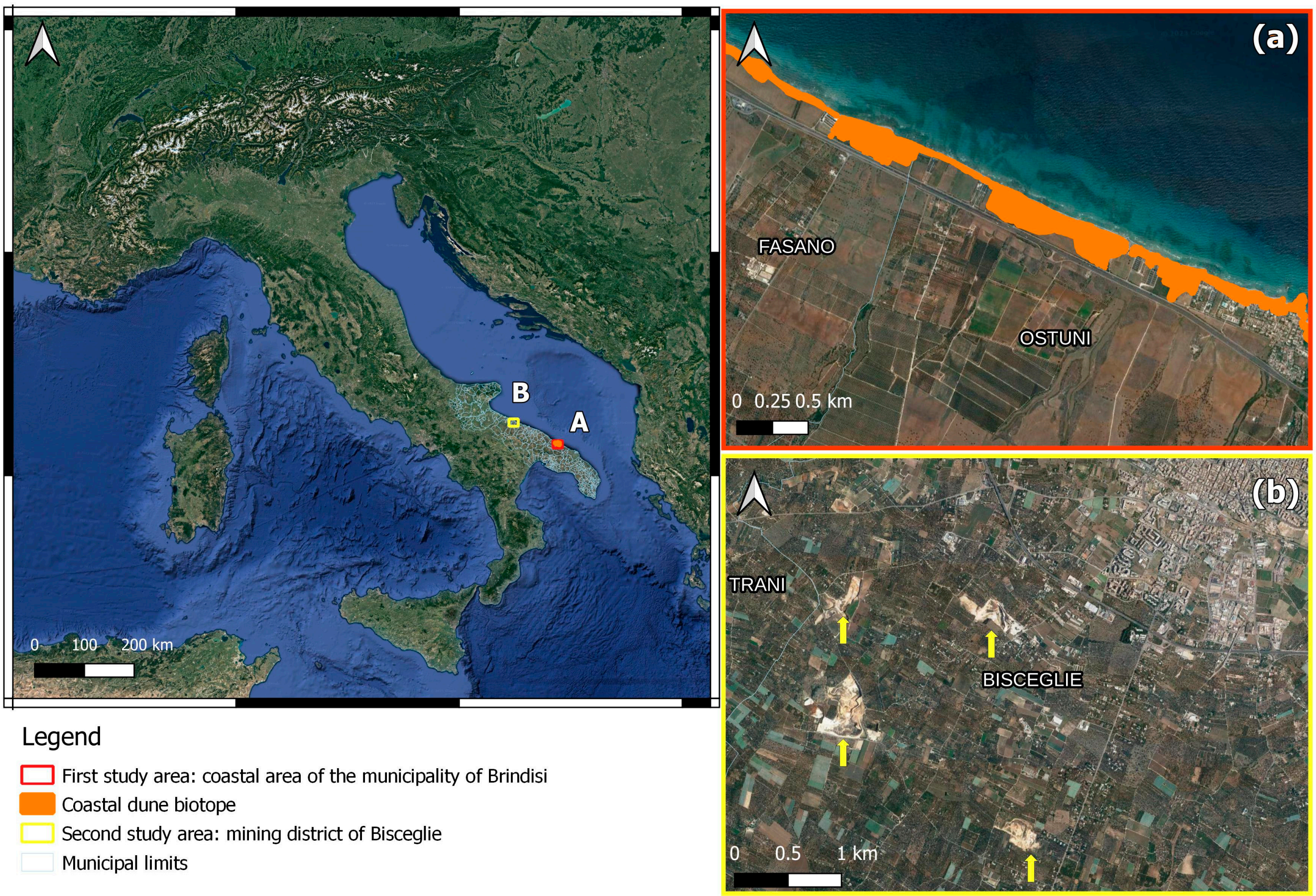

Figure 1. Study areas in *Puglia* Region (South of Italy): (**a**) coastal habitats in orange, and (**b**) with the yellow arrows areas with the presence of quarries.

In summary, all the habitats considered are coded as 1150, 1210, 1240, 1310, 1410, 1420, 2110, 2120, 2230, 2250, and 2260 as reported in the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, so-called Habitats Directive. This Directive identifies a series of habitats of Community interest that are concretely protected in the Special Areas of Conservation (S.A.C.), which in turn derive from an initial designation of Sites of Community Importance (S.C.I.). These form the network of Natura 2000 sites [31].

