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Chapter 13

Short-Term Burn Severity differentiated Sentinel-2 computation in Segesta area park: LR16/96 Shrubland Heritage Vegetation Multi-Index AHP method

* Salvatore Polverino

1. Introduction: Segestae site, Elymians and Magna Grecia

Segestae, or Aegesta, (Greek: Εγεστα) acropolis, presents an eminent public structure, also known as *stoa*, that constituted the pinnacle of Elymian civilization during the Late-Hellenistic period, by the hand of its people, around the IXth century B.C.
This ancient city was settled down upon *Mt. Barbaro*, and its ruins of the political and administrative landmarks are nowadays still visible. As evidence of its Hellenization, a large and unfinished Doric Temple together with the Hellenistic Theater, both erected on two magnificent peaks of *Mt. Barbaro*, have been preserved over the centuries and during the last decade a few remarkable archaeological campaigns (Olivito and Taccola, 2014), that included 3D Structure from Motion, Lidar and Modelling techniques, mutually terrestrial and aero-photogrammetric, which have determined an "archaeological practice and digital archaeological practice" (Huvila and Huggett, 2018) (Wilson, A., 2021), bringing to light a detailed planimetric restitution of the Segestaen public square. Herewith, these results were accounted in this study, thanks to the clarity of these excavations, conducted by a dual partnership, *Laboratorio di Disegno e Restauro at the Dipartimento di Civiltà e Forme del Sapere* (LADIRE), together with the DreamsLab, at the *Scuola Normale Superiore of Pisa*; this scenography urbanization, as a whole, supported the identification of the pertinent heritage archaeology, in the matter of paths, squares, and Hellenistic lexicon, all giving consistency to the different residual sites, and the specific urban-model of the Greek inhabitants in Sicily, characterized by the cult of unique "theatricality" (Ampolo C. et al., 2016), also transferred to the urban physiognomy, with attributes of scenography solemnity, gigantism, in correspondence with high acclivity of the sites.

Another object-based evidence, of the uniqueness of Segestae surrounding, was categorized by the national cadastral agency (*Agenzia delle Entrate*), backed up by conceptualized landscape masterplan (*Agenzia Regionale per la Protezione dell'Ambiente Sicilia*, land cover land use, 2017-2018), that highlighted the allocation of specific plant communities, so that these scattered ecological values, have been validated, and gradually recognized to obtain a legal protection (Troia et al., 2016).

At the European level, to fight this threat, Mediterranean temporary ponds have been only recently listed as "priority habitat" in the EU "Habitats" Directive (92/43/EEC), trespassing siege and "reclamation" attempts (The temporary Wetland complex of Anguillara and its key role for the botanical heritage of western Sicily), rare biogeographic and conservation features, finally recognized across a multi-scalar levels of protection, within the vallies of Jato and Belìce Destro, determing "tendency lines" (Alfano and Muratore , 2014), that accomunate larger areas in the western side of Sicily.

Corresponding Author: * S. Polverino
Department of Training and Internationalization, Ordine degli Architetti, Pianificatori, Paesaggisti, Conservatori di Napoli e Provincia Napoli, Italy
e-mail: formazione@napoli.archiworld.it; polverinosalvatore@outlook.com

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Regional administration has gradually accepted this conservation value, mutually confirmed by European Red List biotope, e.g. *Pilularia minuta Durieu* species that was considered extinct in Italy, by conscripting firefighters body (*Corpo Nazionale dei Vigili del Fuoco*), against the menace of fire (*Legge regionale 16/96*), with the designation of Landscape Heritage guardians: "*Assessorato Beni Culturali e dell' Identità Siciliana*" (Department), "*Soprintendenza Beni Culturali e Ambientali di Trapani*", that operate under the shield of "*Ministero della Cultura*" (MiBACT). In the territory of Italy, however, the designation of such environmental actors, seem to remain under these levels of protection within the perimeters of area parks, due to the fact, that the consume of the soil is addressed to the sensibility of local administrations and not fully monitored: outside these boundaries, e.g. for Sicily, the legislative void is merely observed through the L.R. n.16/2016, "*Recepimento del Testo Unico delle disposizioni legislative e regolamentari in materia edilizia*", as consequence, Eolic and photovoltaic parks have severely destabilized its preservation.

Figure 1. The Vale and Temple of Segestae Sicily. Author: Thomas Cole, 1844. CC BY License.
Figure 2. Parthenon in "Excursions daguerriennes". Author: Pierre-Gustave Joly (1798-1865) and Frédéric Martens (Engraver) (1806-1885). CC BY License.

1.1. Heritage Theory, from Carta del Restauro, 1932, to the Declaration of Segesta, 1995

The Italian nation, due to a leadership in the sector of Heritage, has summoned, in the course of the 20th century, top tier academic bodies by organizing conferences among all nations, with the purpose of defining a shareable scheme of protection, universally comprehended, applied and regulated. Prior to the extensive Heritage awareness est. in 1995 with the "*Dichiarazione di Segesta*" - as an application of the: 1) *Convention for the safeguarding of the European architectural heritage* (Granada, 1985), and 2) *European Convention for the Protection of the Archaeological Heritage* (Malta, 1992) - that announced the specific soundscape and fragility as witnessed by "The Ancient Theatres of the Mediterranean as integrated survey experience" (Bianchini et al., 2016):

"*banning construction or permanent arrangements that would disfigure the buildings, instead creating temporary installations, which are on site only for the period of the shows and which do not impede the usability of the monument. Also, these facilities, temporary structures must be conceived in such a way as to make the architecture better understood ancient*";

"controlling the evolution of monuments through land management and planning of the surrounding area in accordance with the legislation on historic monuments".

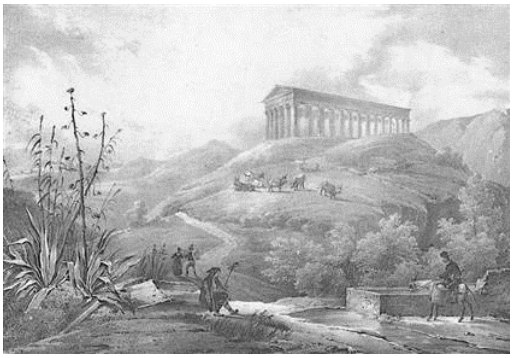
sixty-three years before, back in 1932, a preliminary document entitled "*Carta Italiana del Restauro", ex facto* without jurisdictional authority of the "*Consiglio Superiore per le Antichità e le Belle Arti"*, part of the "*Ministero della Pubblica Istruzione"*, extended the concept of a sensitivity for the conservation of Italian monuments, to pictorial and sculptural art.

The innovation of such a conference record, was priorly inspired in 1931, in occasion of the "*Conferenza Internazionale di Architetti ad Atene"*, (Athens).

Nevertheless, the act of rendering void erroneous restorations was set formally merely in 1938, under the "*Istituto Centrale del Restauro"*, which elected a ministerial cabinet capable to supervise, on the premise of a shareable and universally accepted archaeological principles.

With the advent of the war bombings, the Italian Heritage became excruciatingly victim not only through a weak supervision, but also because of a compulsive sentimentalism, so that in 1972, the Italian *"Ministero della Pubblica Istruzione"* body, enlisted a set of ten rules to be respected in defense of the Heritage domain, both material and intellectual; the second article is reported as follows:

"In addition to the works indicated in the previous article, the building complexes of monumental, historical or environmental interest, particularly the historic centers, are assimilated to these, to ensure their preservation and restoration; the artistic collections and furnishings preserved in their traditional arrangement; the ***Gardens*** *and* ***parks*** *that are considered of particular importance ".*



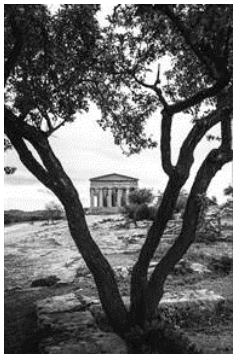


Figure 3. Segestae Theater. CC BY Unsplash License. **Figure 4.** "Ruins of Segestae Temple in Sicily". Copper engraving for "*Atlante Illustrativo*", Transhumance of shepherds (Volpe et al. (2015) among the spoiled structures (Mannoni C., 2014,2021). Author: Zuccagni Orlandini, Florence, 1844. **Figure 5.** Mediterranean vegetation and the Temple east façade. CC BY Unsplash License.

The sixth article partially observes:

"In relation to the purposes for which, pursuant to art. 4 must correspond to the safeguarding and restoration operations, for all the works of art referred to in articles 1,2,3 is prohibited without distinction:

I_"Style or analogue additions, even in simplified forms and even if there are graphic or plastic documents that can indicate what "the appearance of the finished work was or should appear";

II_"Removers or demolitions that cancel the passage of the work through time, unless it is limited disfiguring or incongruous alterations with respect to the historical values of the work or stylistic additions that falsify the work";

III_"Removal, reconstruction or relocation to places other than the original ones; unless this is determined by superior conservation reasons";

IV_"Alteration of the ancillary or environmental conditions on which the work of art, the monumental or environmental complex, the furniture complex, the garden, the park have come down to our time".

The conservation of the ecological values, as a part of the monument, has been finally executed in Segestae through the "*Schema del Regolamento recante le Modalità d'uso, I vincoli, I divieti vigenti nel parco archeologico di Segesta*", in which the erection of whatsoever type of structure, pre-built modules, ground excavations, the alteration of biological and geological values from a chemical perspective, the extraction of fossils, minerals, rocks, even though superficial and fragmented, or pieces of vegetation, to displease animal species, nests and burrows, and practice sport activities. Among these sub-articles, the abstraction of the Mediterranean vegetation is severely punished.

Figure 6. 7. 8. Spontaneous vegetation of Pistacia lentiscus (Greek: μαστίχα mastíkha) on the Acropolis of Ischia (Greek: Πιθηκοῦσσαι or Pithecusae), Italy. Copyright: Author. Courtesy of Sir Francesco Castagna.

Figure 9. *Pistacia lentiscus* harvesting at the Greece *Association of Mastic Producers of Chios*, Chios, Greece. CC BY License. This biotope fully covers the southern slopes of Chios Island of Greece (Özden, S., 2019), constituting the almost totality of its Mediterranean shrub percentage, homologically comparable to the Hellenistic economy net-value, to produce Chios mastic. The shrub has been appreciated in the last 50 years for medicinal, aromatic, and also chromatic properties in painting. Recently its re-assignment is also driven by protection of soil governance, taking advantage to its complacence within dry environments, as well salty air.

"As regards the individual elements through which the protection of the organism as a whole is implemented, both the building elements and the other elements constituting the external spaces (streets, squares, etc.) and internal (courtyards, squares, etc.) must be taken into consideration, ***gardens, free spaces****, etc.), to other significant structures (walls, doors,* ***rocks****, etc.),* ***as well as any natural elements that accompany the whole, characterizing it more or less accentuatedly (natural contours, waterways, phyto-morphological singularities, etc.)****";*
"The building elements that are part of it must be preserved not only in their formal aspects that qualify their architectural or environmental expression, but also in their ***typological characteristics*** *as an expression of functions that have characterized the use of the elements over time.* ***Each restoration intervention must be preceded, in order to ascertain all urban planning, architectural, environmental, typological,*** *constructive values, etc., by a careful historical-critical reading operation [...] operational differentiation [...] operate with homogeneous criteria - rather, the identification of the various different degrees of intervention [...] << conservative reorganization >>".*

In this regard, it should be noted that by conservative rehabilitation we must first understand the maintenance of road-building structures in general (maintenance of the route, conservation of the road network, isolated perimeter, etc.); and also the maintenance of the general characteristics of the environment that involve the integrated conservation of the ***most significant monumental and environmental emergencies*** *and the adaptation of the other elements [...] considering only exceptional replacements, even partial, of the elements themselves and only to the extent that this is compatible with the* ***preservation of the general character of the structures of the historic centre****".*

1.2. Shrubland Heritage Vegetation and Study Area

Fire protection service is served by several key tools with regard of quantitative analysis and operational interventions. This role is executed at a regional stage, by the "*Comando del Corpo Forestale della Regione*

Siciliana"(C.F.R.S.), a specific forestry body whose influences rely on fire deterrence models, e.g. area patrolling, aerial support, cutting of buffer vegetation, easily triggerable, against various criminal or spontaneous behaviours:

"*by forest fire we mean a fire with susceptibility to spreading over areas wooded, bushy or tree-lined, including any anthropized structures and infrastructures located within the aforementioned areas, or on cultivated or uncultivated land and pastures adjacent to these areas.*" In compliance with the "*Legge Regionale*", 6 April 1996, n.16.

Figure 10. Canadair in action in Calatafimi-Segestae unloading 14.000 water liters, September 17th, 2022. CC BY License. **Figure 11.** Segestae Temple with Mediterranean shrubs. CC BY Unsplash License.

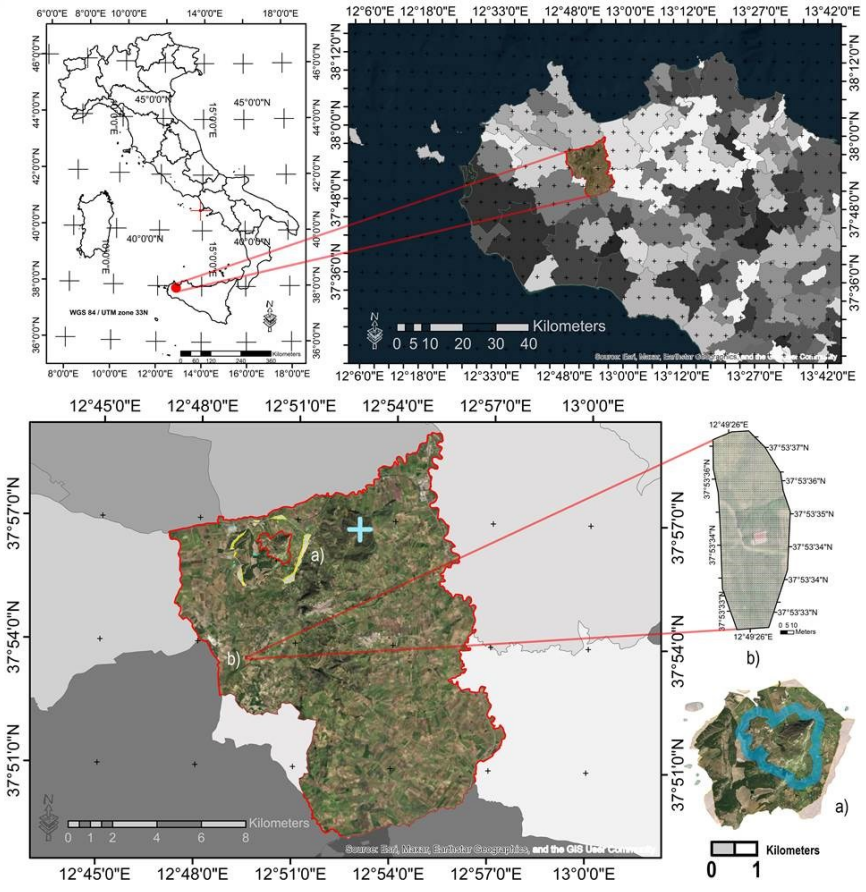


Figure 12 (upper left). Cartographic framework WGS UTM 33 N at a national scale. Coordinates of analysis est. between 12°47'16.96"E and 12°57'0"E (Longitude), 37°51'0"N and 37°59'25.99"N (Latitude) at a regional scale. Red cross symbolizes the *Pistacia lentiscus* biotope localization (island of Ischia). **Figure 13.** Framework on a provincial basis of Trapani, for the Municipality of *Segestae-Calatafimi*. **Figure 14.** Geographic Information System preliminary identification of the Segestae Archaeological Park. The sub-entity (b) was not included into this study as well the peripheral delimitations under the D.lgs. 2004, n.42

law. Presence of fire event occurred in *Angimbé* Mediterranean shrubs forest (*Calatafimi* locality) is placed with a cyan placeholder. The red limited contour area (a) represents the inner area, A, state property owned, surrounded by a buffer zoning, B1 (blue contour), under the L.R. 78/76, landscape-archaeological value zone, B2 (RGB colours), under the art.142, 136, "*Codice dei Beni Culturali e del Paesaggio*", and a mere landscape value district, C (white-yellow).

Objects	References	Purpose of the investigation
1.a) L.R. 01/08/77; L.R. n. 20/2000, part II; n.10 2000, D.lgs. 6263 11 luglio 2001.	Assessorato Regionale dei Beni Culturali e dell'Identità Siciliana, n.028/GAB 29/08/2018; Codice dei Beni Culturali e del Paesaggio, art. 101.	(1) Heritage documental analysis of the shapefile identification. Lecture of Heritage built environment.
1.b) Digital models, parcel cadastral boundaries	Agenzia delle Entrate, Istituto Superiore per la Protezione e la Ricerca Ambientale.	(2) Delineate Heritage and usage census, Agricultural plowing and pedological needs, geodatabase-based.
2) Sentinel 2-A Multi-spectral tiles products.	Copernicus Programme, Global Monitoring for Environment and Security.	(3) Assessing Burned Area Indexes. Mapping a GIS based layout

Table 1. Strategy for this study.

2. Materials and Methods

2.1. Operational framework

The study did not account field measurements, i.e. a Geometrically structured Composite Burn Index (GeoCBI) including vegetation strata, since the geospatial comparison was aimed at novel heterogeneous Sentinel-based criteria, with initial a separability index (below).

$$M = \frac{|\mu_b - \mu_u|}{\sigma_b + \sigma_u}$$

used to estimate the effectiveness of individual bands and spectral indices discriminate burned and unburned land and Bottom Rayleigh Reflectance (BRR) correction (Santer et al., 2010) through SNAP program. The subsequent protocols are resumed as follows.

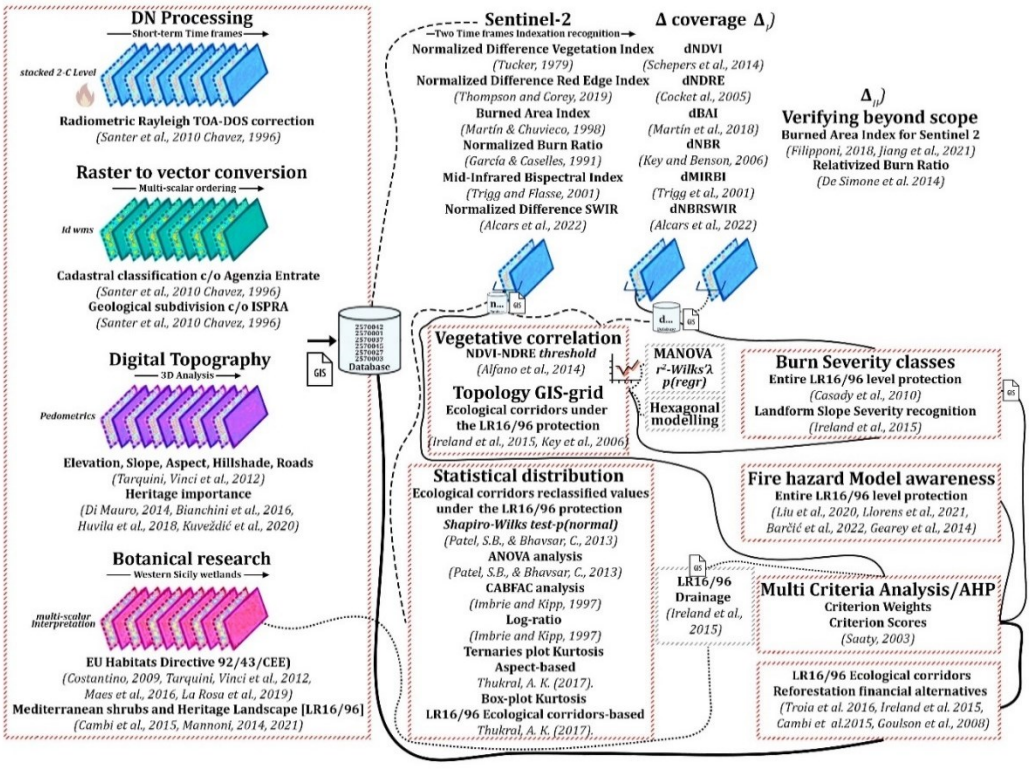


Figure 15. Flowchart of feature selection: database-structured progression and mutual relationships.

2.2. Terrain Analysis of Segestae Archaeological Park

Sensing criteria simultaneously followed altitude and azimuth properties by enhancing a 3D model comprehension of sun's angle of elevation. Study area is characterized by a convenient exposition around the

theatre (a), Greek palace and ruins (b-c) and Temple (e). Steepness accompanies northernmost sides of the hills (d-f). The three methods are followed by multidimensional geospatial projections (Figures 18-19).

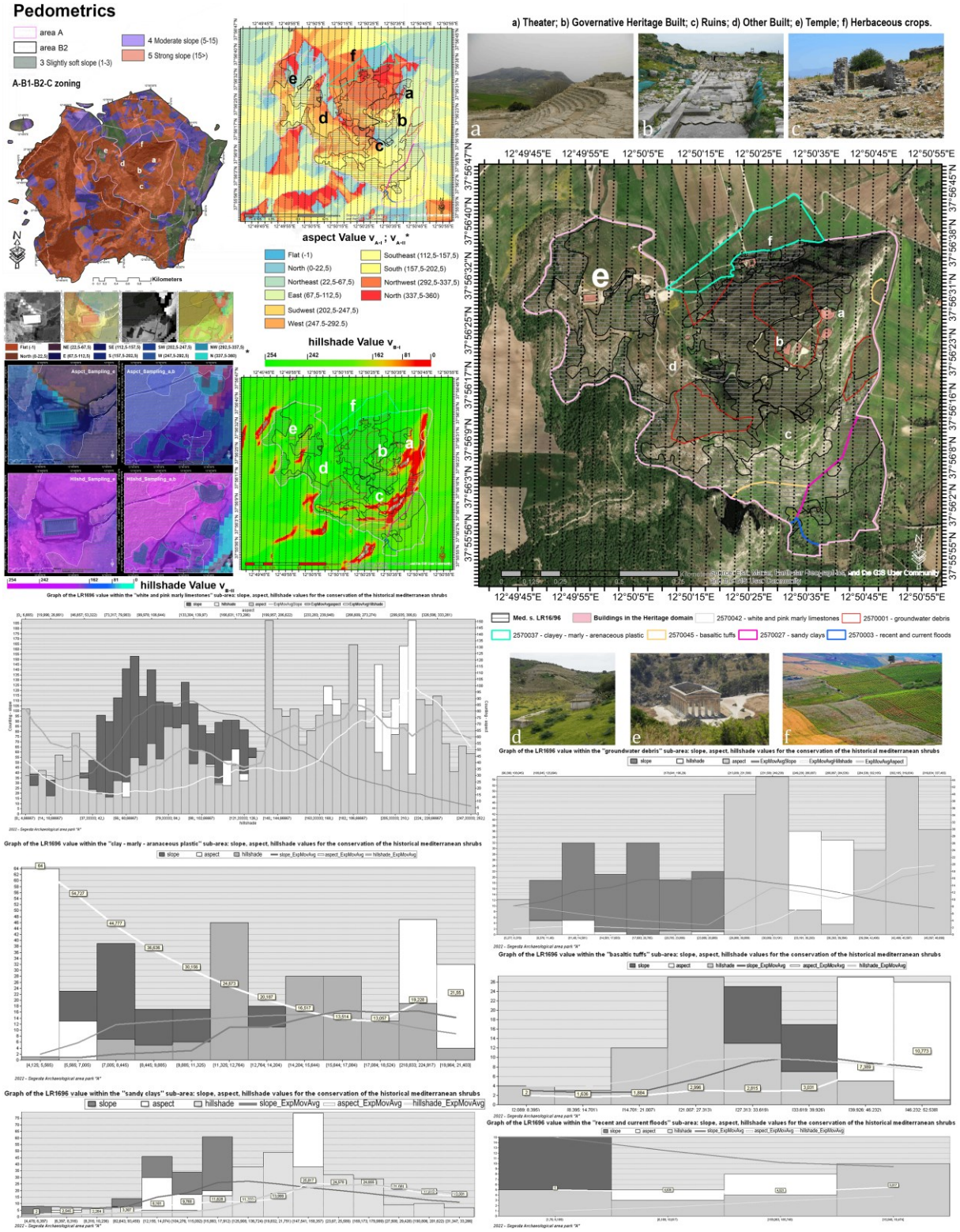


Figure 16. Preliminary Surface detection and comparison, geological based in six groups, fully areally extended.

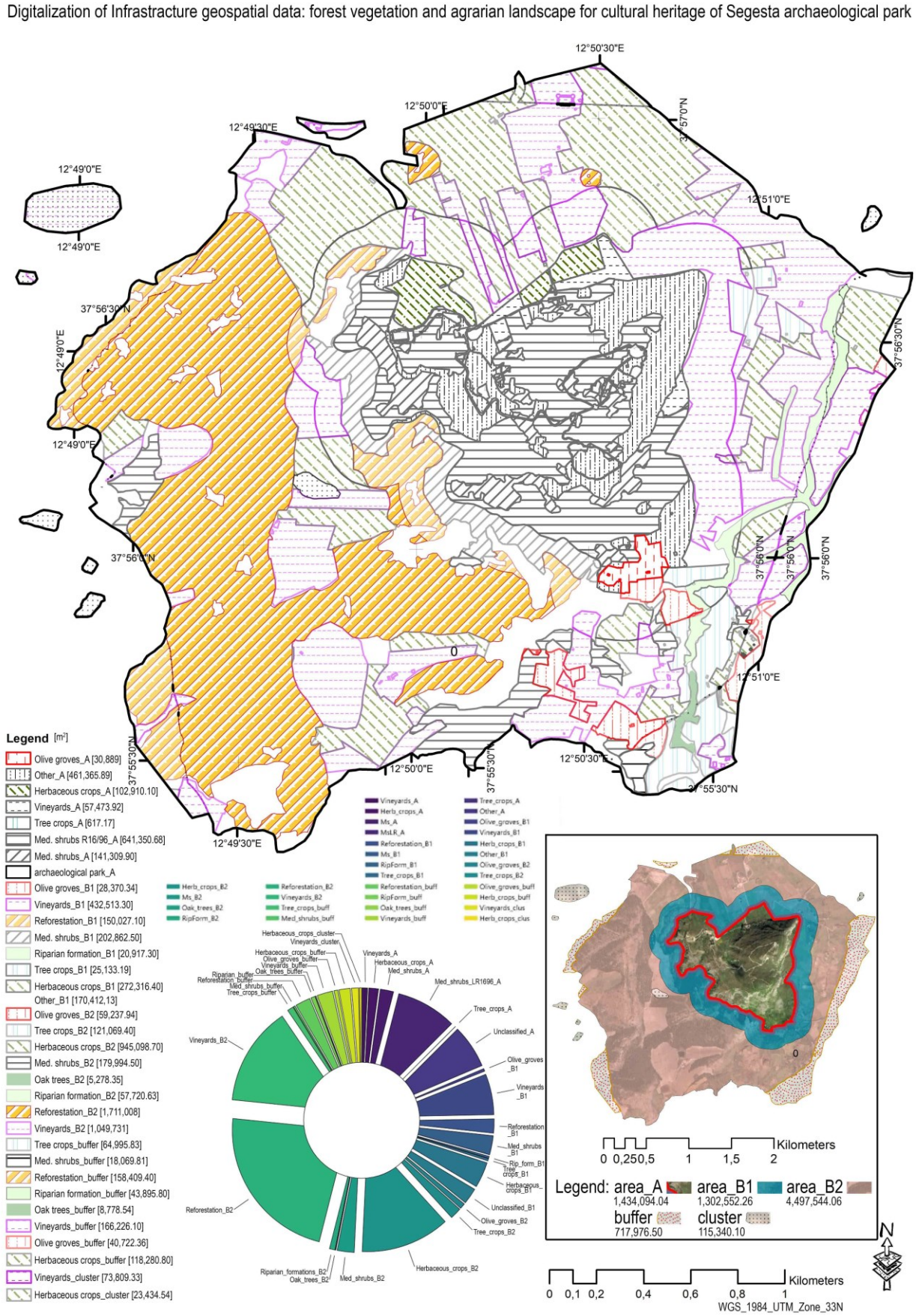


Figure 17. Cadastral-based analysis. Mediterranean shrubs area under the regional protection law amounts to 641,350.68 m² within the "A" inner core, with six different covers surroundings, both agricultural and forestry.

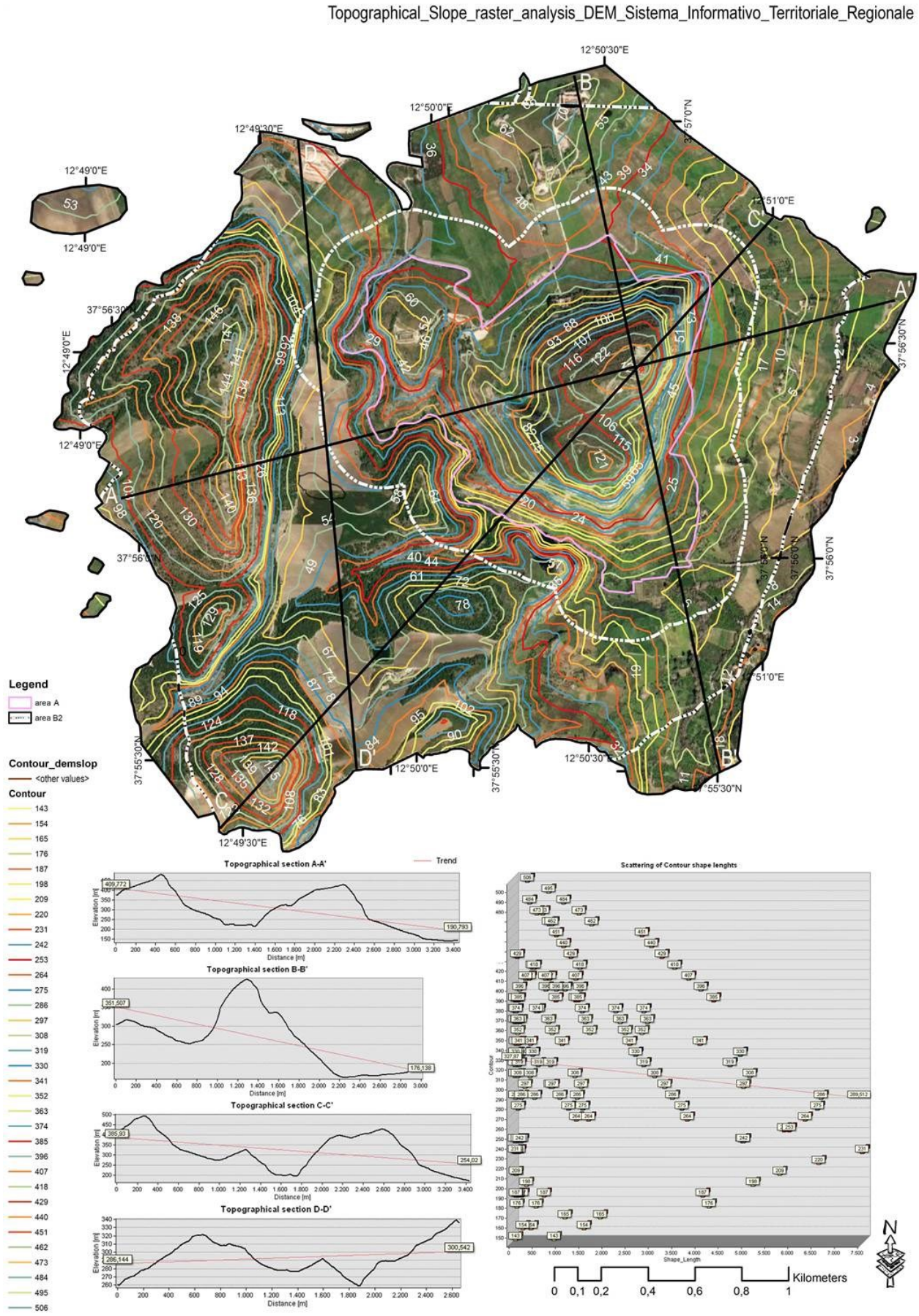


Figure 18. Topographical relationships from slope values. Profiles and altitude plotting [m].

3. Results

3.1. Sentinel 2-A Level analysis

Eleven post-fire burned mapping indices were processed as of two sensing dates from the Sentinel-2 inventory (from C to A product type). According to the following literature on novel mapping combustion for the landscape, I concluded to pass forward by discriminating pre- and post-date multispectral paths, and to enhance the palette of the results by adapting such samplings to the official United States Geological Survey (USGS) indication or maximizing the hypothesis of fire combustion, whereby the loss of chlorophyll was evident.

Band name	Sensor	Band number	Sentinel-2A Level	
			Central wavelength (nm)	Bandwidth (nm)
Coastal aerosol	MSI	1	443.9	20
Blue	MSI	2	496.6	65
Green	MSI	3	560.0	35
Red	MSI	4	664.5	30
Vegetation Red Edge	MSI	5	703.9	15
Vegetation Red Edge	MSI	6	740.2	15
Vegetation Red Edge	MSI	7	782.5	20
NIR	MSI	8	835.1	115
Narrow NIR	MSI	9	864.8	20
Water vapour	MSI	10	945.0	20
SWIR - Cirrus	MSI	11	1373.5	30
SWIR	MSI	12	1613.7	90
SWIR	MSI	13	2202.4	180

Table 2. Wavelength intervals. Source: https://sentinel.esa.int.

Name	Formula	Reference
Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{(NIR - R)}{(NIR + R)}$	Tucker, (1979) Schepers et al., (2014) and Escuin et al., (2008)
Difference normalized vegetation index (dNDVI)	$\Delta NDVI = NDVI_{pre\text{-}fire} - NDVI_{post\text{-}fire}$	
Normalized Difference Red Edge (NDRE) Vegetation red edge (RE)	$NDRE = \frac{NIR - RE}{NIR + RE}$	Thompson & Corey, (2019)
Normalized Burn Ratio (NBR)	$NBR = \frac{(NIR - SWIR)}{(NIR + SWIR)}$	García & Caselles, (1991)
differenced Normalized Burn Ratio (dNBR)	$\Delta NBR = NBR_{pre\text{-}fire} - NBR_{post\text{-}fire}$	Key and Benson, (2006) Murphy, Reynolds & Koltun, (2008)
Burned Area Index (BAI)	$BAI = \frac{1}{(0.1 - R)^2 + (0.06 - NIR)^2}$	Martín & Chuvieco, (1998) et al., (2018)
Burned Area Index (BAI) for Sentinel 2	$BAI2 = 1 - \left(\sqrt{\frac{RE6 * RE7 * REA}{Red}}\right) * \left(\frac{SWIR12 - REA}{\sqrt{SWIR12 + REA}} + 1\right)$	Filipponi, (2018) Jiang et al., (2021)
differenced Mid-Infrared Bispectral Index	$\Delta MIRBI = 10 * SWIR\ 2 - 9.8 * SWIR1 + 2$	Trigg and Flasse, (2001)
Normalized Difference SWIR	$NBRSWIR = (SWIR - SWIR_{Cirrus} - 0.02)/(SWIR - SWIR_{Cirrus} + 0.1)$	Alcars et al., (2022)
differenced Normalized Difference SWIR	$\Delta NBRSWIR = NBRSWIR_{pre\text{-}fire} - NBRSWIR_{post\text{-}fire}$	Liu, Zheng , Dalponte et al., (2020)
Relative differenced Normalized Burn Ratio (RdNBR or RBR)	$RBR = \frac{\Delta NBR}{(NBR_{pre-fire} + 1.001)}$ $R\Delta NBR = \frac{dNBR}{(abs(NBR_{pre-fire}/1000))^{0.5}}$	De Simone et al., (2014) Parks, Dillon, & Miller, (2014)

Table 3. Twelve spectral indices examined.

3.2. Normalized Difference Vegetation Index

Initially the NDVI, regularly calculated to detect high-level reflection of vegetation in the NIR wavelengths, served to comprehend visually and quantitatively important radiation by chlorophyll in the red spectral region.

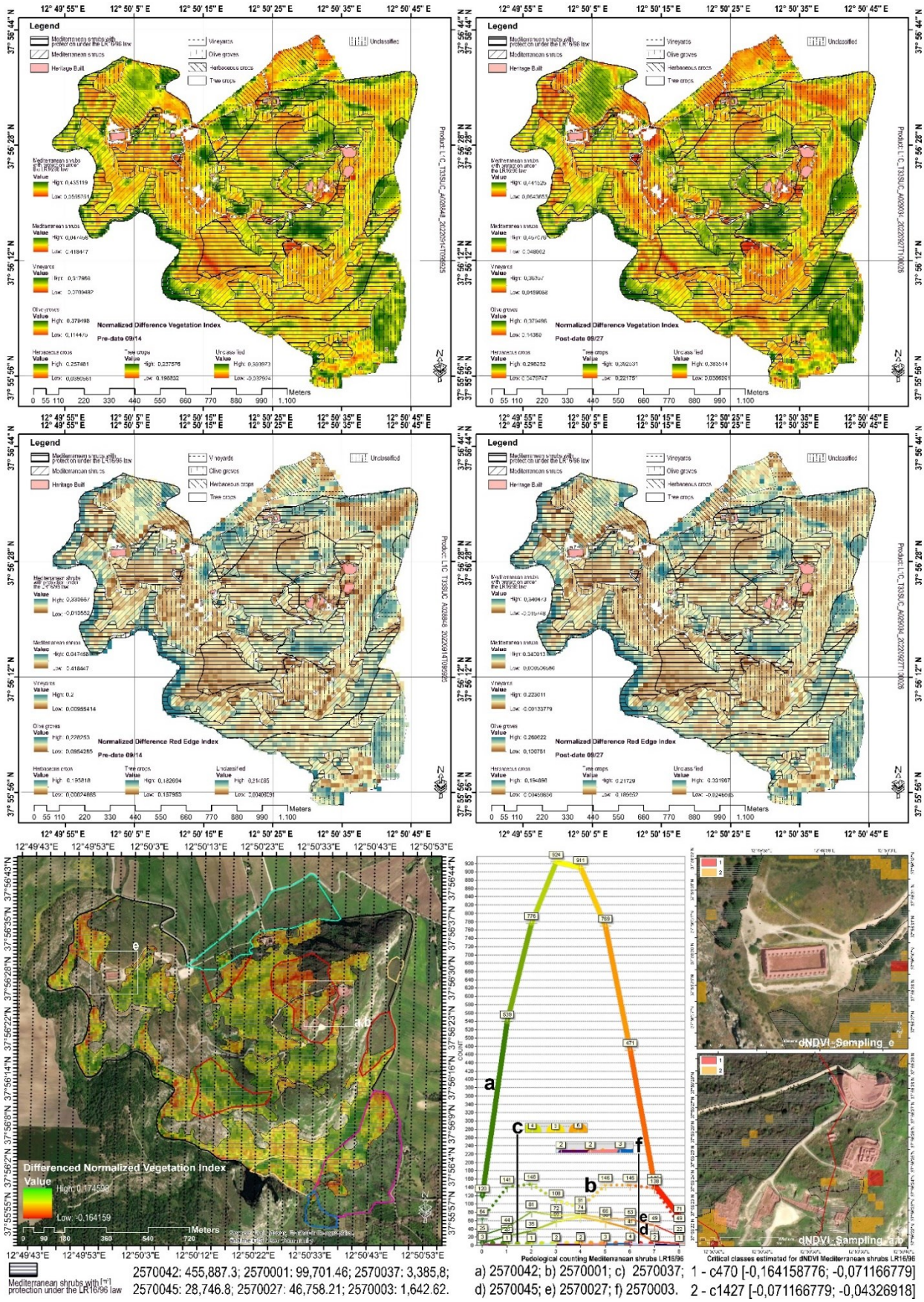


Figure 19. NDVI (a) growth curve and NDRE measurements (b). (a) yellow mainly enhance general endangered values of zoning under the LR16/96 protection. (b): -1 to 0.2 bare soil, 0.2 to 0.6, unhealthy, 0.6 to 1 healthy.