The second study area is an area with the presence of quarries and construction site activities (Figure 1b). These activities are often active for many years also to serve other interventions, in particular, quarries tend to consolidate themselves as extraction sites even after the conclusion of the construction work, often later becoming landfills. Creating a quarry alters the morphology of the territory, due to excavations, embankments, and tunnels for the procurement of building materials. These activities produce profound changes and interference with the quality and quantity of surface and groundwater, as well as erosion, compaction, and sealing of the soil, changes in solid transport and hydrological regimes, leaching of mineral salts, increased risk of landslides, with the direct degradation and destruction of habitats and ecosystem services [7,32].

2.2. *Dune's Study Case with Anthropic Fragmentation of Biotopes*

The indicators for the determination of Anthropic Pressure compiled by ISPRA provide an estimate of the degree of disturbance induced on a biotope [10]. Three indices are calculated including the degree of fragmentation of a biotope produced by the road network, the constriction of the biotope, and the spread of anthropic disturbance. In the work, some improvements are proposed to obtain a more detailed estimate of the anthropic pressure on the biotope of the coastal dunes.

The degree of fragmentation of a biotope produced by the road network is an indicator that represents the length of road infrastructure that crosses each biotope with respect to the size of the biotope. The indicator considers major road networks such as highways, state roads, provincial roads, and railways, giving weight to each infrastructure. The result of the calculation is the attribution of different weights for each stretch of a road network that intersects the biotope, multiplying the length by the weight. For each biotope, the indicator assumes the numerical value equal to the sum of the weighted lengths of all the stretches of a road network that cross it divided by the area of the polygon. The infrastructures considered are the motorway (weight 3, dimensionless number), the state and provincial road (weight 2), and the railway (weight 1). Considering the biotope of the coastal dunes, these are not affected by any of the previous road networks. This leads to an underestimation of the anthropic pressure on the biotope. Here, the road network has been implemented by adding the paths created by the seasonal tourist flows to reach the sea, through the dunes. In order to carry out a detailed assessment of the tourist impact on the biotype, a site survey was organised. During this survey, in a test area, the paths were photographed to attribute real weight (weight between 0.1 and 0.2). By reporting the photographic documentation on the Quantum GIS software [33], the weight estimation is more truthful, not based merely on remote images. The attribution of the chosen weight for the paths created by tourists on the coastal dunes is empirical. This value is based on knowledge deriving from the principles of environmental continuity [34]. Such paths correspond to linear barriers that affect ecological barriers.

The second index, the constriction of the biotope, represents the disturbance represented by the proximity of the biotope to anthropic environments. For each anthropogenic habitat a weight is assigned: plantations and pastures urban parks, agricultural fields, lagoons, and artificial canals; archaeological sites; abandoned industries and quarries; active industries. In the above index, the lack of a mapping of the updated habitat type leads to poor reliability of the data. This index allows the totality of the weighted boundary lengths between habitat and biotope.

The third index estimates the degree of disturbance induced on the biotope by the surrounding urban centre considering the size of the built-up area, the population (based on the ISTAT census), and any geomorphological impediments. The diffusion of the anthropic disturbance of each inhabited centre is calculated, creating a cumulative raster given by the sum of the disturbing values of all the considered locations. In order to obtain the index, the average noise value of pixels falling within the same biotope is calculated.

The main changes to the ISPRA method [10] concern the first index, a method revised in this paper. In this way we obtain a calculation that makes use of the truth on the ground, based on more precise metrics, obtaining a truthful and appropriate estimate of the anthropic pressure.

2.3. Quarry's Study Case with Elevation Profile from DEM Generation

The Quarry weekly profile estimation is based on the integration of remote observation methodology and Quantum GIS software. This method allows to obtain free good results, and the potential to analyse the relationships between past and present images for land monitoring. The process is described from the retrieval of data to its analysis.

2.3.1. Pre-Processing

The first point to do is to capture all the useful data: Sentinel data imagine and perimeter regional extractive sites in the shapefile format. On 3 April 2014 was launched Sentinel-1A and on 25 April 2016 Sentinel-1B, the first Copernicus Sentinel series. They represent two identical radar imaging satellites in the same orbit and provide a reserve of images of the Earth's surface in any weather, day, or night. This Sentinel-1 mission develops in C-band synthetic aperture radar imaging with different resolutions and coverage. This mission establishes a new period of available spaceborne radar imagery. This characteristic makes the Sentinel-1 image suitable for our study case for the monitoring and mapping of the land surface. The Sentinel-1A images can be downloaded for free from several platforms such as Copernicus Open Access Center, Copernicus Dedicated Access Center, The NASA Vertex platform or Alaska Satellite Facility (ASF), Copernicus Access Center mirrors by the National Center of Space Studies (CNES), EO platform [35]. A Digital Elevation Model (DEM) based on data from Sentinel-1 data was used to create a longitudinal profile of the limestone quarry and to analyse the elevation divergence. Based on the data made available by the region land registry, the correlation of the DEM with the orthophoto map highlights illegal environmental development. For the analysis, with C-band synthetic aperture radar instrument, was chosen the Interferometric Wide swath (IW) as the acquisition mode in Level 1 product for Sentinel-1. The Interferometric Wide swath using terrain observation with the TOPSAR technique. This technique provides homogeneous image quality throughout the 250 km of the swath. The level 1 products are characterised by 29–46 incidence angle, 5 × 20 m resolution, 250 km swath width, HH + HV − VH + VV − HH or VV (horizontal and vertical) polarisation. In single-look complex products, in IW mode marked by 2.7 × 22 m to 3.5 × 22 m Resolution, 2.3 × 14.1 mm Pixel spacing, 1 × 1 number of looks and 1 equivalent number of independent looks (ENL).