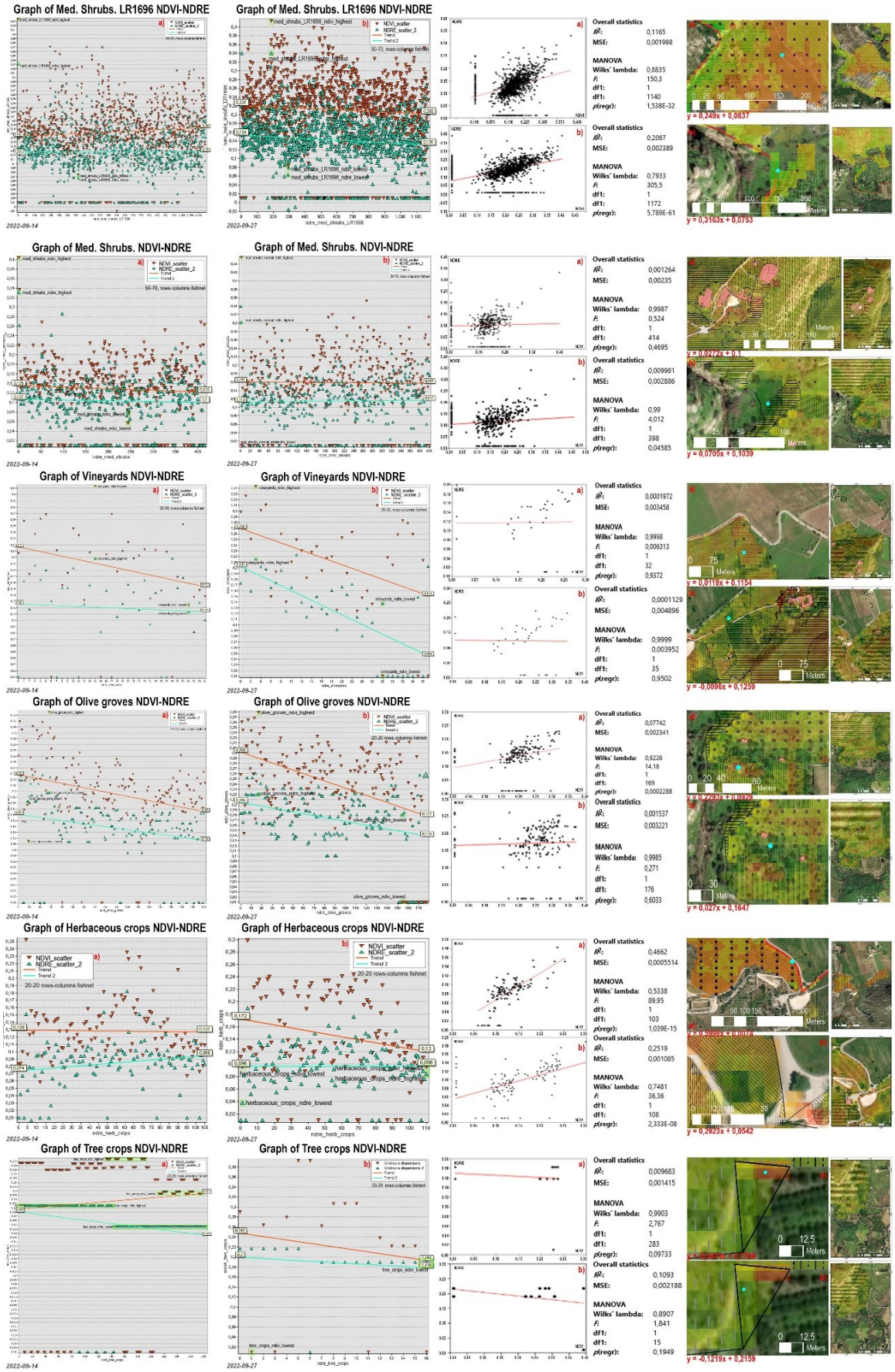
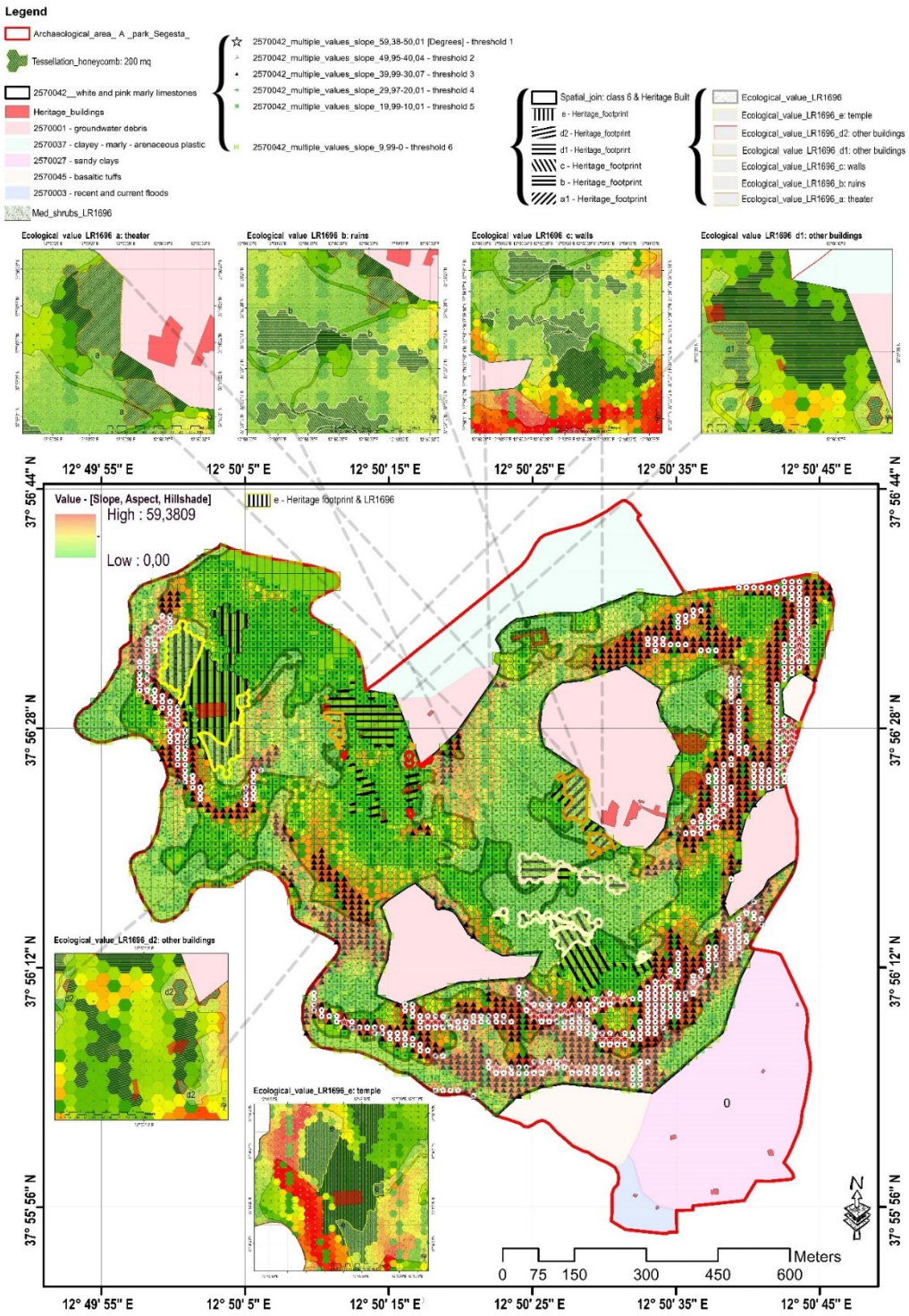


Table 4. NDVI (secondarily map based) -NDRE correlation of six cadastral agricultural types: highest r^2 (0.4662) detected for Herbaceous crops (a) and LR16/96 (0.2067) (b): hereby, NDRE, suitably applied mid-to-

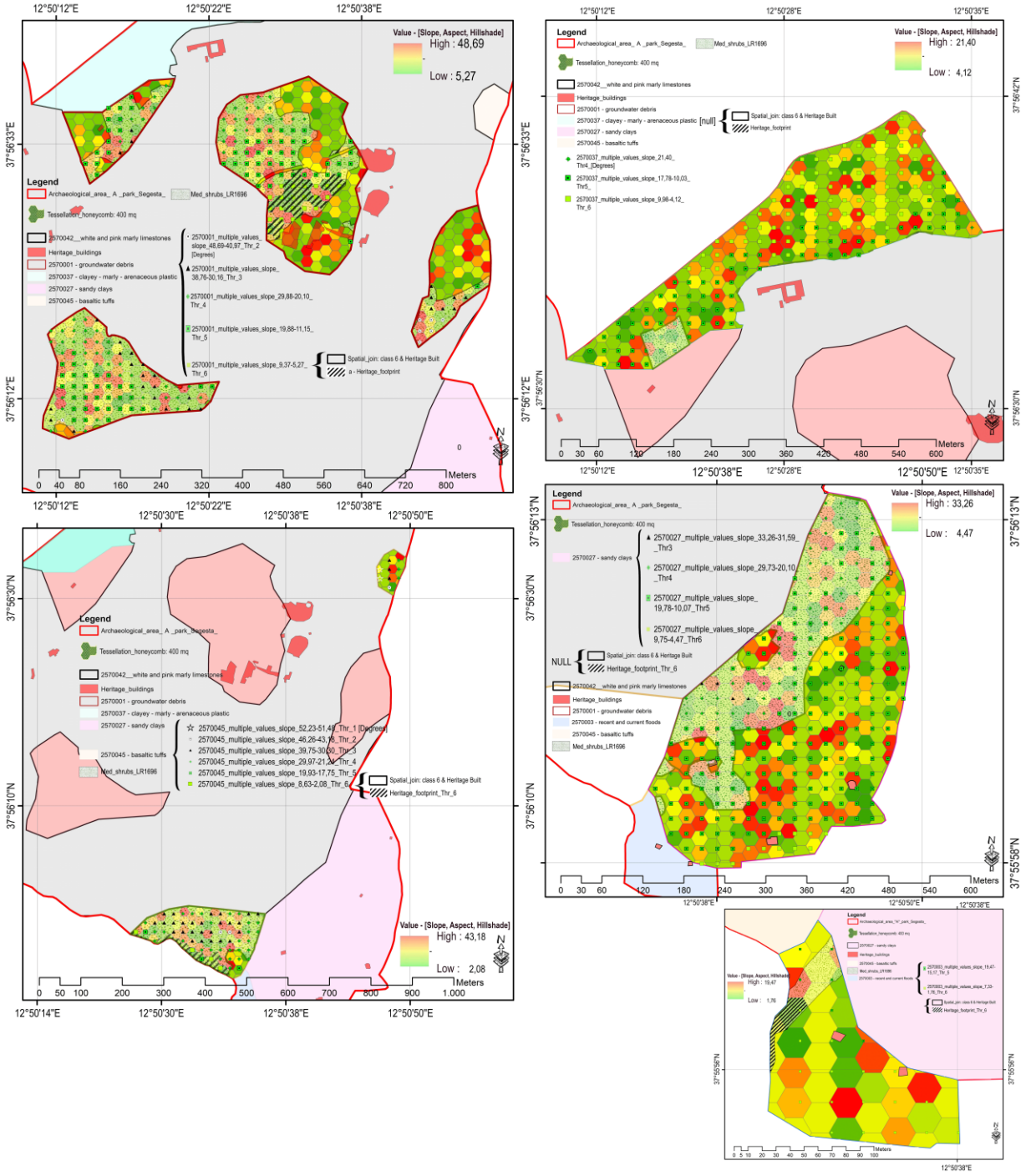
late flourishing season, shows growth inflection between 0.074 and 0.095 (a), 0.154 and 0.131 (b). Wilks lambda between 0.99-0.53.

3.3. Quantitative Terrain Analysis of Segestae Archaeological Park sub-areas

Simultaneously, by enforcing vector geometric entities, each hexagon was computed including Slope, Aspect and Hill shade, in order to ensure consistency and initial feature connectivity allocated in a 200 m^2 based cell grid.



Figures 20 (up) - 21 (below). Six slope thresholds detected precise impervious areas, displacing 0 to 9,99 degrees slope zoning topologically convenient for experimenting the reforestation with regard of biotope ecological corridors: a_1 5,857.33 - a_2 7,364.23 – b 5,711.27 – c 6,919.80 – d_1 1,561.42 – d_2 775.11 – e 13,633 [m^2].



3.4. Burned status and quantitatively profiling arrangement of emerging bareness

The Burn Area Index benefits of pixel values from the red band (Red) and from the near infrared band (NIR) differentiation between two dates is evident furthermore with the result of a differenced index $BAI_{pre\text{-}fire} - BAI_{post\text{-}fire}$ and served to emphasize the carbon residue-based signal here subdivided in three classes for shrubs under the LR16/96 legislation: within the 2570042 sector, positive health status is allocated along the north-west cliff (a-b-c-d-e) in contrast with worst conditions along the eastern-south precipice (f) and below the Greek palace ruins (g). In the sector, five slope levels are quantitatively compared. Most evident sun illumination impact affects the third (29.97-20.01 degrees) and fourth group (19.99-10.01 deg.). Seven proposed corridors are in-depth measured and expose: five scattered peaks (corresponding to the LR16/96 relevance), three (unclassified coverage) and two groups distinguishable arranged under good management (herbaceous and vineyards).

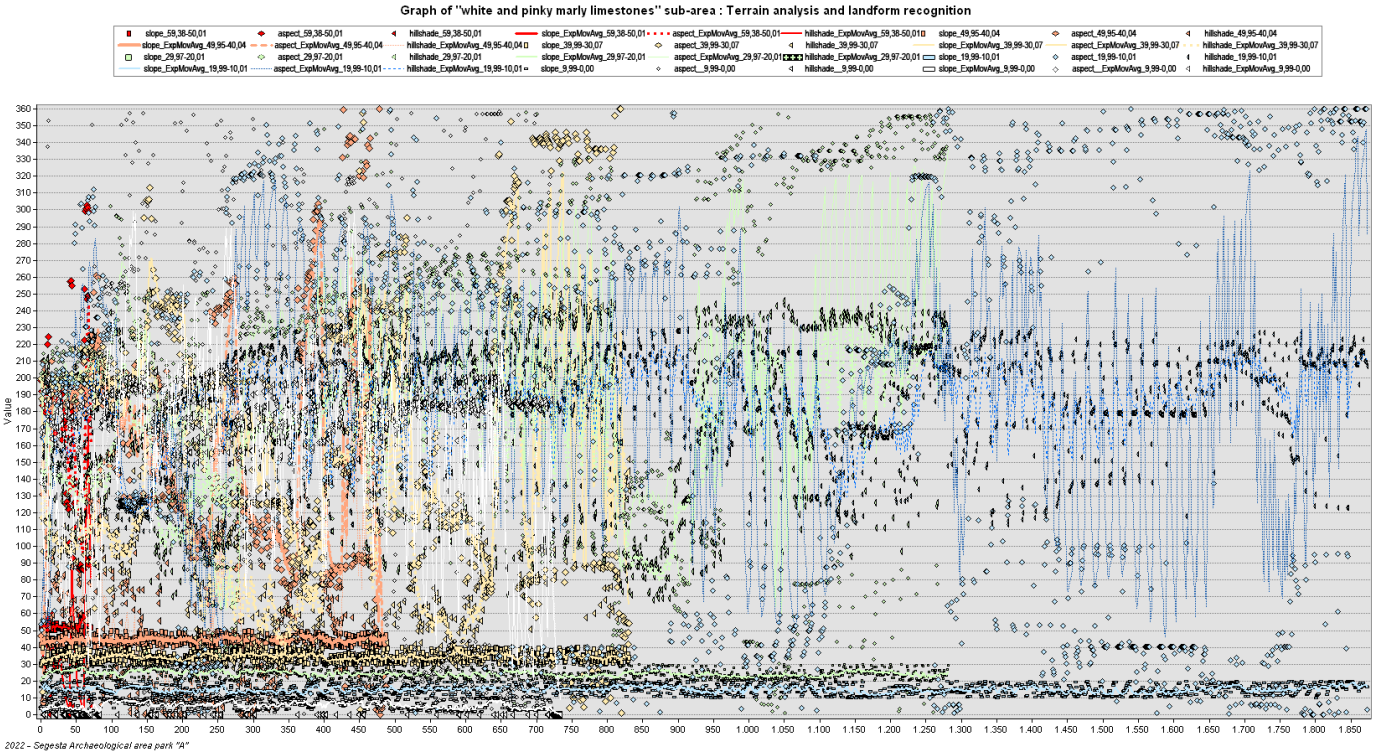


Table 5. 2570042 terrain analysis and landform recognition filtered in five slope groups (Ireland et al., 2015).

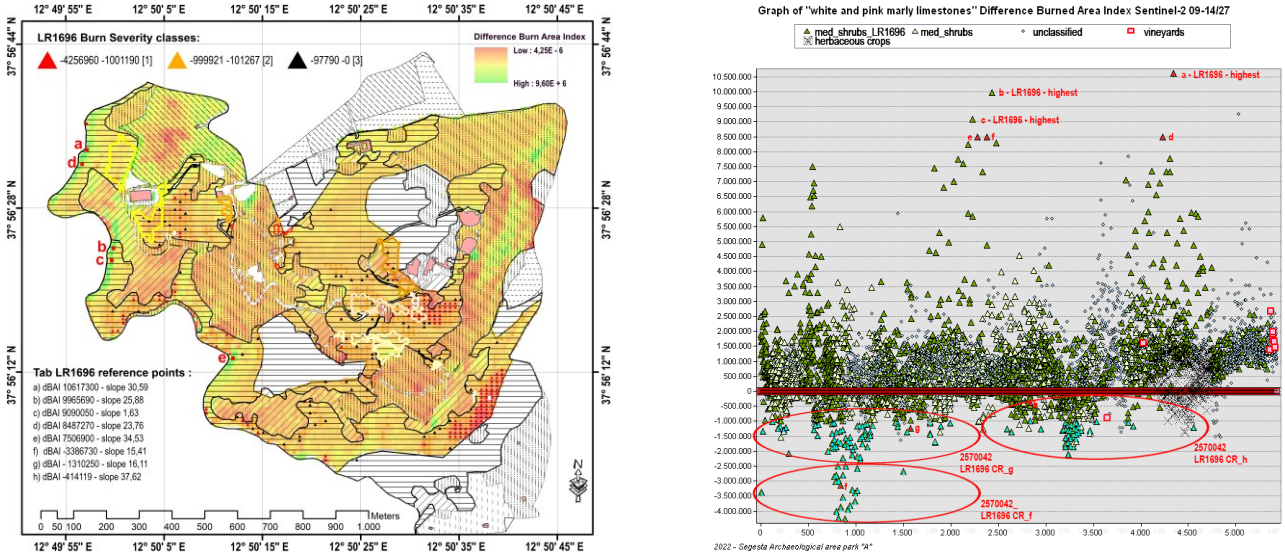
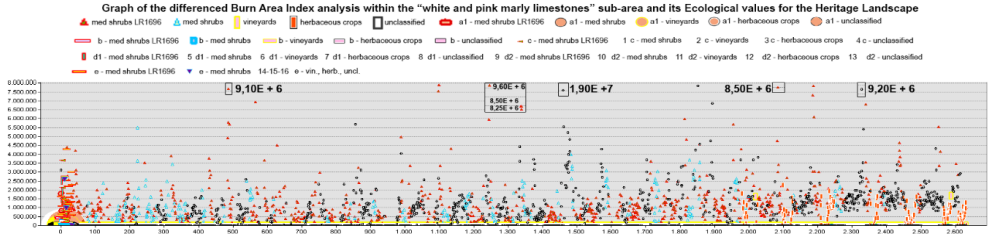
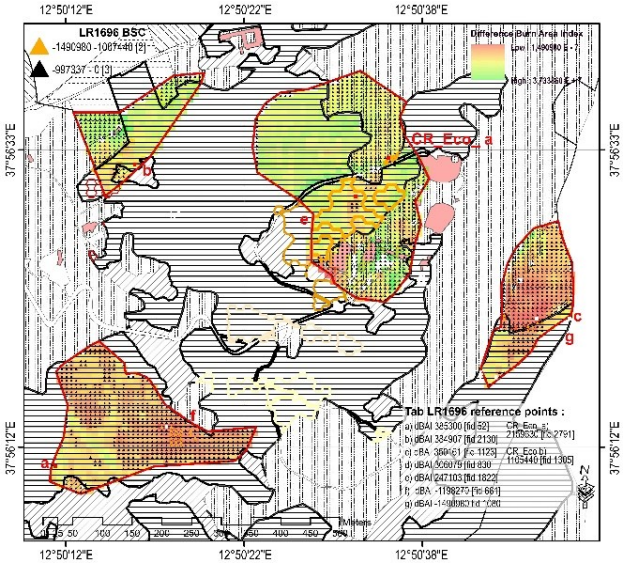


Figure 22. 2570042 dBAI referenced based. **Table 6.** 2570042 plotting five dBAI crops values and sorting three group critical clusters (Casady and Grant, 2010). **Table 7 (below).** Area "A" covers seven ecological corridors, agricultural and forestry projection.





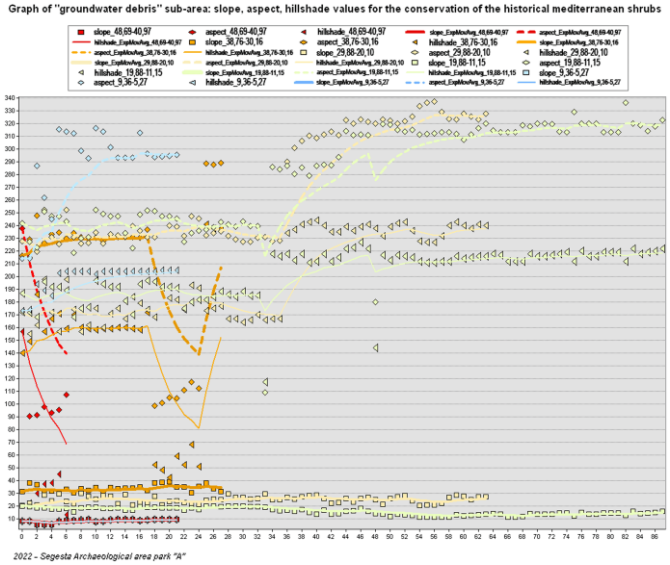
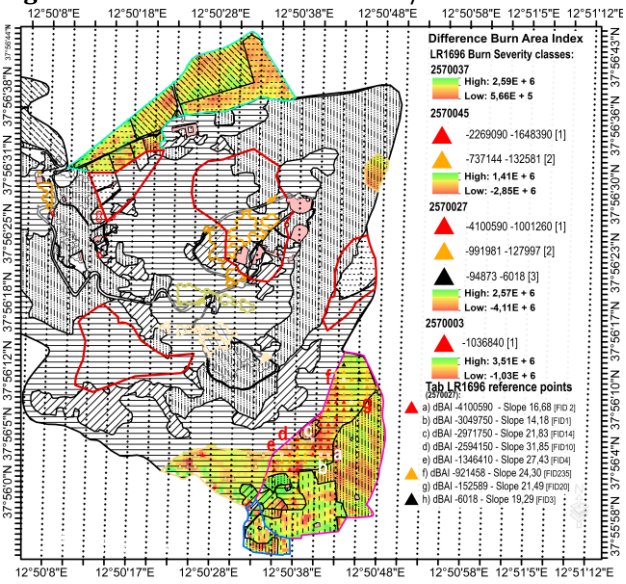


Figure 23. 2570001 dBAI and LR16/96 detection. **Table 8.** 2570001 terrain analysis and landform recognition.



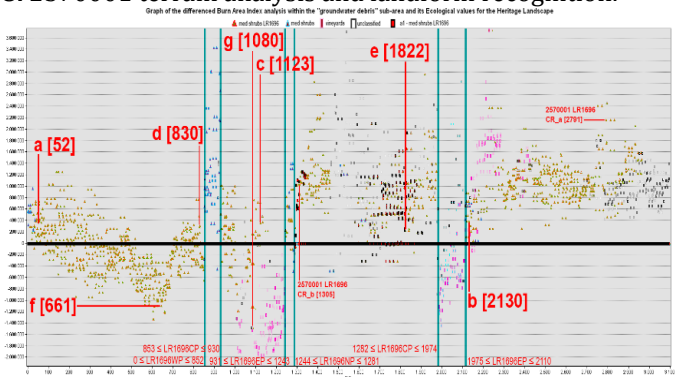
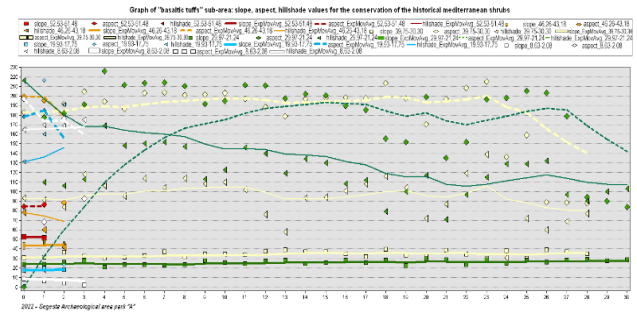
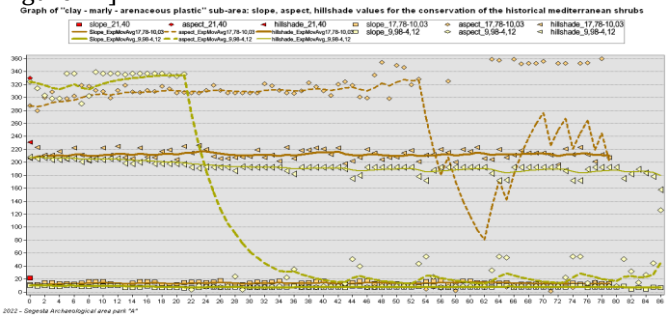
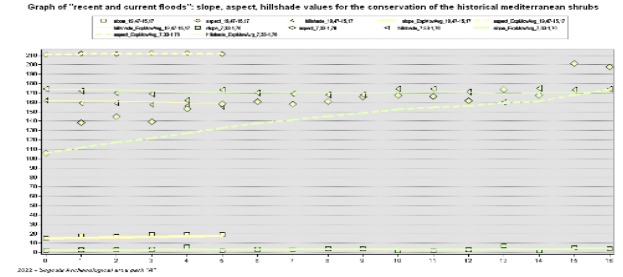


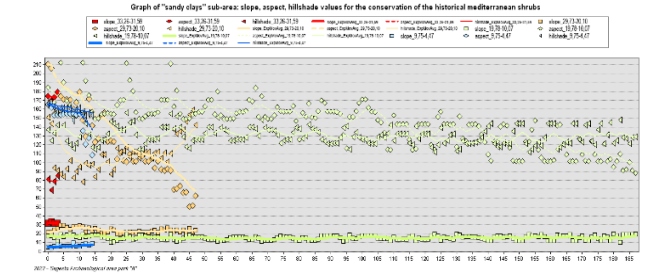
Figure 24. 2570037-27-45-03 dBAI. **Table 9.** 2570001 plotting five dBAI crops values. Attribute stratification with regard of Left Parcellation boundary (LP), Central Parcellation (CP), North Parcellation (NP),West Parcellation (WP) and East Parcellation (EP). Critical burn severity is reported herewith along the : a) b) c) d) e) f) [See Figure 22].





Tables 10-11-12-13. 2570045 **(left)** 37 **(right)** 03 **(below left)** and 27 **(below right)** terrain analysis and landform recognition filtered in slope groups.





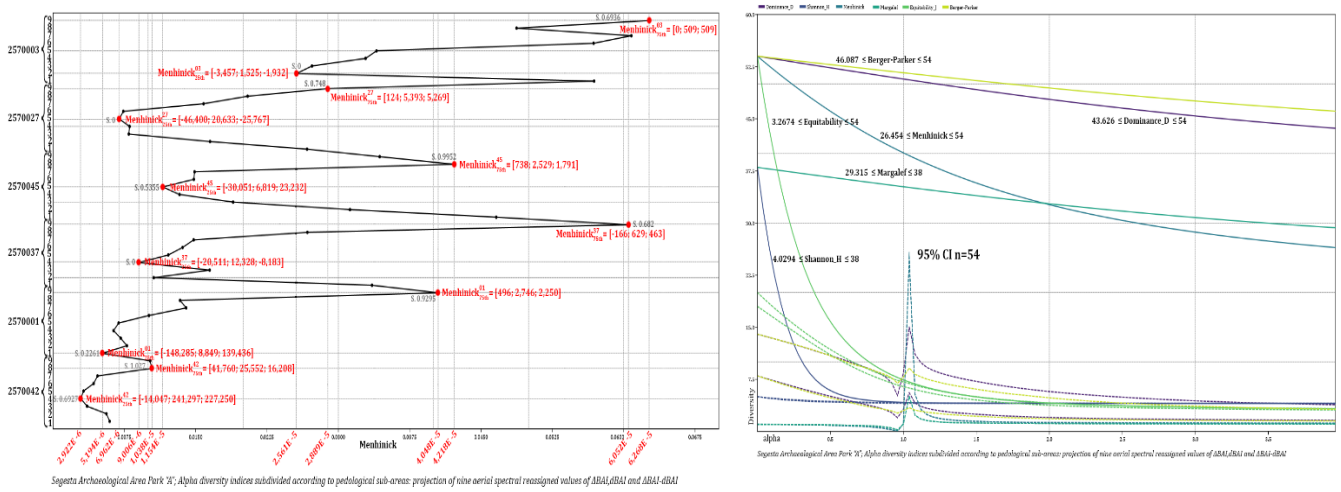
2570042	1	121,964	90,354	1,249	N/A	21,709	N/A	111,679		1	106,906	5,306	17	N/A	3,294	N/A	56,982	-157,467
	2	216,356	183,096	27,889	N/A	45,249	N/A	190,870		2	147,335	8,095	426	N/A	20,387	N/A	35,350	-26,293
	3	203,794	118,090	28,589	N/A	11,106	N/A	161,646		3	182,562	12,770	295	N/A	27,999	N/A	50,051	-45,157
	4	130,250	68,120	13,769	N/A	4,820	N/A	110,942		4	126,065	13,496	145	N/A	8,183	N/A	49,204	-14,047
	5	116,653	78,854	102	N/A	2,407	N/A	107,158		5	130,171	18,818	199	N/A	1,757	N/A	44,317	-13,009
	6	104,718	60,525	12	N/A	2,133	N/A	53,210		6	117,428	26,585	40	N/A	875	N/A	39,675	-47,983
	7	57,747	50,468	70	N/A	967	N/A	40,619		7	92,024	20,512	65	N/A	784	N/A	28,486	-8,000
	8	19,291	15,897	14	N/A	1,132	N/A	16,658		8	60,467	17,218	1	N/A	663	N/A	16,403	41,760
	9	907	579	N/A	N/A	10	N/A	1,677		9	21,105	5,837	6	N/A	478	N/A	5,203	29,456
2570001	1	83,294	N/A	99	N/A	N/A	N/A	79,966		1	10,059	N/A	88	N/A	N/A	N/A	4,927	-148,285
	2	57,485	43,583	42,005	N/A	N/A	N/A	62,625		2	11,123	12	1,018	N/A	N/A	N/A	3,870	-189,675
	3	92,555	62,331	25,341	N/A	N/A	N/A	84,288		3	23,134	1,331	3,641	N/A	N/A	N/A	6,294	-230,115
	4	50,389	5,737	19,655	N/A	N/A	N/A	37,323		4	22,382	461	1,679	N/A	N/A	N/A	2,825	-85,757
	5	44,031	27,474	12,766	N/A	N/A	N/A	39,564		5	24,837	790	1,011	N/A	N/A	N/A	1,957	-95,240
	6	11,527	3,576	2,407	N/A	N/A	N/A	12,189		6	7,182	1,888	5,954	N/A	N/A	N/A	3,595	-11,080
	7	1,361	1,151	N/A	N/A	N/A	N/A	3,090		7	2,803	604	4339	N/A	N/A	N/A	3,844	5,988
	8	N/A	1,387	N/A	N/A	N/A	N/A	1,576		8	16	653	129	N/A	N/A	N/A	652	-1,513
	9	N/A	N/A	N/A	N/A	N/A	N/A	117		9	N/A	170	N/A	N/A	N/A	N/A	443	496
2570037	1	1,249	N/A	2,492	N/A	432	N/A	1,199		1	1,622	N/A	1,039	N/A	1	N/A	65	2,636
	2	76,838	N/A	76,578	N/A	30,623	N/A	76,547		2	55,516	N/A	13,036	N/A	11,491	N/A	1,479	-179,064
	3	10,062	N/A	31,886	N/A	22,782	N/A	15,160		3	34,567	N/A	13,120	N/A	18,011	N/A	1,113	-13,079
	4	8,012	N/A	11,944	N/A	5,468	N/A	7,749		4	2,748	N/A	6,274	N/A	3,448	N/A	192	-20,511
	5	1,537	N/A	4,236	N/A	3,302	N/A	99		5	1,262	N/A	2,633	N/A	2,721	N/A	108	-2,450
	6	239	N/A	1,487	N/A	2,221	N/A	1,027		6	N/A	N/A	904	N/A	1,241	N/A	1	-2,828
	7	N/A	N/A	523	N/A	508	N/A	326		7	N/A	N/A	272	N/A	202	N/A	33	-850
	8	N/A	N/A	12	N/A	N/A	N/A	82		8	N/A	N/A	97	N/A	116	N/A	44	163
	9	N/A	N/A	177	N/A	N/A	N/A	N/A		9	N/A	N/A	11	N/A	N/A	N/A	N/A	-166
2570045	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A		1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	2	198	N/A	N/A	N/A	N/A	N/A	99		2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-297
	3	297	396	N/A	N/A	N/A	N/A	99		3	390	25	N/A	N/A	N/A	N/A	4	-373
	4	2,775	1,271	N/A	N/A	N/A	N/A	11,431		4	621	305	N/A	N/A	N/A	N/A	643	-13,908
	5	14,366	8,694	N/A	N/A	N/A	N/A	12,966		5	3,561	1,479	N/A	N/A	N/A	N/A	935	-30,051
	6	21,824	463	N/A	N/A	N/A	N/A	6,589		6	7,417	226	N/A	N/A	N/A	N/A	2,990	-18,243
	7	13,442	198	N/A	N/A	N/A	N/A	N/A		7	9,197	N/A	N/A	N/A	N/A	N/A	293	-4,150
	8	5,710	99	N/A	N/A	N/A	N/A	N/A		8	6,310	236	N/A	N/A	N/A	N/A	1	738
	9	N/A	N/A	N/A	N/A	N/A	N/A	N/A		9	1,984	145	N/A	N/A	N/A	N/A	N/A	2,129
2570027	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A		1	N/A	N/A	N/A	N/A	N/A	N/A	65	65
	2	1,970	1,484	N/A	4,238	N/A	N/A	2,744		2	99	178	N/A	N/A	N/A	N/A	1,479	-8,680
	3	21,992	1,286	N/A	17,194	N/A	7,345	35,974		3	631	349	N/A	4,602	N/A	N/A	1,113	-77,096
	4	41,644	22,729	N/A	23,555	N/A	847	49,046		4	7,695	1,817	N/A	8,301	N/A	257	192	-119,559
	5	25,860	8,402	N/A	9,281	N/A	198	21,875		5	13,494	931	N/A	4,548	N/A	135	108	-46,400
	6	14,270	612	N/A	N/A	N/A	99	12,866		6	9,023	237	N/A	5,319	N/A	69	1	-13,198
	7	9,500	N/A	N/A	N/A	N/A	N/A	99		7	11,523	5	N/A	1,645	N/A	95	33	3,702
	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A		8	4,465	N/A	N/A	78	N/A	N/A	44	4,587
	9	N/A	N/A	N/A	N/A	N/A	N/A	N/A		9	124	N/A	N/A	N/A	N/A	N/A	N/A	124
2570003	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A		1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	2	1,583	N/A	N/A	1,484	N/A	N/A	1,484		2	965	N/A	N/A	88	N/A	N/A	41	-3,457
	3	1,286	N/A	N/A	2,383	N/A	N/A	2,109		3	121	N/A	N/A	1,062	N/A	N/A	348	-4,247
	4	297	N/A	N/A	23,898	N/A	N/A	3,237		4	114	N/A	N/A	1,199	N/A	N/A	2,361	-23,758
	5	1,187	N/A	N/A	2,217	N/A	N/A	1,611		5	8	N/A	N/A	1,641	N/A	N/A	620	2,269
	6	99	N/A	N/A	791	N/A	N/A	297		6	7	N/A	N/A	1,842	N/A	N/A	89	751
	7	N/A	N/A	N/A	N/A	N/A	N/A	N/A		7	N/A	N/A	N/A	127	N/A	N/A	N/A	127
	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A		8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	9	N/A	N/A	N/A	N/A	N/A	N/A	N/A		9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2570042	1	4,402	2,908	137	N/A	4,120	N/A	16,606	-129,294
	2	24,646	12,510	64	N/A	8,065	N/A	55,096	26,293
	3	64,045	24,069	263	N/A	9,341	N/A	80,271	132,832
	4	111,938	25,164	370	N/A	8,368	N/A	95,457	227,250
	5	115,565	25,772	292	N/A	9,207	N/A	50,240	188,067
	6	85,296	17,713	301	N/A	8,993	N/A	21,330	85,650
	7	27,330	12,563	461	N/A	8,288	N/A	8,579	125,633
	8	11,576	4,821	197	N/A	6,594	N/A	2,364	16,208
	9	5,791	1,089	133	N/A	1,569	N/A	298	-20,576
2570001	1	5,226	659	2,267	N/A	N/A	N/A	697	139,436
	2	11,854	594	2,684	N/A	N/A	N/A	1,423	-173,120
	3	14,103	632	2,191	N/A	N/A	N/A	2,826	-210,363
	4	14,424	892	2,370	N/A	N/A	N/A	6,975	-61,096
	5	12,371	492	1,748	N/A	N/A	N/A	6,384	-74,245
	6	18,052	1,287	1,139	N/A	N/A	N/A	4,724	14,122
	7	17,585	1,026	1,503	N/A	N/A	N/A	2,852	16,978
	8	5,278	721	3,384	N/A	N/A	N/A	2,578	10,448
	9	1,297	396	557	N/A	N/A	N/A	496	2,250
2570037	1	197	N/A	1,569	N/A	2,142	N/A	266	1,538
	2	492	N/A	5,448	N/A	2,771	N/A	198	-170,155
	3	591	N/A	6,720	N/A	6,044	N/A	560	836
	4	591	N/A	5,605	N/A	5,535	N/A	597	-8,183
	5	394	N/A	7,345	N/A	6,542	N/A	560	12,391
	6	686	N/A	5,303	N/A	6,094	N/A	99	9,354
	7	520	N/A	3,754	N/A	4,494	N/A	800	8,718
	8	366	N/A	1,572	N/A	3,851	N/A	502	6,128
	9	98	N/A	98	N/A	365	N/A	68	463
2570045	1	591	N/A	N/A	N/A	N/A	N/A	330	921
	2	1,379	233	N/A	N/A	N/A	N/A	588	1,903
	3	4,692	195	N/A	N/A	N/A	N/A	882	5,396
	4	4,315	195	N/A	N/A	N/A	N/A	1,141	-8,257
	5	6,054	390	N/A	N/A	N/A	N/A	375	23,232
	6	6,363	292	N/A	N/A	N/A	N/A	835	10,753
	7	3,761	195	N/A	N/A	N/A	N/A	557	-363
	8	1,638	390	N/A	N/A	N/A	N/A	501	1,791
	9	866	195	N/A	N/A	N/A	N/A	201	-867
2570027	1	2,828	313	N/A	1,122	N/A	93	1,952	6,243
	2	4,134	567	N/A	2,525	N/A	93	4,353	2,992
	3	4,734	344	N/A	3,086	N/A	224	7,363	-61,345
	4	4,562	472	N/A	3,648	N/A	60	6,668	-104,149
	5	9,198	189	N/A	3,554	N/A	N/A	7,692	-25,767
	6	7,246	438	N/A	4,115	N/A	N/A	6,502	-5,103
	7	7,927	567	N/A	3,273	N/A	N/A	6,195	14,260
	8	3,061	567	N/A	1,752	N/A	N/A	5,367	6,160
	9	1,537	94	N/A	1,590	N/A	N/A	2,172	5,269

2570003	N/A	N/A	N/A	200	N/A	N/A	418	618
	104	N/A	N/A	899	N/A	N/A	522	-1,932
	341	N/A	N/A	799	N/A	N/A	209	-2,898
	208	N/A	N/A	300	N/A	N/A	418	-22,832
	N/A	N/A	N/A	699	N/A	N/A	489	-1,081
	N/A	N/A	N/A	799	N/A	N/A	594	642
	N/A	N/A	N/A	799	N/A	N/A	418	1090
	N/A	N/A	N/A	499	N/A	N/A	343	842
	N/A	N/A	N/A	300	N/A	N/A	209	509

42BAI_0914_MMed

Tab. 14. BAI surface coverage: a = Med. Shrubs LR1696; b = Med. Shrubs; c = Vineyards; d = Olive groves; e = Herbaceous crops; f = Tree crops [integer values]. Delta in absolute terms (Chao et al., 2016, Thukral, 2017).