The extraction sites were received from data provided by the regional *Puglia* authorities in 2022 and updated by us.

2.3.2. Processing

Phase one to begin, for a successful DEM generation, are the selection of two appropriate images [36]. These two images allow advantageous conditions as short temporal and convenient perpendicular baselines and suitable atmospheric conditions. The main software provided by ESA development, making use of their satellite constellations for the scientific exploitation of Earth Observation, is the free open-source Sentinel Application Platform (SNAP) software [37]. After downloading, from Copernicus Open Access Hub, the two products use the SNAPHU unwrapping algorithm for phase unpacking. As a first step, it needs to import the two Sentinel-1 zip file products and apply the coregistration with S1 TOPS Split. The S1 TOPS Split is used to choose only those bursts required for the analysis, to reduce the area of interest by selecting the sub-swath and VV polarisation. As a second step, it was used the Apply Orbit File determination to improve the precise orbit determination and the geometric accuracy for both split products. Next, the application of the S-1 Back Geocoding operator, a coregistration step to generate a stack of co-registered data, has been applied. To raise the quality of the coregistration shall apply the Enhanced spectral diversity operator. Apply the Interferogram formation and the Flat Earth phase to remove the phase linked to the Earth's curvature is calculated using the orbital metadata information and subtracted from the complex interferogram. The S1 TOPS Deburst allows fusion bursts by removing the overlap and creating a single continuous image. For the image corrections, the quality of the fringes existing in the interferogram can be implemented by applying specialised phase filters such as Golden Phase Filter, a phase noise-sensitive filter. To prevent unwrapping errors is used to apply the Subset function to remove the grainy parts of the image. To remove any errors in the estimation of the phase difference related to the topography of the acquired area, Topo Phase Removal has been estimated. Phase Unwrapping is capable to bind the interferometric phase to the topographic height in three actions export, unwrapping, and import. Next, it has been applied Phase to elevation to transform the radian units into absolute heights and Terrain Correction to generate a map-projected product. For running the DEM, the best option is Shuttle Radar Topography Mission (SRTM) 1sec HGT. Finally, the latter procedure before saving the product, the ground correction geocoding lets to create a projected map as UTM/WGS84.

Many techniques make it possible to obtain an altitude profile from a DEM. Within the Quantum GIS software 3.28.6 '*Firenze*', we could consider: the plugin Profile tool [38], the plugin qProf [39], Whitebox Tools for Processing [40], and SAGA Terrain analysis profiles [41]. The plugin Profile tool turns out to be the most expeditious altitude profile calculator while the SAGA method allows building customizable profiles.

3. Results

The results concern monitoring human activities and their impact on ecosystems. To accomplish this, the reference considered were the metrics for the determination of the Anthropic Pressure of ISPRA [10]. The first case study concerns the calculation of the fragmentation of the coastal dune biotope caused by the road network. The second case study concerns a proposal for a territorial analysis for the control of mining activities. Mining activities, both abandoned and active quarries, are important parameters for the calculation of anthropic pressure on a region.

3.1. Antropic Fragmentation of Biotipe into Dune Biotipe

The calculation of the fragmentation of the coastal dune biotope has revealed a situation with a major threat to the ecosystem. The calculation, according to ISPRA [10], considers the official and main road network, while this proposal considers the road network and the paths created by tourists and by tourist commercial activities. The roads created to reach the sea in some stretches of coastline are located at distances of a few tens of meters (Figure 2). Figure 2 shows a stretch of coast with coastal dunes intensely crossed by paths with related photographs. The photographs in Figure 2 show three different situations of conservation of the dune. The image in Figure 2A represents the worst situation, with the destruction of the vegetation and the dune relief, and the creation of a pathway about 2 m wide (Figure 2A). The image in Figure 2C represents a section of the dune with a higher state of conservation than the previous one but limited vegetation (Figure 2C). Finally, the image in Figure 2B represents a section of the dune with a state of conservation intermediate between images A and C (Figure 2B).