Segesta Archaeological Area Park "A", Alpha diversity indices subdivided according to pedological sub-areas: projection of nine aerial spectral reassigned values of ΔBAI,dBAI and ΔBAI-dBAI

Tab. 15. Menhimick ΔBAI, dBAI, ΔBAI-dBAI margin: $value^{pedological\ id}_{percentile}$. **Tab.16.** Alpha diversity: Dominance Shannon, Men., Margalef, Equitability, Parker.

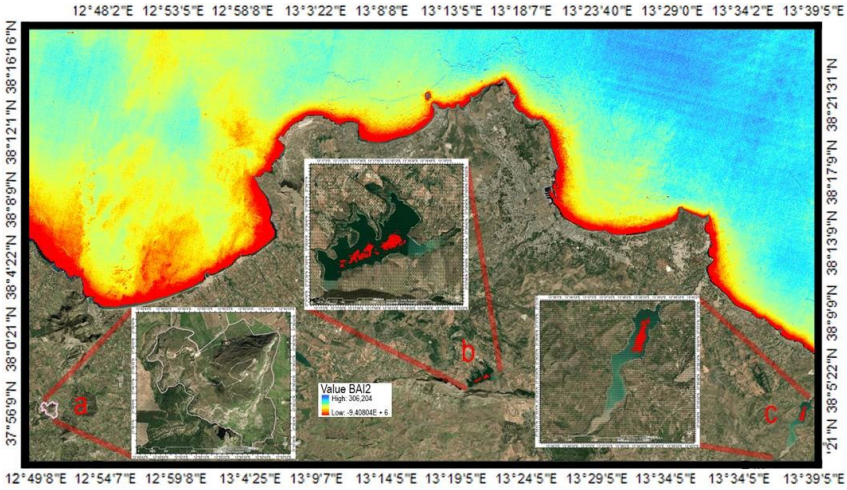


Figure 25. Surface water body extraction: **a)** area "A", **b)** Piana degli Albenesi lake, **c)** Rosamarina lake.

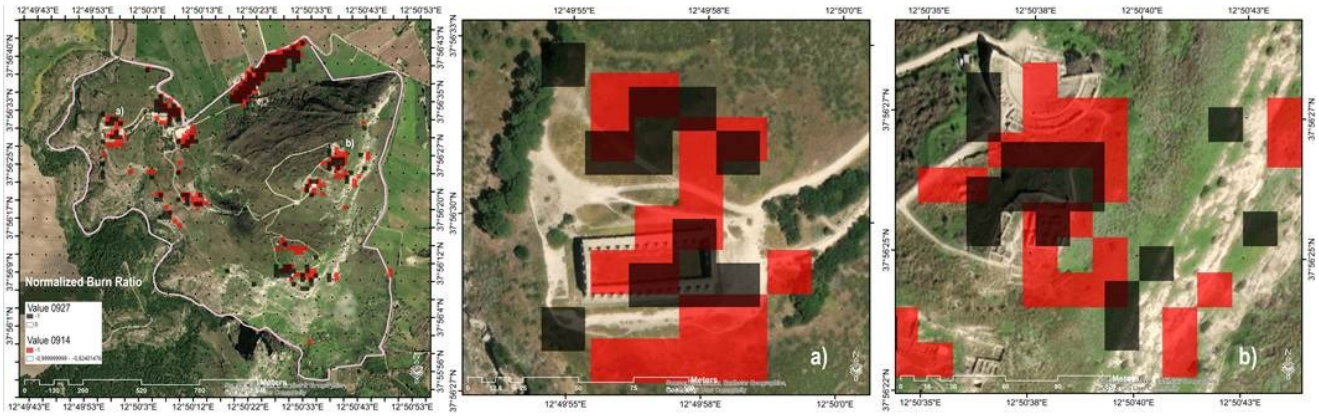


Figure 26. Normalized Burn Ratio. Detection of critical burnt areas of Mediterranean shrubs under the LR16/96 law: **a)** N 37°56′28′′ E 12°49′53′′ (Temple), **b)** N 37°56′25′′ E 12°50′40′′ (Theatre), N 37°56′33′′ E 12°50′3′′ (Terminal arrival), N 37°56′41′′ E 12°50′23′ (Herbaceous Crops), N 37°56′17′′ E 12°50′5′ (dipping), N 37°56′9′′ E 12°50′33′ (southern peak) and N 37°56′9′′ E 12°50′33′ (unclassified burned scar area).

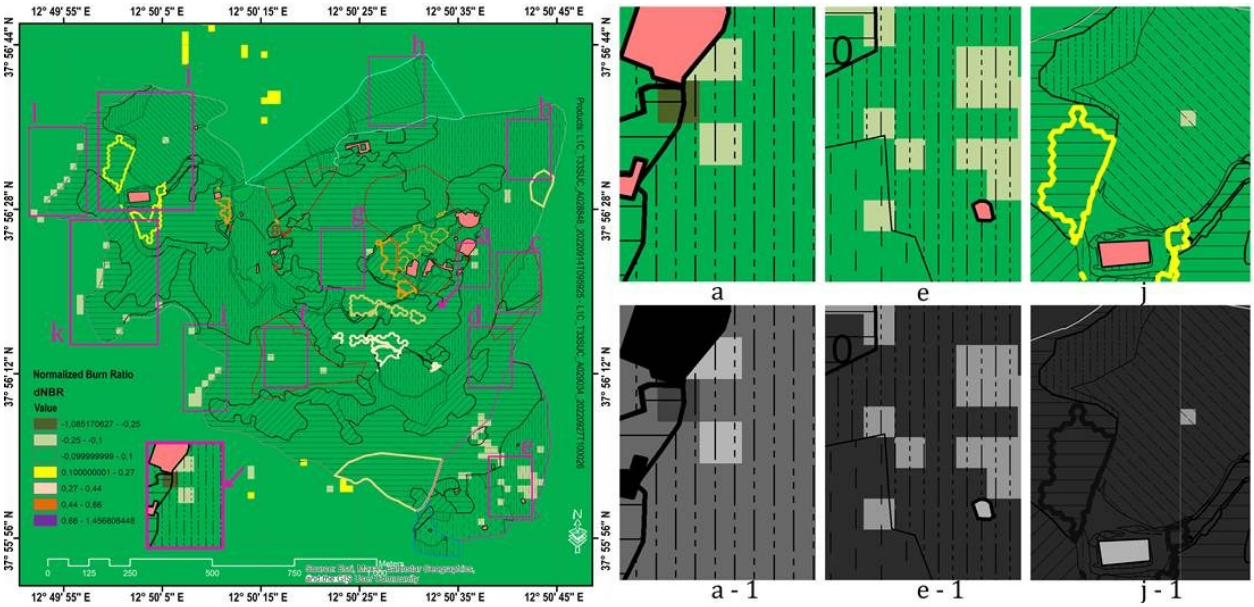


Figure 27. Burn Severity levels encouraged by USGS. Gray scale values highlight darker pixels and indicate burned areas: a-1) high post-fire regrowth under the Greek theatre, e-1) unclassified/generic cover crop, e) Greek Temple.

Range	*Burn severity*
< – 0.25	High post-fire regrowth
– 0.25 to – 0.1	Low post-fire regrowth
– 0.1 to + 0.1	Unburned
0.1 to 0.27	Low-severity
0.27 to 0.44	Moderate-low severity
0.44 to 0.66	Moderate-high severity
>0.66	High-severity

Table 17. Severity category definitions (©USGS).

Severity Level	*ΔNBR Range**	*ΔNBR Range (not scaled)*
Enhanced Regrowth, high (post fire)	-500 to -251	-500 to -0.251
Enhanced Regrowth, low (post-fire)	-250 to -101	-0.250 to -0.101
Unburned	-100 to +99	-0.100 to +0.99
Low Severity	+100 to +269	+0.100 to +0.269
Moderate-low Severity	+270 to +439	+0.270 to +0.439
Moderate-high Severity	+440 to +659	+0.440 to +0.659
High Severity	+660 to +1300	+0.660 to +1.300

Table 18. Burn severity levels obtained calculating ΔNBR, proposed by USGS. ΔNBR Range* is scaled by 103.

This index has reached popularity in the professional field of geosciences and environment by promoting recognizable levels of severity. The complexity of its formula is analogue to NDVI, except of the fact that it also includes near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths (Rivera et al. 2022).

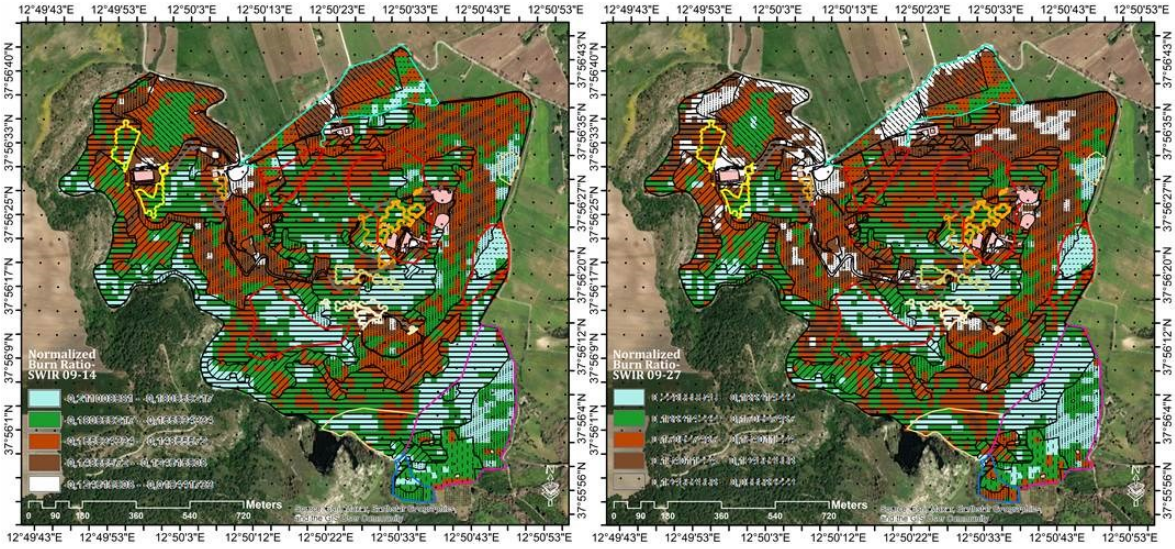


Figure 28. Normalized Burn Ratio SWIR, pre and post short term date.

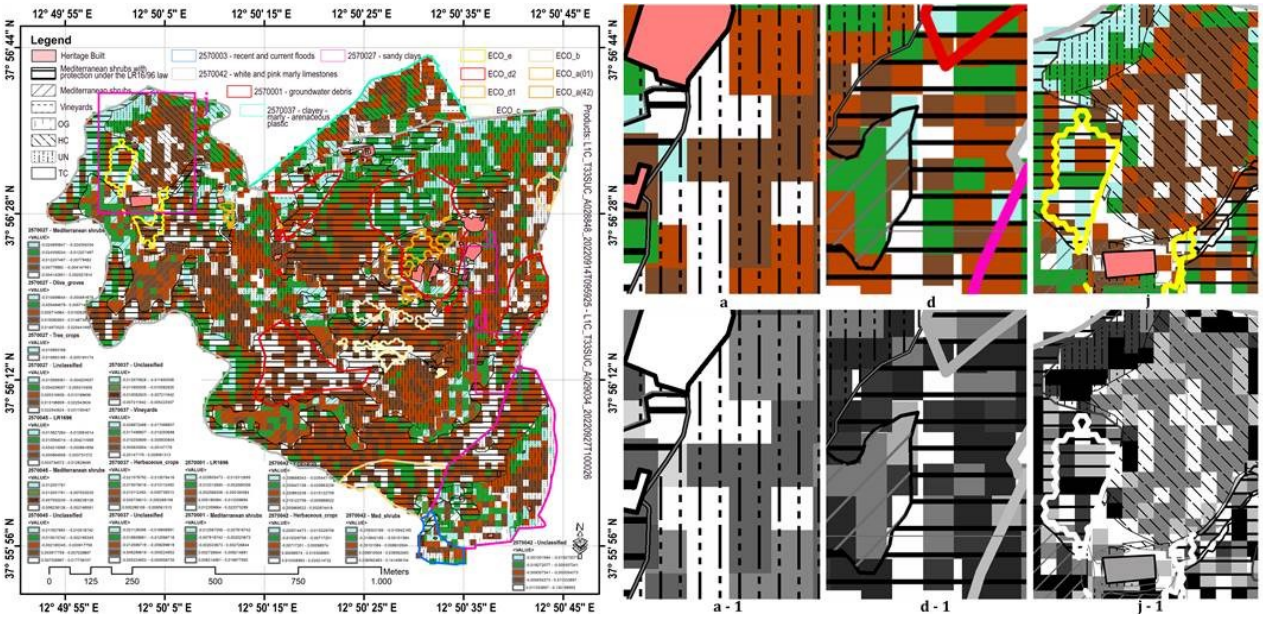
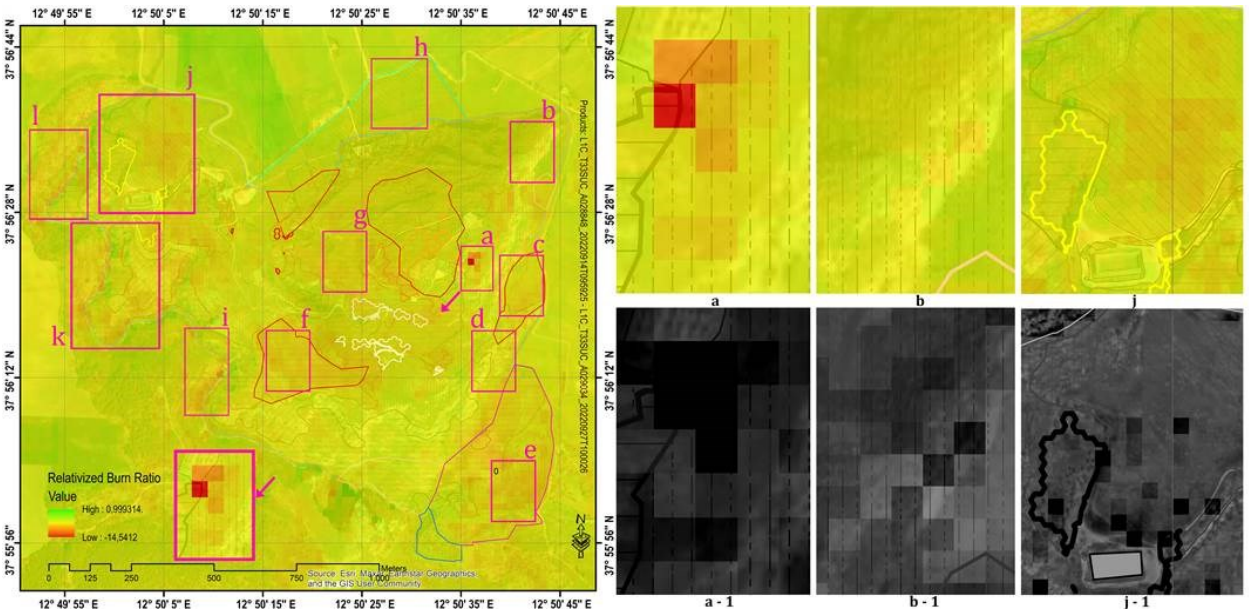
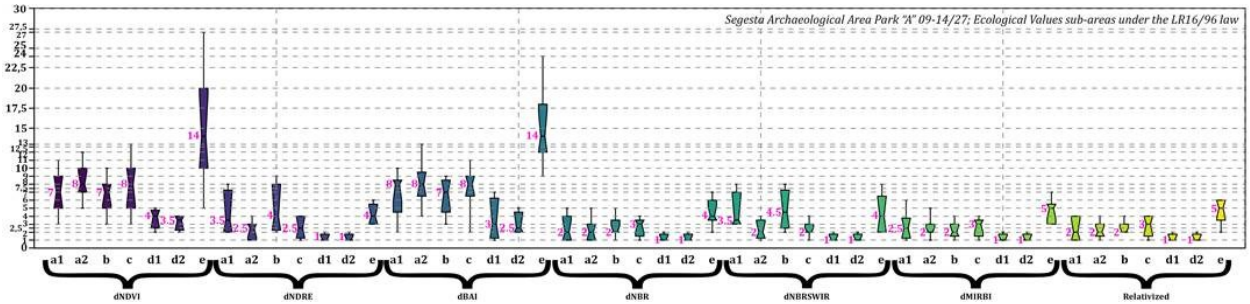
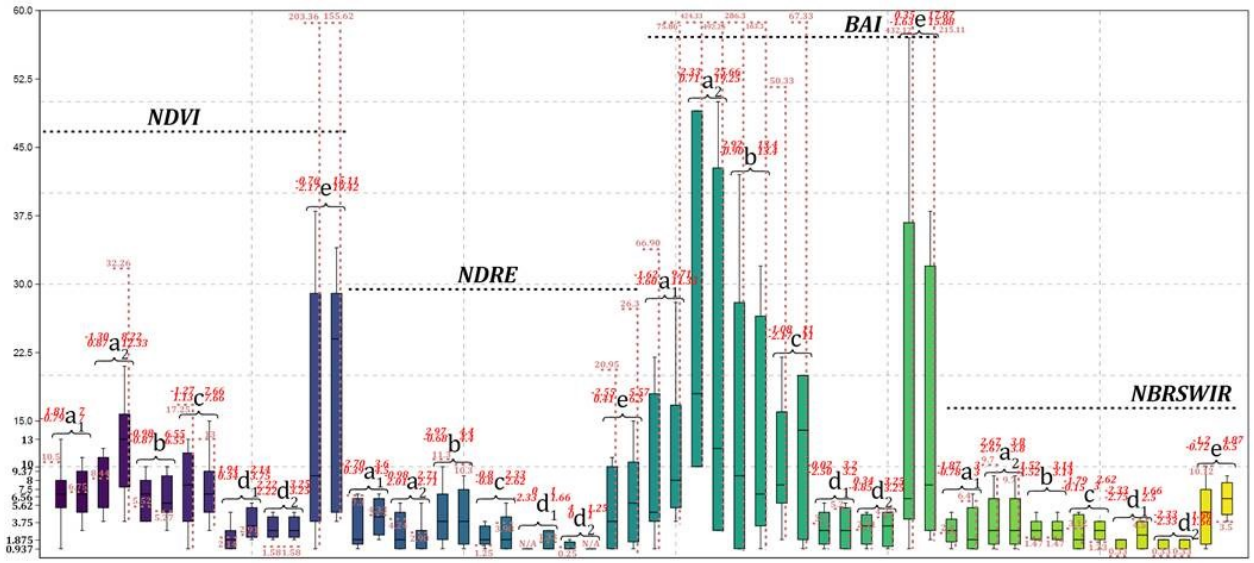


Figure 29. Δ Normalized Burn Ratio SWIR. Gray scale values highlight darker pixels and indicate burned areas (white). **Figure 30 (below).** Relativized Burn Ratio (RBR) otherwise known as the dNBR, divided by an adjustment applied to the pre-fire NBR. Its denominator sees the adding of value 1.001 (to guarantee that the denominator won't be zero, far from reaching infinity and failing (Parks, Dillon & Miller, 2014). For this application to the case study, only lowest values close to -14.54 were accounted to introduce specifically just most critical burnt areas or object of critical health.