Figure 2. A stretch of the coastal dunes study area (**top left**), with three ground truths photographs ((**A**)—pathway about 2 m wide with the destruction of vegetation and dune relief, (**B**)—pathway about 1 m wide with destruction of the vegetation, (**C**)—section of the dune that has a greater conservation status than the previous one) at different points in March 2023 (base map, Orthophoto 2019 [42]).

The test area choice of coastal dune biotopes extends to an area of 92 ha. In Figure 3, the results from three areas with a different anthropogenic impact are shown: the first far away from the tourist infrastructure (Figure 3(a1,a2)), the second close to a beach resort and parking (Figure 3(b1,b2)), and the third near a big holiday village (Figure 3(a1,c2)).

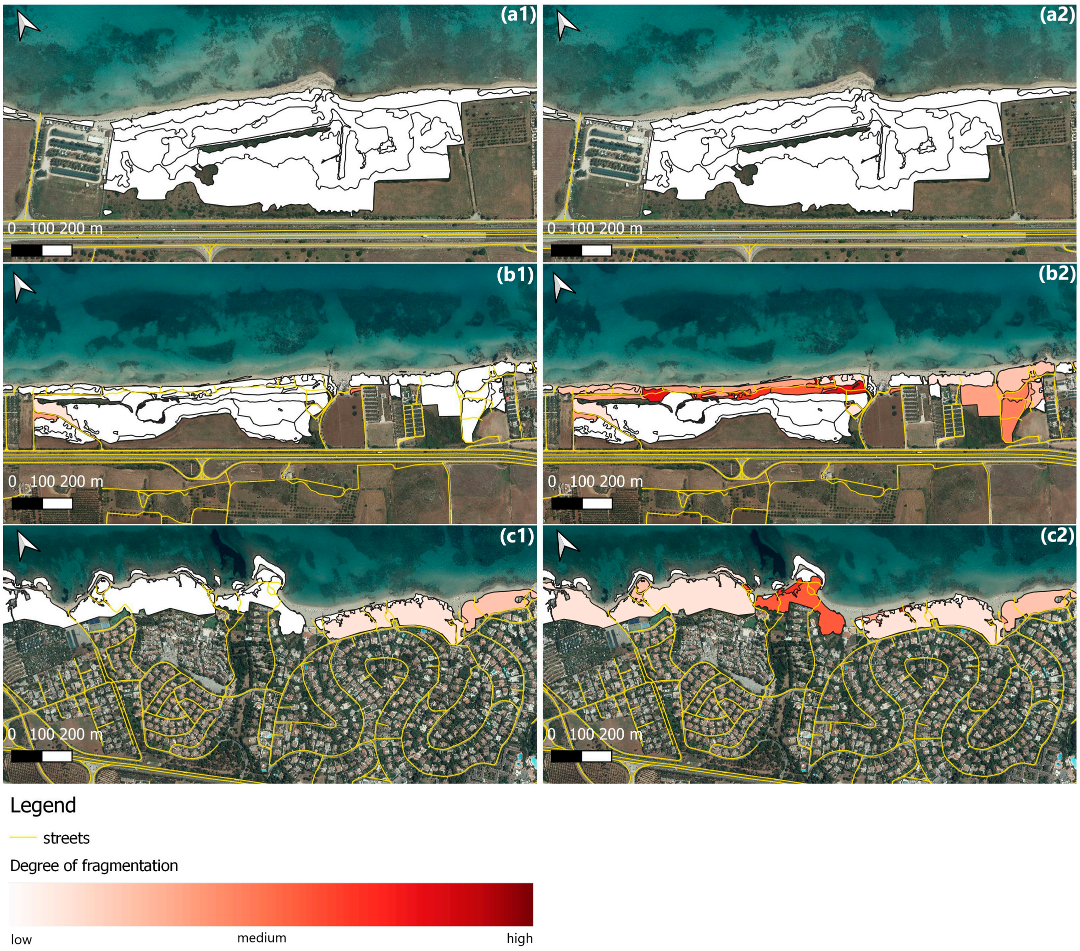

Figure 3. Calculation of biotope fragmentation. Images (**a1**–**c1**) report the result of the calculation according to ISPRA guidelines [10] images (**a2**–**c2**) report the calculation updated according to our suggested methodology (base map, Orthophoto 2019 [42]).

The calculation of fragmentation, following the ISPRA method, returns an image of a habitat with a low fragmentation. The degree of fragmentation is low-pitched because road infrastructure seldom crosses the coastal dune habitat (Figure 3(a1–c1)). On the other hand, the calculation of fragmentation, considering the road network and the paths created by tourists, shows a different situation with high fragmentation (Figure 3(a2–c2)). The results have been normalised to make them comparable.