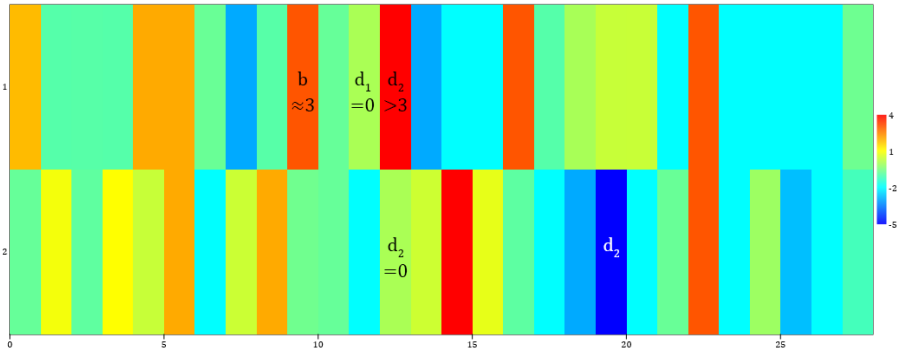


Tab. 19. Differenced indexations of this study.



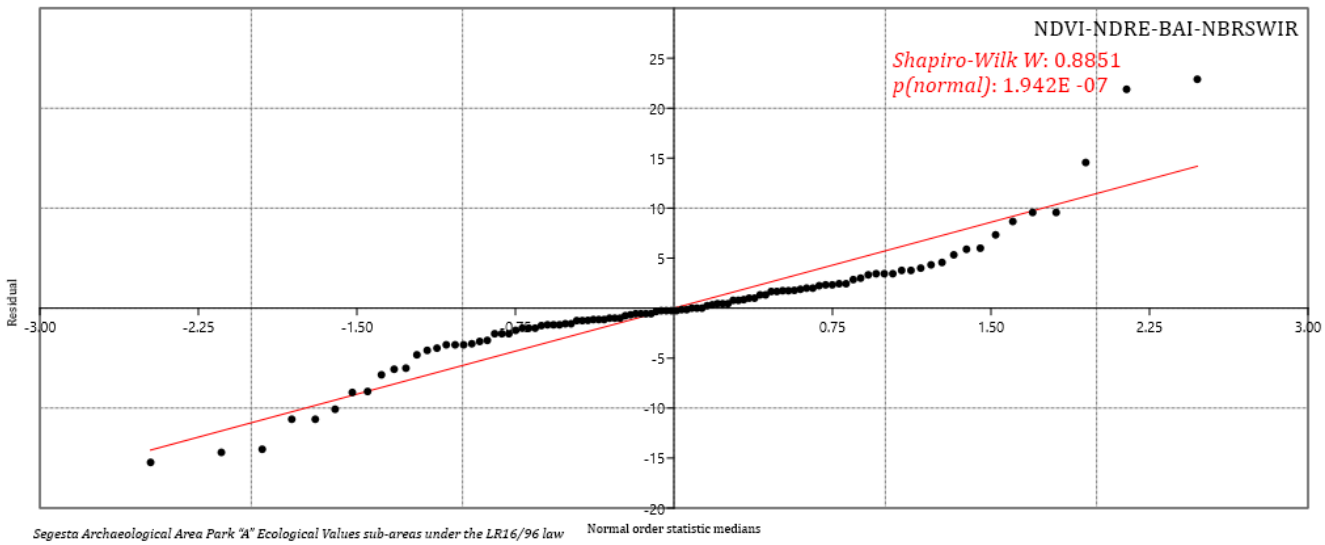
Segesta Archaeological Area Park "A" 09-14/27; Ecological Values sub-areas under the LR16/96 law

Tab. 20. Indexations whereby $\frac{kurtosis_1}{kurtosis_2} n \frac{median_1}{median_2}$.



Kurtosis values of Ecological subareas of Segesta Archaeological area park "A" 09-14/27 under the LR16/96 law: NDRI-NDRE-BAI-NBRSWIR

Tab. 21. Distribution kurtosis 14th (1) 27 th (2)- Platykurtic peak (d_2-NDRE), mesokurtic (b-NDRE), leptokurtic (d_2-BAI).



Segesta Archaeological Area Park "A" Ecological Values sub-areas under the LR16/96 law

Figure 31. Shapiro-Wilks test for normality of four indexation datasets.

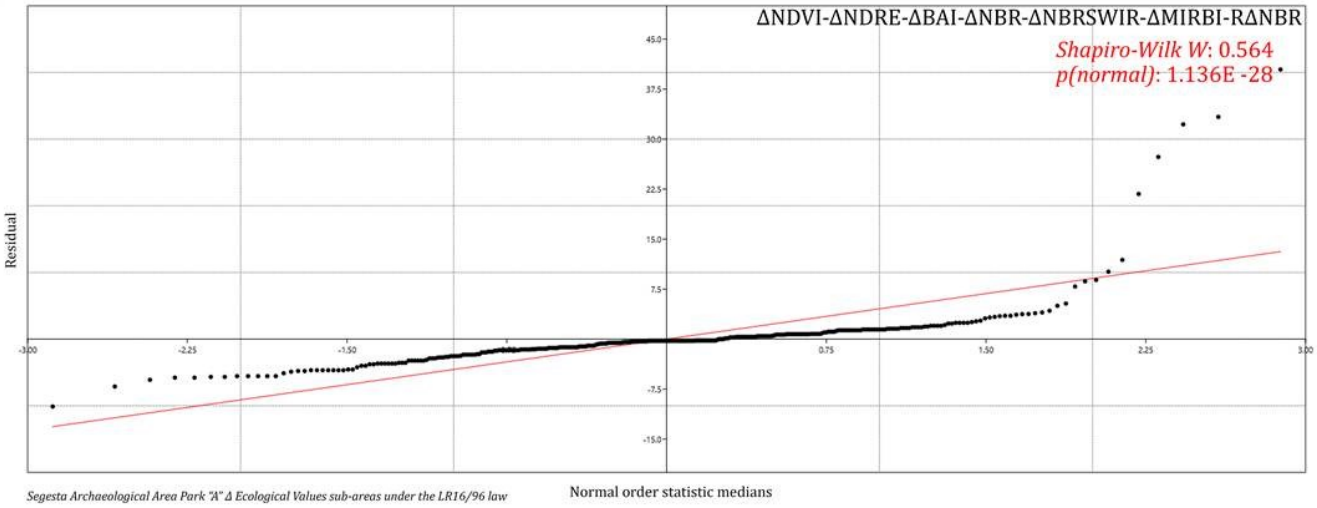


Figure 32. Shapiro-Wilks test for normality of seven differenced indexation datasets.

Indexing	*Sequence*		*Sum of squares*	*df*	*Mean square*	*F*	*p (same)*	*Permutation p*
NDVI-NDRE-BAI-NBRSWIR	All values	Btw groups	2,2026.46	13	155.881	4.268	1.583E -05	0.00024
		Within groups	3,287.04	90	36.52			
		Total	5,313.5	103	N/A			
ΔNDVI-ΔNDRE-ΔBAI-ΔNBR-ΔNBRSWIR-ΔMIRBI-RΔNBR	All values	Btw groups	3,564.69	48	74.2643	3.123	1.449E - 09	5E -05
		Within groups	7,181.92	302	23.7812			
		Total	10,746.6	350	N/A			

Tab. 22. One Way ANOVA (analysis of variance). $\boldsymbol{SSn} = \sum_{i=1}^{m} \boldsymbol{exp2}(\boldsymbol{y_i} - \boldsymbol{\bar{y}_n})$. Weighted Average: $\boldsymbol{E}(\boldsymbol{x_n}) = \frac{\sum_{i=1}^{n} \boldsymbol{x_i} * \boldsymbol{w_i}}{\sum_{i=1}^{n} \boldsymbol{w_i}} = \boldsymbol{E}\ (\boldsymbol{x})$.

Indexing	*Sequence*	*Variation(group)*	*Variation(error)*	*ICC*	*Omega²*
NDVI-NDRE-BAI-NBRSWIR	All values	16.1599	36.5227	0.306741	0.29
ΔNDVI-ΔNDRE-ΔBAI-ΔNBR-ΔNBRSWIR-ΔMIRBI-RΔNBR	All values	7.06417	23.7812	0.229019	0.225

Tab. 23. Components of variance for randomization of possible effects.

Indexing	*Sequence*	*Levene's test (means) p(same)*	*Levene's test (medians) p(same)*
NDVI-NDRE-BAI-NBRSWIR	All values	5.039E -14	1.789E -06
ΔNDVI-ΔNDRE-ΔBAI-ΔNBR-ΔNBRSWIR-ΔMIRBI-RΔNBR	All values	7.399E -06	0.9294

Tab. 24. Homogeneity of variance.

Indexing	*Sequence*	*F*	*df*	*p*
NDVI-NDRE-BAI-NBRSWIR	All values	6.369	30.36	1.343E -05
ΔNDVI-ΔNDRE-ΔBAI-ΔNBR-ΔNBRSWIR-ΔMIRBI-RΔNBR	All values	10.92	85.33	3.827E -21

Tab. 25. Welch test for unequal variances.

Indexing	*Sequence*	*Factor*
NDVI-NDRE-BAI-NBRSWIR	All values	839.4
ΔNDVI-ΔNDRE-ΔBAI-ΔNBR-ΔNBRSWIR-ΔMIRBI-RΔNBR	All values	3.544E 07

Tab. 26. Bayes.

Indexing	*Sequence*	*H (χ^2)*	*H_c (tie adjusted)*	*P (same)*	*E(x)*
NDVI-NDRE-BAI-NBRSWIR (14-27)	All values	154.5	156.5	1.121E -11	5.033
	75th	54.63	55	0.4746	17.762
	50th	54.18	55	0.4746	1.026
	25th	38.9	55	0.4746	2.357
ΔNDVI-ΔNDRE-ΔBAI-ΔNBR-ΔNBRSWIR-ΔMIRBI-RΔNBR	All values	209.3	213.6	9.409E -23	5.253
	75th	46.76	48	0.4728	7.57
	50th	47.02	48	0.4728	4.428
	25th	38.72	47	0.4726	2.166

Tab. 27. One Way Anova (1) and Kruskal- Wallis-Test (2). $\boldsymbol{\chi^2} = \frac{\boldsymbol{n-1}}{\boldsymbol{n}} * \sum_{i=1}^{k} \frac{\boldsymbol{n_i}\,(\boldsymbol{\bar{R}_i} - \boldsymbol{E_R})^2}{\boldsymbol{\sigma_R^2}}$.

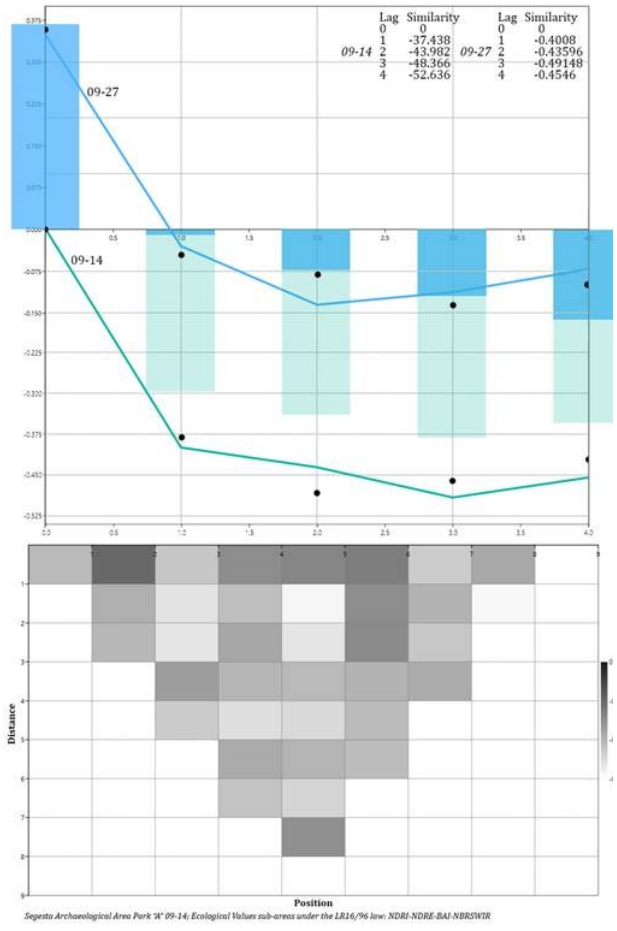
Indexing	*Sequence*	*Whittaker*	*Harrison*	*Cody*	*Routledge*	*Wilson-Shmida*	*Mourelle*
date-based	09-14	0.42373	0.015694	33.5	0.10025	5.2994	0.19628
	09-27	0.55556	0.020576	36.5	0.12877	6.3086	0.23365
Δ sensing	All values	0.28198	0.0058745	61	0.071924	8.689	0.18102

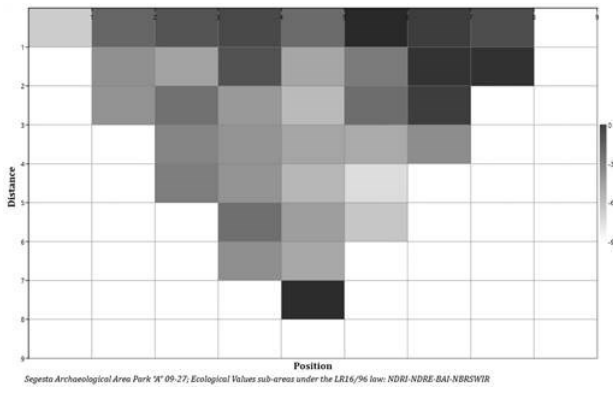
Tab. 28. Beta diversity.

a)																												
	NDVI							*NDRE*							*BAI*							*NBRSWIR*						
ID	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**
1	5	4	4	4	1	2	4	1	1	4	3	1	1	2	18	18	1	16	3	4	1	0	0	0	2	1	0	0
2	8	12	4	12	1	3	38	7	3	4	2	1	1	10	22	49	42	16	6	5	42	4	0	2	2	2	0	1
3	7	9	7	10	2	3	37	6	1	10	2	1	1	10	14	10	14	8	4	3	57	4	3	2	1	2	0	1
4	6	5	10	6	3	5	21	2	2	3	2	1	2	11	4	0	9	22	2	1	21	5	9	5	5	0	1	6
5	8	7	7	8	2	0	17	2	5	1	2	1	0	1	4	0	1	7	1	0	6	2	4	4	5	0	2	10
6	6	10	6	11	5	0	9	0	6	0	4	0	0	4	5	0	0	6	0	0	7	2	1	2	1	0	2	5
7	9	9	10	13	1	0	4	0	1	0	4	0	0	1	1	0	0	2	0	0	4	1	2	3	1	0	0	8
8	13	12	4	4	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	5	0	0	4	4	0	0	5
9	1	6	7	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

b)																												
	NDVI							*NDRE*							*BAI*							*NBRSWIR*						
ID	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**	**a1**	**a2**	**b**	**c**	**d1**	**d2**	**e**
1	3	0	6	4	4	2	11	2	1	4	1	3	1	2	28	3	1	1	3	2	8	0	0	2	3	0	0	0
2	7	4	5	10	3	3	24	5	2	6	5	1	1	5	8	50	32	14	5	5	35	7	0	2	4	0	0	0
3	7	9	3	9	6	3	29	7	3	9	1	1	1	15	13	21	21	20	6	1	29	1	0	4	4	0	0	4
4	11	12	6	7	2	5	34	4	3	1	3	0	1	9	9	3	7	20	1	5	38	5	3	5	4	0	0	7
5	6	14	9	6	0	0	29	0	3	2	6	0	1	7	4	0	6	15	1	0	19	1	9	3	2	0	1	5
6	9	21	9	9	0	0	5	0	6	0	3	0	0	1	6	0	0	5	0	0	6	3	4	4	1	0	2	9
7	10	14	10	6	0	0	4	0	1	0	1	0	0	0	0	0	0	2	0	0	3	1	1	2	3	0	2	8
8	5	0	5	15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	2	0	0	4	0	6
9	5	0	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0

Tab. 29. a) 09-14 Ecological values spectral reassignment; **b)** 09-27 Ecological values spectral reassignment.





Figures 33-34-35. Scalograms plotting highlighting similarities between two different time series, and Mantel correlogram (Dutilleul et al., 2000) whereby y-axis corresponds to Mean similarity and x-axis to Lag. Gower chosen as Similarity index. Two couples of columns were developed in two different spreadsheets and then reassembled together to manifest their distances. In the second correlogram, the upside-down vertex represents highest value.

3.5. CABFAC Environmental factor analysis

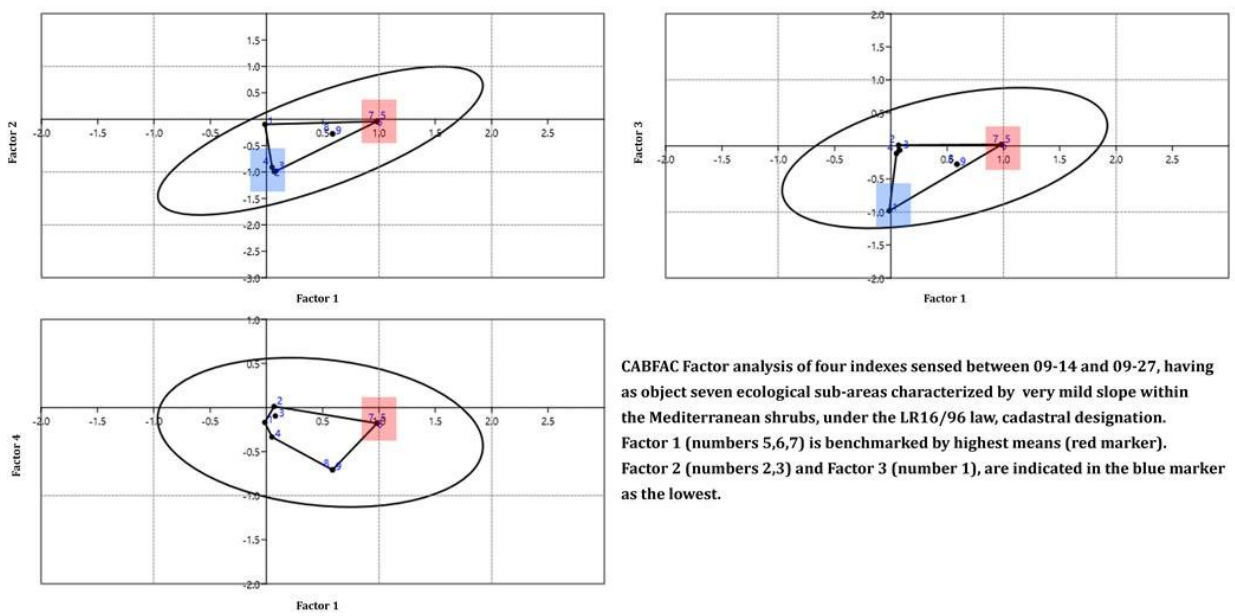
The regression used second-order method by Imbrie and Kipp (1997) and displaced the following environmental values.