The paths taken by tourists to reach the sea intensify in this stretch of coast at distances of a few tens of meters from each other. The biotope appears heavily fragmented due to its proximity to tourist facilities and the urban area. These paths intensify near the car parks and the holiday centres (Figure 3(b2,c2), in red the intensely fragmented areas). Other areas, far from the main tourist infrastructure, manage to maintain a low fragmentation (Figure 3(a2), in white the low fragmented areas). The result of the creation of these corridors is the reduction of the continuity of the coastal dune ecosystem. The percentage of biotopes affected by fragmentation increases from 4.5% to 30.1% between the two calculations.

To validate the usefulness of the calculation, the difference between the two normalised calculation methods was performed (Figure 4). In the areas not crossed by the road network, the differences are not significant (in white colour). In contrast, areas ranging from moderate to strongly fragmented appear to be the most prevalent (in shades of colour between light blue and blue). The detailed mapping of the paths illegally created by tourists has allowed a true estimate of the degree of fragmentation of the area. The normalised difference shows a considerable underestimation of the reduction in the continuity of ecosystems, habitats, and landscape units if we do not consider local roads, walking paths, and areas created by recreational tourism activities.

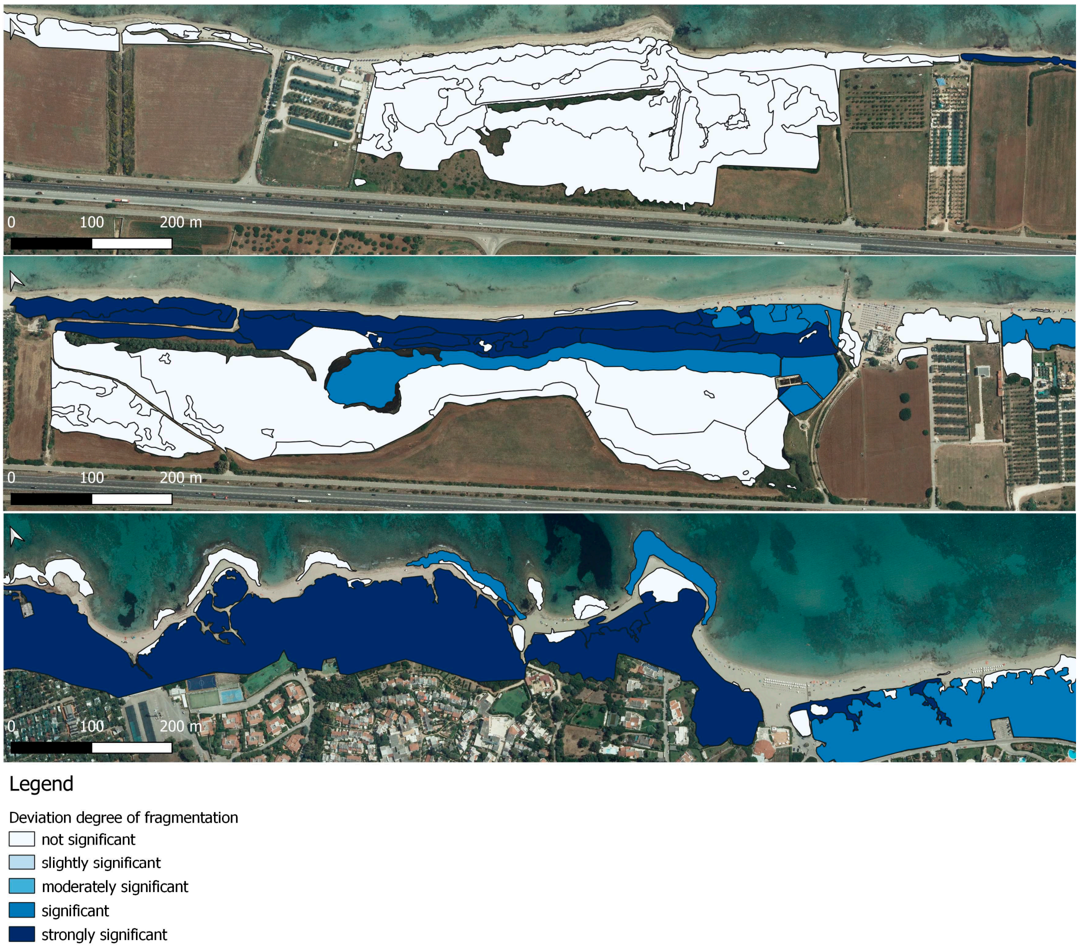

Figure 4. Calculation of the difference between the original index of biotope fragmentation calculated according to the ISPRA guidelines and the updating of the calculation (base map, Orthophoto 2019 [42]).