	Factor 1	*Factor 2*	*Factor 3*	*Factor 4*
1	-0,013947	-0,09627	-0,98078	-0,16869
2	0,068321	-0,98974	0,011783	0,012783
3	0,079326	-0,98686	-0,064702	-0,09529
4	0,049695	-0,90864	-0,11395	-0,33408
5	0,98257	-0,04118	0,021051	-0,1784
6	0,98257	-0,04118	0,021051	-0,1784
7	0,98257	-0,04118	0,021051	-0,1784
8	0,58722	-0,27581	-0,27675	-0,7064
9	0,58722	-0,27581	-0,27675	-0,7064

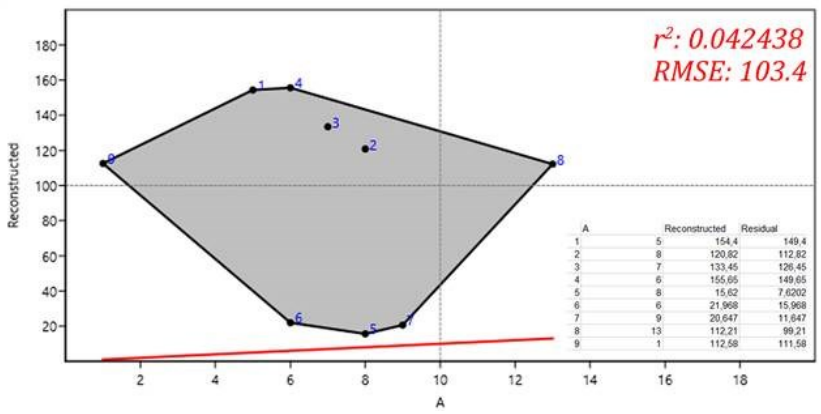
Tab. 30. Factors.

PC	*Eigenvalue*	*% variance*
1	4,8321	53,69
2	2,5853	28,73
3	1,18	13,11
4	0,3243	3,6
5	0,072441	0,8
6	0,0057978	0,06

Tab. 31. Statistical classification of CABFAC Factor analysis whereby the first factor explained 53.69 % of variance, and the fifth and sixth factors do not exceed 1 %.

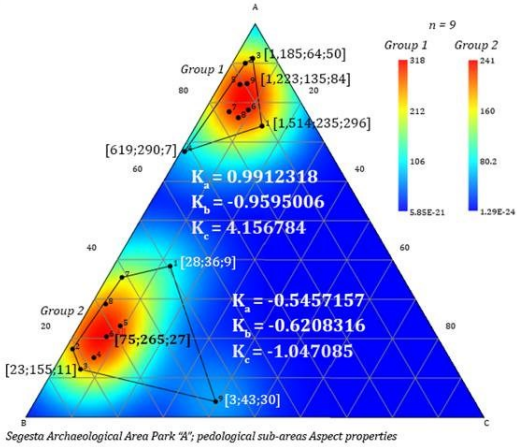


Figures 36-37-38. CABFAC Factor analysis. **Fig. 39 (below).** residual reconstruction.

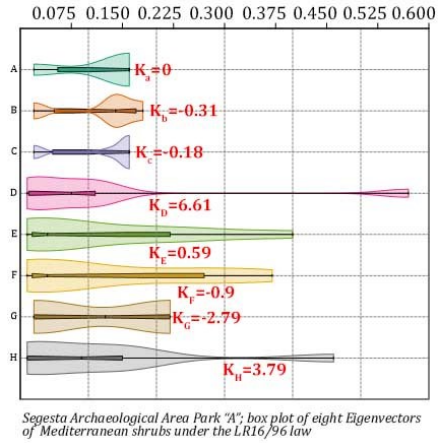


4. Analytical Hierarchical Process Results

For each driver of the Analytical Hierarchical Process (AHP) (Vargas, 2010 and Saaty and Thomas L., 2003) was generated a proper factor, on the basis of a weighting for those qualities before mentioned across the archaeological park.



Segesta Archaeological Area Park "A"; pedological sub-areas Aspect properties



Segesta Archaeological Area Park "A"; box plot of eight Eigenvectors of Mediterranean shrubs under the LR16/96 law

Figure 40. Ternaries plots. **Fig. 41.** Eigenvectors of LR16/96 corridors proposed for the Hierarchy model.

Priority	*Definition*	*Insight*
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgment slightly favour one over the other
5	Much more important	Experience and judgment strongly favour one over the other.
7	Very much more important	Experience and judgment very strongly favour one over the other. Its importance is demonstrated in practice
9	Absolutely more important.	The evidence favouring one over the other is of the highest possible validity.
2, 4, 6, 8	Intermediate values	When compromise is needed

Tab. 32. AHP scale Priorities (Saaty and Vargas, 1991) accounted for this study.

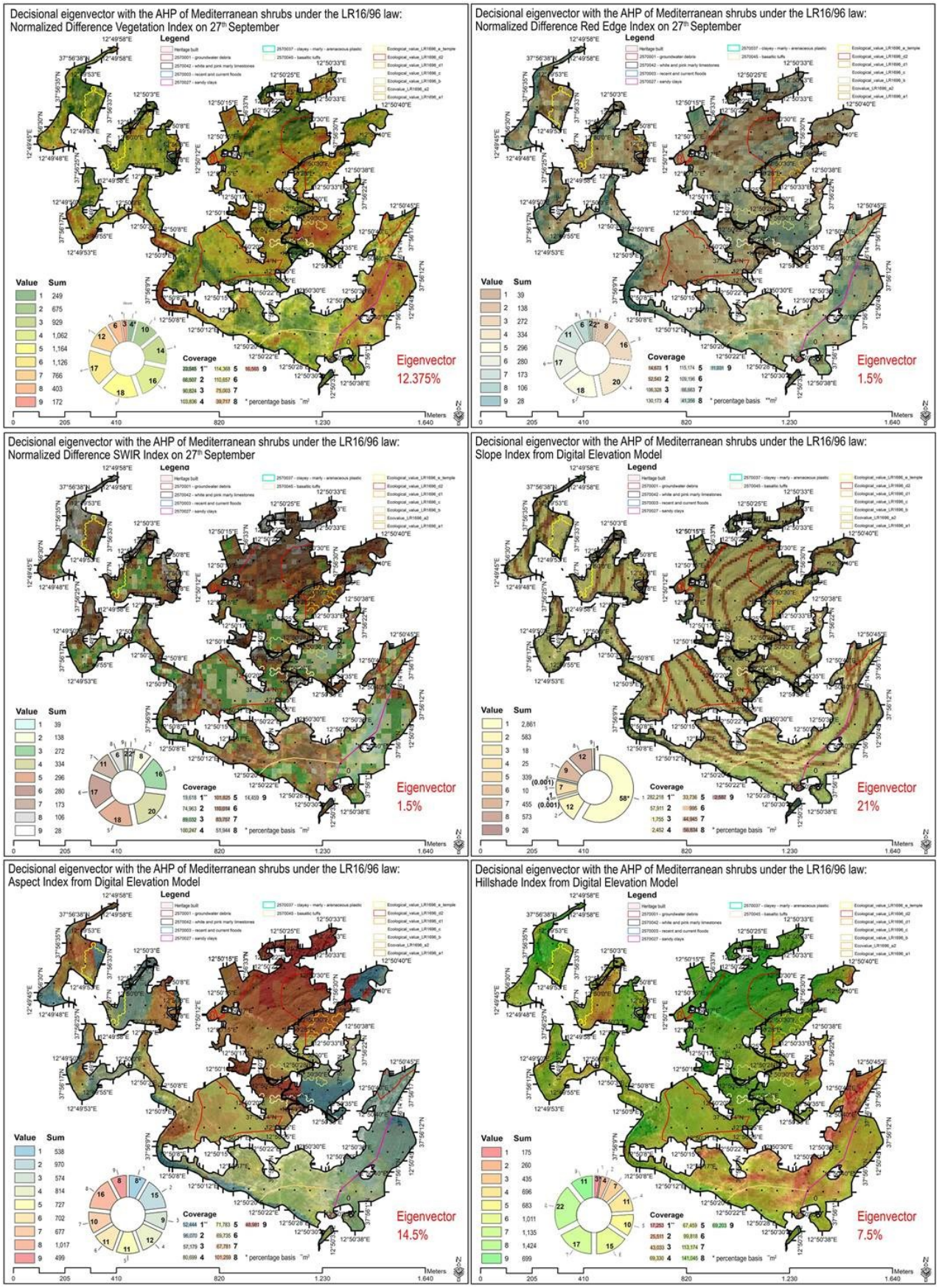
	NDVI	*NDRE*	*NBRSWIR*	*Slope*	*Aspect*	*Hillshade*	*Drainage*	*Soil type*
n	8	8	8	8	8	8	8	8
Minimum	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.01
Maximum	0.16	0.18	0.16	0.57	0.4	0.37	0.22	0.46
Sum	1	0.96	0.97	0.98	0.98	1.01	0.97	0.97
Mean	0.125	0.12	0.12125	0.1225	0.1225	0.12625	0.12125	0.12125
Std. error	0.02291288	0.02267787	0.02239559	0.06592068	0.05031153	0.05045994	0.03734193	0.05389929
Variance	0.0042	0.004114286	0.0040125	0.03476429	0.02025	0.02036964	0.01115536	0.02324107
Stand. Dev.	0,064807	0,064143	0,063344	0,186452	0,142303	0,142722	0,105619	0,15245
Median	0,16	0,14	0,16	0,075	0,04	0,04	0,125	0,09
25 percentil	0,055	0,05	0,0475	0,0125	0,0175	0,0175	0,02	0,01
75 percentil	0,16	0,17	0,16	0,11	0,22	0,27	0,22	0,15

Tab. 33. Summary statistics.

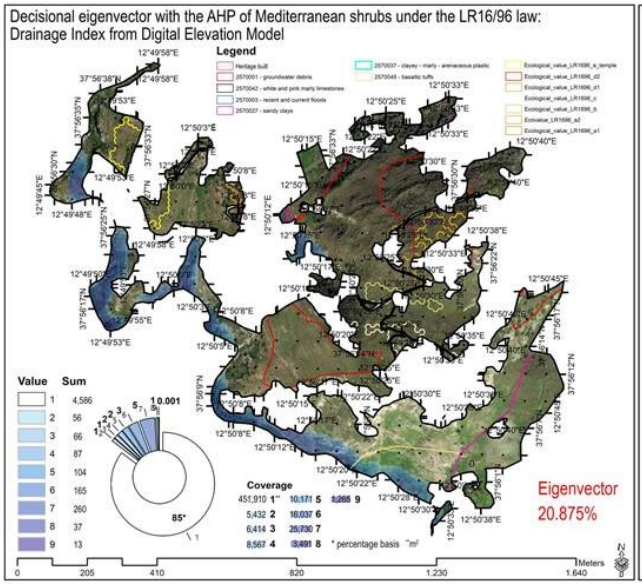
	NDVI	*NDRE*	*NBRSWIR*	*Slope*	*Aspect*	*Hillshade*	*Drainage*	*Soil type*
NDVI		7	7	1	1	1	1	1
NDRE	1/7		1	1/7	1/7	1/7	1/9	1/9
NBRSWIR	1/7	1		1/9	1/9	1/9	1/9	1/9
Slope	1	7	9		5	5	1	3
Aspect	1	7	9	5		1	1/9	1/5
Hillshade	1	7	9	1/5	1		1/7	1/9
Drainage	1	9	9	1	9	7		1
Soil type	1	9	9	1/3	5	9	1	
Total (SUM)	6.28	48	54	8.79	22.25	24.25	4.47	6.53

Tab. 34. Pair wise comparison and normalization. **Tab. 35. (below).** Sums of criteria.

	NDVI	*NDRE*	*NBRSWIR*	*Slope*	*Aspect*	*Hillshade*	*Drainage*	*Soil type*
NDVI		0.14	0.13	0.11	0.04	0.04	0.22	0.15
NDRE	0.02		0.02	0.01	0.01	0.01	0.02	0.01
NBRSWIR	0.02	0.02		0.01	0.01	0.01	0.02	0.01
Slope	0.16	0.14	0.16		0.22	0.21	0.22	0.46
Aspect	0.16	0.14	0.16	0.57		0.04	0.02	0.03
Hillshade	0.16	0.14	0.16	0.02	0.04		0.03	0.01
Drainage	0.16	0.18	0.16	0.11	0.4	0.29		0.15
Soil type	0.16	0.18	0.16	0.04	0.22	0.37	0.22	
Total (SUM)	6.28	48	54	8.79	22.25	24.25	4.47	6.53



Figures 42-43-44-45-46-47. AHP Factors: NDVI 12.375%, NDRE 1.5%, NBRSWIR 1.5%, Slope 21%, Aspect 14.5%, Hillshade 7.5%, Drainage 20.875% and Soil type 18.75%.



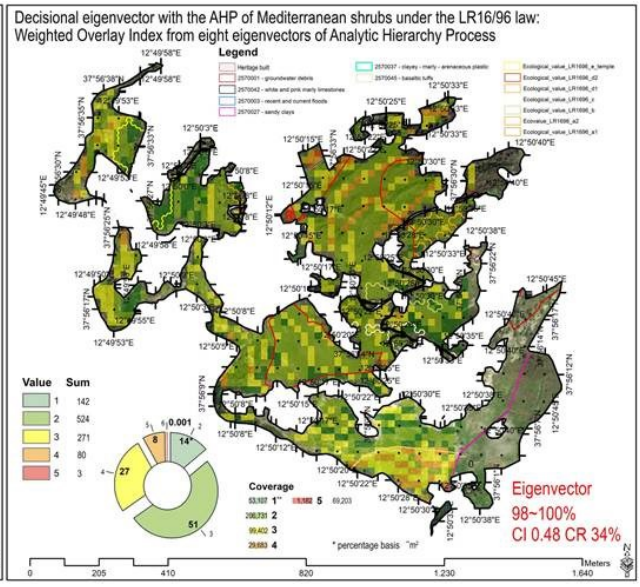


Figure 48. Drainage factor properties: 2,273.19 meters total length stream, drainage density 0.0016, area basin m² 1,434,094.04. **Fig. 49.** Weighted Overlay as final output of the research: higher depreciation at N 37°56′33′′ E 12°50′15′′.

	NDVI	***NDRE***	***NBRSWIR***	***Slope***	***Aspect***	***Hillshade***	***Drainage***	***Soil type***
Eigenvector	0.12375	0.015	0.015	0.21	0.145	0.075	0.20875	0.1875
Total (SUM)	6.28	48	54	8.79	22.25	24.25	4.47	6.53
Maximum Eigenvalue 11.3555375								
CI 0.4793625								
CR 34%								

Tab. 36. Approximation of the Consistency Index: measure and ratio.

Cadastral Id	***Pedological profile***	***Pedometrics and equipment***	***Weight***	***Coverage****
2570027	Sandy clays	10-20 cm deep multi furrow ploughs	1	458,008
2570001	Groundwater debris	Possible presence of groundwater	1	101,639
2570042	White and pink marly limestones	Immediate breaking plow and mechanical augers	1	47,139
2570003	Recent and current floods	Impenetrability barren land	5	1,158
2570037	Clayey – marly – arenaceous plastic	Difficult drilling	7	3,590
2570045	Basaltic tuffs	Immediate breaking plow and mechanical augers	8	29,580

Tab. 37. Pedological priority. Ground extraction difficulties weighted and accounted for this reforestation.

Group	***Coverage****	***Pistacia lenticus (piece €)***	***Counting***	***Cost₁***	***Excavation** (m³ €)***	***N/mm²***		***Cost₂***
5	1,182	90,9	591	53,722	4,26	-	0.5	5,035.32
4	29,683	72,72	14,841	1,079,237.52	6,14	4	10	182,253.62
3	99,402	54,54	49,701	2,710,692.54	10,98	10	20	1,091,433.96
2	206,731	36,36	103,365	3,758.351	21,15	20	40	4,372,360.65
1	53,107	18,18	26,553	482,742.63	28,71	40	75	1,524,701.97

Tab. 38. Investment priority. Cost$_1$: biotope accounted for this reforestation within a 2-meter grid scheme. Cost2: excavation and drilling derived from Sicily regional price list [Section 1.1.1 – part 1: excavations, backgrounds, demolitions, scarification, employments, no-dig techniques, mini tricees and attachments].

5. Final dissertation from the scientific methodologies

Thematic GIS data have initially served the purpose of environmental awareness, verifying registration, orienteering and to keep in mind supplementing scratches of partial information by overwriting Web Map Service maps into vectorial inputs indicating cadastral use registered at the national fiscal agency, operating under the Ministry of economy and finances; Datum clearly stated for Sicily is WGS 84 / UTM zone 33N.

Cloud coverage did not affect two-time frames in particular before and after an infamous fire ignited on September 17th so the selection was given to L1C_T33SUC_A028848_20220914T095925 and L1C_T33SUC_A029034_20220927T100026, respectively 14th and 27th September, Sentinel-2 products, distinct-order level L1C. This European multi-spectral imaging mission has gathered profound estimation by academics and scientists since its data availability from November 2015 thanks to 13 spectral bands: from visible and near infrared (NIR) to the shortwave infrared (SWIR).

In according to an extensive literature on security, emergency response and fire assistance, an initial Top of the atmosphere (TOA) reflectance was measured with ESA SNAP software and returned to ESRI© suite licensed version owned by the author.

Ordering the various data committed the authorship to a time-consuming multiscale perspective that gradually checked the scene recognizers prior to arranging; in Figure 12, four levels of protection of Segesta Park have been parcellated (a), with exclusion of a small cluster area but however indicated (b) due to non-proximity.

Ecosystem Awareness (EA) requested a legislative comprehension having: 1) a national profile - Heritage reconnaissance leading to Declaration of Segesta in 1995, passing through ICOMOS Fontainebleau in 1971, Committee of Gardens and Historic Sites in 1981 and the definition of Historic Gardens by IFLA in 1982 - 2) Sicily region special level of protection accounting: Landscape Heritage (LH) and cadastral MS LR.
Spanning from a level to another, gauging different subjects, a common LH component was hence advocated and appreciated for a common object-based scaled index investigation.