3.2. Impacts of Anthropic Pressure Due to Quarry

The results of the analysis of the mining activities in the area led to the expeditious identification and evaluation of the excavations. In detail, we consider the case study of the quarry in *Bisceglie* (Figure 5). The topographic profile execution was made with the Terrain profile plugin in the Quantum GIS software, considering the limits of the resolution. Two different profiles, perpendicular to each other, were used for verification (profile EF in red and GH in green). The quarry extends for about 700 m on the EF profile and for 400 m on the perpendicular profile. From the profiles detected, it is possible to see how the methodology developed for the DEM generation perfectly follows the elevations of the land, providing valid information on the progress of mining activities. The maximum depth is about 50 m, we distinguish the faces of the quarry, the buildings, and the accumulations of material. Very quickly and remotely you can recognise substantial changes in the topography. For the control of the lateral expansion of the quarries on the territory, the images in orthophotos are the most suitable, but they are produced at unsuitable times and are expensive. Orthophoto images cannot lead to a resolution of the problem allowing effective monitoring, quickly and at low cost.

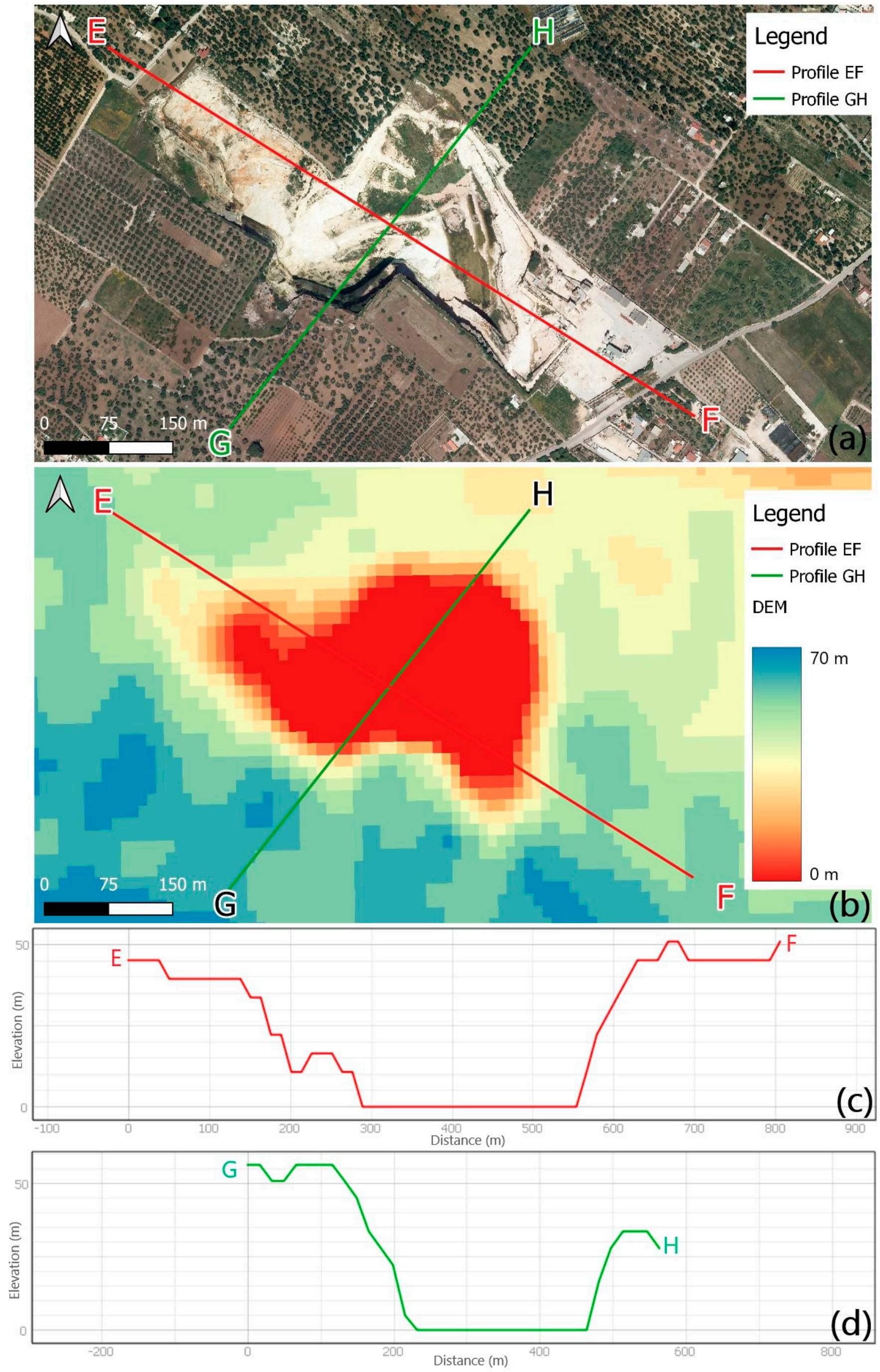

Figure 5. The same extraction site is represented in Aerial image (**a**) and with the DEM generated by Sentinel-1 (**b**). Below are two topographical profiles EF (in red, (**c**)) and GH (in green, (**d**)), made with the plugin Terrain profile (base map, Orthophoto 2019 [42]).

4. Discussion

Human activities must be carried out by accepting a compromise between economic activities and safeguarding ecosystems.

The procedure developed for calculating the fragmentation of habitats allows for obtaining a more accurate knowledge of the state of the same. Results in Figure 3(a1–c1) show the difference of the values obtained by evaluating the fragmentation with the calculation suggested by us compared to the one provided by the Italian Higher Institute for Environmental Protection and Research (ISPRA) [10]. According to the methodology currently applied, the habitats of the study area would not be subject to any human pressure just because they are not intersected by any main road infrastructure. By calculating the value of fragmentation with our method, a very different situation emerges (Figures 3(a2–c2) and 4). The results show that some areas, compared to others, need more attention from a protection point of view: look, for example, at those coloured with more intense colour. The verification activities on land have confirmed the hypothesis of the presence of a certain degree of fragmentation of these sensitive habitats. The images reported as truth on the ground indicate how men can negatively affect these habitats by increasing their fragmentation (Figure 4).

Compared to our methodology, other authors propose different methods of calculating the fragmentation based on updating the connectivity index which is based on the metapopulation model [43,44]. Other methods aim to assess fragmentation by identifying the state of habitats on different patches of the landscape [45]. They consider local roads and railways with a friction coefficient value equal to zero and for high-speed roads and railways a value equal to 16 (dimensionless number) [46]. In this way, no weight is given to local roads such as those analyzed in this study.

In more recent papers [47], some metrics for the evaluation of habitat fragmentation have been compared by evaluating the impact of some human activities on protected areas. From these proposed methodologies [48,49] we note how the main difference consists in the use of the overall formula for calculating the value of fragmentation. This work is not proposed a detailed analysis of roads for ecosystems as fragile and confined. In other studies, the proposed formulas analyze fragmentation on a larger scale. They highlighted, for the evaluation of the fragmentation of large landscape units in Italy, an in-depth analysis related to the assessment of the growth of urban agglomerations. They consider the nature of the urban area (industrial, business district, intensive residential areas, and extensive residential areas) in terms of land use [50].

The more detailed characterisation of the state of the habitats makes it possible to acquire more appropriate levels of knowledge. It allows an administrator of the territory to better manage the presence of tourism and concessions on the beach in the presence of these types of sensitive and rare habitats. Let us not forget that these habitats are also very important from the point of view of ecosystem services [51]. The suggested processings are also preparatory to obtaining more detailed values of the indicators (i) constraints of the biotope, which represents the disturbance affecting a biotope due to its proximity to anthropic-type environments such as agricultural areas, inhabited centres, quarries, and (ii) diffusion of anthropic disturbance, which estimates for each biotope the overall degree of disturbance induced by the surrounding urban nuclei, proportionally to the size and resident population of the urban centre and inversely to the distance from it and any geomorphological impediments. For the latter indicators, the calculation of which is foreseen in the Italian manuals and guidelines for the mapping and evaluation of habitats [10], the results would be more representative and in greater detail.

In addition, detailed monitoring of quarries is a very important activity in order to ensure the sustainability of mining activities and improve the management of environmental problems deriving. The methodology developed aims to ensure the strengthening of monitoring and control activities of the territory. The mining sector requires important technological, organisational, and managerial innovations aimed at controlling and protecting the environment. Often illegal activities are hidden behind such activities [52,53] and therefore it is considered necessary to deepen the levels of knowledge also aimed at preventing any illegal activities. In particular, the methodology developed for the characterisation of the areas affected by mining activities implements a cognitive model, in a GIS environment. It allows us to identify detailed information and evaluate the extensions of the quarry fronts and the depth of the excavations. This technique analyses the trends of the activities in space and in time and evaluates the temporal transformations with change detection [54,55]. The proposed methodology is very expeditious and based on the wide availability and high temporal resolution of satellite images. It allows detailed monitoring of the progress of the extraction of quarry materials allowing the administrator to know the status of the activity with adequate frequency. This important step forward is necessary because, until now, monitoring delegates base the assessment of the state of the quarry activities on-site inspections. Currently, it is possible to identify the critical issues (with a certain margin of error) in the proper time to operate and monitor the state of the places. This method avoids wasting time or avoidable environmental damage. Other very valid methods consulted [56] are based on LIDAR surveys integrated with SAPR surveys and terrestrial laser scanners in order to obtain a representative result of detail. However, these surveys, in the monitoring of quarries, are carried out along slopes and in complex extractive districts. In our study area, the quarries are on a flat surface. It can be achieved valid results with lower time and money [57].

In addition, the cognitive model obtained based on the needs of the territories can be implemented and can make use of the integration of the following relevant data:

- waste which disappears every year;
- complaints about environmental offences managed by organised crime;
- verification of contamination.

The development, consolidation, and enhancement of synergistic operating practices through an updating, monitoring, and increase of information flow between different subjects favor the circularity of information. This is functional for the state of environmental health and for the assessment of land restoration projects in the territory of *Puglia* [58].

From an ecological point of view, the dunes of the sandy coasts, often associated with wetlands behind, are among the most vulnerable and threatened ecosystems at a global and national level by anthropic pressure [59]. These habitats are destined to disappear if decisive measures are not applied for their survival. On the other hand, human activities represent important opportunities for economic growth for communities but at the same time they can constitute if not adequately controlled, factors of threat as they can predominantly upset the environmental, social, and economic balances.

It is known that environmental degradation is only the precursor of further degradation and very dangerous activities [52,60], for example, the abandonment of the countryside (an aspect of environmental degradation) is the precursor of illegal phenomena such as illegal disposal. It is therefore important to maintain the right balance to ensure a correct way of using natural resources by facilitating their intrinsic resilience capacity. To solve this problem, a very effective solution is to resort to naturalistic engineering, a technique with which it is possible to intervene to protect and restore degraded dune systems, without altering the local physical, landscape, and cultural aspects. Many experiences [61–63] demonstrate that it is possible to obtain good results especially when the restoration work is carried out with the utmost respect for the naturalness of involved ecosystems. These interventions have a cost, certainly much lower than the usual coastal engineering interventions. The naturalistic engineering initiatives aimed at reconstructing dunes similar to the original ones rigorously using only autochthonous herbaceous and shrub plant species for their stabilisation through botanical studies [64]. Latter creating windbreak barriers and walkways on designed and identified paths for areas where the continuous passage of man creates erosion phenomena. They are simple constructions made of wooden slats or twigs, or jute or coconut fiber mesh structures, in a single or double row with the function of bridling the sand. Equally advantageous are the initiatives aimed at regulating tourist flows, reducing the number of people who visit the study areas (at certain times of the year), and increasing environmental awareness with training actions, and education activities involving local populations. It is not conceivable to reject tourism or confine it or to put an end to the need to mine raw materials. It is a question of identifying appropriate policies shared by all stakeholders in order to impose a development model in balance with the environment and traditional culture, a system in which the population is directly involved as much as possible in businesses or however, it enjoys the socio-economic benefits that arise from such activities. It is necessary to maintain the integrity of the territory, protect the areas at risk and enhance the peculiar aspects and identify a correct method of communication.

The goal can be achieved through greater control of the tourist flow, the implementation of slow mobility, greater controls, and the introduction of stricter tax regimes for certain activities and at certain times of the year. Finally, it is also necessary to be more severe for those guilty of environmental crimes.

The acceptable compromise consists of a more conscious use of natural resources by a man who, at the same time, must become more aware of his actions in compliance with the rules, rights, and duties.

5. Conclusions

The proposed methodology acts on two aspects concerning the assessment of the impact of human activities on habitats and ecosystems. In particular, the levels of knowledge have been improved concerning the following very critical aspects: environmental fragmentation and extractive activities. By applying the proposed methodologies, it would be possible to carry out more representative monitoring of the state of the places capable of highlighting in a more accurate way where to intervene to restore the habitats from fragmentation phenomena. Monitoring carried out with satellite images also makes it possible to intervene more quickly in the event of illegal conduct related to the conduct of high-impact activities, such as above all the extraction of materials from the subsoil.

If the area is not carefully monitored, the resulting impacts affect the functionality of ecosystem services causing a depletion of resources and giving rise to phenomena of environmental degradation which represent the starting point for the establishment of illicit activities. Therefore, the controls that can be implemented with the proposed methodology act in the direction of enhanced environmental control to make some activities with a strong impact on the territory more sustainable. To achieve this condition, it is necessary to resort to actions that concern both engineering and socio-cultural aspects. The peculiarities of the territory must also be promoted through synergies between administrators and research institutions, local professionals, and social operators. We need to be able to make an accurate assessment of the impacts of human activities at any time, which is currently not possible.

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