The magnitude of such ecological regarding Shrubland Heritage Vegetation (HV) finally acquired consistency during the Terrain Analysis and Pedometric, derived from the regional Digital Elevation Model (DEM) and highlighted the presence of three tops (nearly 500 meters above surface) and an important depression from north to south (≈ 250 meters). North and Northwest solar exposition is primarily present norther the Theater site, presenting a good workability of the grounds and very partially moderate Herbaceous Crop (HC) values (+0.038 to +0.257, by USGS chart +0.2 to +0.5). By correlating NDVI and NDRE, HC values show respectively a pre-date threshold between +0.129 to +0.127 (NDVI), +0.074 to +0.095 (NDRE), and post-date, +0.172 and +0.12 (NDVI), +0.096 to +0.098 (NDRE). HC pre-date R^2 indicates a good consistency, considering a high counting of the point-grid to the features extraction point-based, estimated at 0.4662 and likelihood ratio Wilks's lambda (Wλ) 0.5338 (Patel and Bhavsar, 2013). On the contrary, post-date HC R^2 value amounts to 0.2519 with a superior (Wλ) 0.7481 coefficient. HC phenology is highly dependent so that it manifests an important Landscape component, with its surrounding around the Greek Temple, and shows sparse changing conditions and can be sustained with crop rotation. HC ideal bbiophysical sites is allocated in the northern surface (clayey marly – arenaceous plastic) within the "A" Park but suffering of illumination conditions; a possible HC false positive is shown (B) at the departure bus stop, probably caused by water pump leaking.
Minor *cultivars* are allocated overall along the southern perimeter, Vineyards (VD), Olive Groves (OG) and Tree Crops (TC). On a NDVI-NDRE scale, these do not exceed the +0.5,

Along the western margin of the park, right below the Temple, the MS LR cadastral zone shows good values but is internally absent with barren rocky portions of land.
By reassigning differenced NDVI in nine ranks, the most critical coverage consisted of 54,969 m^2 while MS LR 20,655 m^2 so that this specific value concerned about this ecological deficit.
At this stage, the analysis was moved forward MS LR and to check its mapping correlation enlisting Slope Severity classes with a final topological designation which helped to define seven Ecological corridors lying within hexagonal values inferior by 9.99 to null degree (Kuveždić et al., 2020) to allocate rare biotope plants given a convenient accessibility and likely workability of the soils. The topology did include three topographical profiles, across six pedological profiles constituting the Park, and its palette is result of such triple interactions. differenced Burned Area Index (dBAI) yielded precise transformations for the MS LR, by using Red and NIR bands to a reference spectral point characterized by fire events (Figure 22 and Table 6): as previously indicated, the Burn Severity Classes (BSC), ad-hoc designated, showed important MS LR damages clustered in three groups: (f) along the southern cliff, (g) below the Greek palace, (h) below the Greek Temple. BSC were developed together with the landform recognition of the three topographical profiles, manifesting complex pedometric plotting. Similarly, the seven corridors were also invested in such estimation, so that four MS LR spots would also consist of important investments to contrast this general decline.

To assume the validity for this novel differenced index, the recategorization was double checked singularly, pre- and post-date, considering this time seven cadastral coverage (unclassified profile, e.g., shrubs and general herbaceous): 4,402 m^2 refers to most urgent MS LR decline within the 2570042 perimeter, 5,226 m^2 2570001, 197 m^2 2570037, 591 m^2 2570045 and 2,828 m^2 2570027. The remaining cover-types are also enlisted at Table 14.

Ancillary metrics of nine spectral classifications for BAI -14 -27 and dBAI, served at this stage to displace such short-term diversity: *a)* Menhimick's index to attempt the comparison of species richness independent of each sample size (2.922 E -6 for the fourth spectral class within the 2570042 profile, lowest, and 6.268E -5, within the 2570003, highest), respectively indicated *b)* under the Shannon system of measurement 5.06927 and 5.06936; entirely for these 54 spectral coefficients highest alpha diversity (Thukral, 2017) *c)* Berger-Parker [46.087; 54], *d)* Dominance D [43.626; 54], *e)* Equitability [32.674;54], *f)* Menhinick [26.454; 54], *g)* Margalef [29.315; 48], *h)* Shannon H [4.03;38].

Another novel BAI formula consisted of observing water bodies extraction visually interpretated as follows in the Figure 25 but did not affect the area study.

A Normalized Burn Ratio (NBR) the notion of fire severity is aimed at the loss of organic matter not just limited to the upper soil but also to the under-soil because of the passage of fire, and the main difference from burn severity, refers to the answer of the environment (Fang and Yang, 2014): for this index *a)* two lowest spectral channels are showed and match with the study analysis before mentioned, *b)* full spectral conformity in accordance with USGS category definition.

The Relativized Burn Ratio this time was limited to highest peak of its own spectral definition, characterized by a small coverage under the Greek theatre.

Statistically, all seven differenced indexes of seven ecological corridors were studied, showing the vegetative importance addressed to *e* buffering Temple with a quantile 50^{th} estimated at 14 for dNDVI and dNDRE.

Higher Kurtosis agreement among NDVI, NDRE, BAI and NBRSWIR, revealed critical importance for the two timeframes within the a_2 corridor, through BAI spectral recognition, platykurtic 2.33 and 0.71, with median 25.66 and 19.25, and standard deviation constituted a value expressed at 424.33, the higher of its category.

To check its normality, σ^2 variance estimated between 0 and +1, differenced values tested by Shapiro-Wilk registered 0.564, with 0.8851 for dual timeframes NDVI-NDRE-BAI-NBRSWIR.

Another analysis of variance (One-Way ANOVA) compared two index-based arrangements channeled in two columns time-based with 13- and 48-degrees freedom respectively between the two groups, 30.36 and 85.33, according to Welch test for unequal variances. The expectations among differences between actual data and data expected, are also enlisted, and vary, 50^{th} quantile referring, 54.18 and 47.02, normal indexes and differenced.

Insisting on four indexes, another reassignment served to plot proper similarity, that is experimentally proposed in a software commonly used for statistics.

The same nine spectral classes were also useful to estimate the environmental CABFAC factor analysis and marked as follows in the Figure 36-37-38-39 residual reconstructions.

The research having maturated such transitions, was considered ready to a final evaluation that could immediately support the MS LR coverage from a financial perspective of Cost-Benefit Analysis.

The AHP method by Saaty fits this necessity to weight eight input drivers for the second timeframe. A visual initial assessment grouped NDVI-NDRE and NBRSWIR into a ternary clustering with Kurtosis respectively registered 0.99, -0.95 and 4.15, and a lower one, 0.54, -0.62 and -1.04, Slope, Aspect and Hill shade.

Regarding the ternary approach, the Figure 40 shows singular values for each independent input.

AHP Factors are as follows reported: NDVI 12.375%, NDRE 1.5%, NBRSWIR 1.5%, Slope 21%, Aspect 14.5%, Hillshade 7.5%, Drainage 20.875% and Soil type 18.75%. NDVI was highly preferred thanks to its higher definition than NDRE. Slope was as well prioritized as we know. Drainage served to check the hydrology mechanics of the Park, because of the intuition derived from the Digital Elevation Model and the presence of smaller southern pedological sub-area exposed by damages of floods and heavy precipitations. The Maximum Eigenvalue computed is 11.35, exceeding by 1.35%, very close to 10 percentage for the most robust architecture of this evaluation.

The last consideration regarded finally two costs for this reforestation, whether the *Soprintendenza* offices of Heritage Preservation would approve or not, the plant itself, *Pistacia lenticus*, and the excavation: the red color represents *a)* most likely convenient investment in those exact areas (See Figure 49) highly damaged, *b)* endangered, orange, *c)* moderately affected by loss, d) loss coherence by less extent (costs per unit area increase as the complexity of geological strata goes by).

Area A [m^2]		Object area-based	Shape_area	2570042	2570001	2570037	2570045	2570027	2570003
7,351,591	FV	Med. shrubs	157,340	142,794	7,442	N/A	2,773	4,331	N/A
		Med. Shrubs R16/96	657,892	470,902	102,103	4,114	29,839	49,064	1,870
	AL	Herbaceous crops	96,682	61,290	N/A	35,392	N/A	N/A	N/A
		Olive groves	29,842	N/A	N/A	N/A	N/A	23,523	6,319
		Tree crops	617	N/A	N/A	N/A	N/A	617	N/A
		Vineyards	57,493	2,688	16,955	37,850	N/A	N/A	N/A
	N/A	Unclassified	426,796	335,162	30,991	5,739	7,239	42,691	4,974
		Built cover	11,929	8,553	2,840	N/A	N/A	456	80

Tab. 39. Summary of the cover types accounted in this case study [m^2].

6. Conclusions, ecological values proposal for Segesta Archaeological inner area Park

Spatial heterogeneity requires bureaucratic awareness in LA and LCA along with governance responsiveness whereby local administrations do not impose precise project property thresholds. An example is represented by healed vegetation actions regarding Mediterranean shrubs under the regional LR16/96 law was not found in public records so that dry crops are uniformly presented.

To meet phenology standards, subject to ignition, a well determined orientation can be assumed statistically over a decade, or the year before. Whether the urgency might not meet remote sensing timing, sensor-based aero-photogrammetry implement can rapidly delineate burning areas backed up by a marking change report in terms of moisture and further vegetation indicators such as Water Index.

From a LA perspective, Segesta Archaeological Park management is attempting to amplify Heritage continuity (Caon et al., 2014, Cambi, De Venuto, Goffredo and Trotta, 2015, Mannonim, 2021): at a regional level, with a biotope recuperation (Troia et al. 2016) as nationally, Club Alpino Italiano (CAI) hiking network from Alps to Sicily and Sardinia. Referring to future sensing platforms, currently Sentinel-2 offers spectral variety (i.e., Red, NIR and three SWIR bands), a 10 m pixel size resolution rather than Landsat 8-9 (30 m pixel size).

To express a degree in terms of rehabilitation, further subdivision of MS LR perimeters, accounting specifically Wetland Botanical Heritage biotope (Troia et al. 2016), whose perennial biology (Domina et al., 2022), ranging differently in eastern Sicily, is mutually compensated for soil nutrient pool recovery (La Rosa, Cambria and Brullo, 2019).

Mediterranean soil is chronically affected by frequent wildfires, (Pausas et al., 2008) with long-term negative results together with drought (Barčić et al., 2022), e.g., hydrophobicity and short-term, such as post combustion nutrients (Delač et al., 2022).

At a regional scale, wildfires on Mediterranean Forest Ecosystem affected Vesuvius National Park "megafire" (Silvestro et al., 2021) in 2017 over a period of 49 days. The research defines a non-universal meaning of "value to ecology" due to the cross-disciplinary debatable interpretation. Interestingly, ecosystem service (ES) market controversially benefits in restoring such burnt areas but presents deficiency of a complete offer by destabilizing a thorough decision-making process.

The danger of a lacking ES weakens indeed consistency in feasibility costs and long-term resilience in wildlife and propagation of biological communities, nutritional range for wild pollinators (Goulson et al., 2008, Fontana and Zanotelli, 2021), far from introducing alien shrubs and micro-fauna.

The research aims to fully consider fire-related quantifications: however due to the coefficient of Eigen factor, exceeding 1.35% value by the ideal limit, it is clear that the Confidence Interval might be reinforced by Kappa Accuracy validation: e.g., severe burning cannot be necessarily linked with steeper slopes, pre-fire, exposition, or elevation; Mapping and Assessment of Ecosystems and their Services (MAES) (Maes et al., 2016) would have increased its robustness, setting up Common Implementation Framework of the Biodiversity Strategy protocols, used to inform the Co-ordination Group for Biodiversity and Nature (CGBN) at an European level.

To mention lower degrees of protection, at a regional scale, the Superintendecy, namely "*Soprintendenza Archeologia, Belle Arti e Paesaggio"*, is responsible for an articulated preservation of material and intangible components (Di Mauro, L., and De Seta Cesare, 2009, Di Mauro L., 2012, 2014), verifying, validating and declaring historical-artistic, architectural and Landscape Heritage characteristics (Gearey and Fletcher, 2015) and is served by Ministry of Economics and Justice to take into action programs of interest, maintenance and restoration, to control current status of conservation, also addressed under the monitoring by third parties.

At a local scale, the discipline is finally ruled by ad-hoc "*Piano Urbanistico Comunale*" (PUC) that demands: Environmental Reports, Environmental Impact Assessments and Chart of the feasibility of the actions of the Plan, useful to map Land Use Land Cover three levels of definition, as warned by the monitoring programme "*Monitoraggio di consumo di suolo*" established by L.132/2016.

The role of Training and Internationalization department has in this case, presented a study comparable and largely adaptable to overlapping in further investigations and ground assessment method, Composite Burn Index (CBI) to complete the ΔNBR since a universal definition of burn severity cannot yet be stated (Cocke et al., 2005).

To conclude, as announced in the previous paragraph, for this instance, it is reported the importance of Heritage Vegetation that was first attributed of its value: 1) in 1971, at the Fontainebleau conference by the *International Committee of Gardens and Historic Sites* set up by ICOMOS-IFLA, 2) on May 21, 1981, at the *ICOMOS-International Council of Monuments and Sites of Florence*, 3) definition of *Charter of Historic Gardens* by IFLA, on 15 December 1982, in order to complete the *Venice Chart* and recognized the seventh article, which partially asserts:

"In relation to the same purposes referred to in Article 6 and for all the works referred to in Articles 1,2,3, the following operations or reintegration are permitted":

VIII_"Any intervention on the work or even in the vicinity of the work for the purposes referred to in Article 4 must be carried out in such a way and with such techniques and materials as to be able to be relied on that in the future will not make a new possible intervention of preservation or restoration. In addition, each intervention must be previously studied and justified in writing (Article V) and a journal must be kept for its course, followed by a final report, with photographic documentation of before, during and after the intervention. Furthermore, all the research and analyses carried out with the aid of physics ***, chemistry, microbiology, and other sciences will be documented****. A copy of all these documents will be kept in the archive of the competent Superintendency, another copy sent to the Central Institute of Restoration [...]";*

IX_The use of [...] new materials, with respect to the procedures and materials whose use is in force or in any case admitted, must be authorized by the Ministry of Public Education on the compliant and motivated opinion of the Central Institute of Restoration, which will also be responsible for to promote action at the Ministry itself to advise against antiquated, ***harmful and in any case untested subjects and methods, to suggest new methods and the use of new subjects*** *[...]";*

*X_* ***The measures intended to protect against polluting actions and atmospheric, thermal and hygrometric variations****, [...] must not be such as to significantly alter the appearance of the material, [...], or to require substantial and permanent changes to the environment in which the works have historically been transmitted";*

XII_"In cases where the attribution of technical skills is doubtful or conflicts arise on the matter, the Minister will decide, based on the reports of the Superintendents or heads of the Institute concerned, after consulting the Superior Council of Antiquities and Fine Arts".

Annex B. Instructions for carrying out pictorial or sculptural restorations. Preliminary operations. Provision to be implemented in the execution of the restoration.

"[...] The adaptation works must be limited to a minimum, carefully preserving the external forms and avoiding significant alterations to the typological individuality, the constructive organism and the sequence of internal paths. [...]".

Annex C. Instructions for the protection of historic centers.

"Coordination must also be considered in relation to the need to safeguard the more general territorial environmental context, especially when this has assumed values of particular significance strictly connected to the historical structures as they have come down to us (such as, for example, the hilly crown around Florence, the Venetian lagoon, the Roman centuriations of Valpadana, the area of the Apulian trulli, etc.)";

art 2 "The historic garden is an architectural composition whose material is mainly vegetal, therefore living and as such perishable and renewable. Its appearance thus results from a perpetual balance, in the cyclical trend of the seasons, between the development and deterioration of nature and the desire for art and artifice which tend to perpetually preserve its state. The art. 5 states that the historic garden is "expression of the close relationship between civilization and nature, a place of pleasure, suitable for meditation and dreaming, the garden thus acquires the cosmic sense of an idealized image of the world, a "paradise" in the etymological sense - logical of the term, but which bears witness to a culture, a style, an era, possibly the originality of a creator".

art 16 "More specifically, the parts of the garden closest to a building may be subject to a possible restoration, in order to bring out their coherence".

The reconstruction of heritage green cover, hence, follows the *anastylosis* approach for neutral or missing parts of the monumental surroundings:

art. 17: "When a garden has totally disappeared or there are only conjectural elements about its successive states, then it will not be possible to undertake a valid restoration of the idea of the historic garden. In this case, the work that will be inspired by traditional forms, on the site of an ancient garden, or where a garden probably

never existed, will then have characteristics of evolution or creation or totally excluding the qualification of historic garden.

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Conflict of Interests

The author declares no conflict of interest. The numerical conclusions, as well as their numerical processing, have not accountability in the role, design, collection, or interpretation of data but aims at demonstrating adequate and fine-tuned methodologies for "*Valutazione Impatto Ambientale*"(VIA) (Environmental Impact Assessment (EIA), "*Valutazione Impatto Strategica*" (VAS) (Strategic Environmental Assessment, SEA), that are derived from three branches in the process of Training and Internationalization c/o the *Ordine degli Architetti Pianificatori Paesaggisti Conservatori di Napoli e Provincia*: architecture of landscape, engineering for the territory and agronomy whose international commitment was inaugurated by former President Arch. Raffaele Sirica (1995-1997) in occasion of the Habitat II program by the second United Nations Conference on Human Settlements, taken place from June 3 to 14, 1996, in Istanbul, Turkey. The Department does not promote any misconduct, e.g., 95/46/EC and Regulation (EC) No 45/2001 (EC) No 45/2001, by endorsing: the reintroduction of historical components ecologically suitable, a sustainable land use perspective and data extraction techniques without animal experimentation and environmental invasive footprint in accordance with the rigorous Italian legislation for the landscape. No research institution, e.g., university teaching, has ever been involved in the research.

References

Abita, A. Maria, Galvano, D. Giovanni, Merlo F. (2019). (https://www.snpambiente.it/2019/09/17/consumo-di-suolo-dinamiche-territoriali-e-servizi-ecosistemici-edizione-2019/.

Alcaras, E., Costantino D., Guastaferro F., Parente C., e Pepe M. (2022). «Normalized Burn Ratio Plus (NBR+): A New Index for Sentinel-2 Imagery». *Remote Sensing* 14, fasc. 7: 1727. https://doi.org/10.3390/rs14071727.

Alfano A., Muratore S. (2014) *SIT e database. Archeologia del paesaggio tra le valli dello Jato e del Belìce Destro*, *«Archeologia e Calcolatori»*, 25, 71-91.

Ampolo, C., Parra, M. C., Caterina, G., Nicolucci, V., Luni, M., Manfredi, V. M., Turano, G., Bonacasa N., Di Vita, A., Marconi, P. et al., (2016). Selinunte: restauri dell'antico. Roma: De Luca editori d'arte : Musa comunicazione. *De Luca Editori d'Arte*. ISBN 978-88-6557-273-3.

Barčić, Damir, Tomislav Dubravac, Mario Ančić, e Roman Rosavec. (2022): «Analysis of the Fire Season of 2020 in the Mediterranean Bioclimatic Zone of Croatian Adriatic». *South-east European forestry* 13, fasc. 2: 2211. https://doi.org/10.15177/seefor.22-11.

Bianchini, Carlo, Carlo Inglese, e Alfonso Ippolito. (2016). I Teatri Antichi del Mediterraneo come esperienza di rilievo integrato / The Ancient Theatres of the Mediterranean as integrated survey experience. Sapienza Università Editrice. ISBN: 9788898533930.

Cambi, Franco, Giovanni De Venuto, Roberto Goffredo, and Trotta Valentina. (2015) a c. di. *STORIA E ARCHEOLOGIA GLOBALE – 2 I pascoli, i campi, il mare. Paesaggi d'altura e di pianura in Italia dall'Età del Bronzo al Medioevo*. IT: EDIPUGLIA, https://doi.org/10.4475/775.

Caon, Lucrezia, V. Ramón Vallejo, Coen J. Ritsema, e Violette Geissen. (2014). «Effects of Wildfire on Soil Nutrients in Mediterranean Ecosystems». *Earth-Science Reviews* 139: 47–58. https://doi.org/10.1016/j.earscirev.2014.09.001.

Casady, Grant M., Willem J. D. van Leeuwen, e Stuart E. Marsh. (2010). «Evaluating Post-Wildfire Vegetation Regeneration as a Response to Multiple Environmental Determinants». *Environmental Modeling & Assessment* 15, fasc. 5: 295–307. https://doi.org/10.1007/s10666-009-9210-x.

Chao, A., & Chiu, C. (2016). Species Richness: Estimation and Comparison. *Wiley StatsRef: Statistics Reference Online,* 1-26.

Chavez P. S. Jr. (1988). An improved dark-objectsubtraction technique for atmospheric scattering correction of multispectral data. *Remote Sensing of Environment*. 24(3):459-479.

Chavez, Pat S. Jr. (1996) «Image-Based Atmospheric Corrections -Revisited and Improved». *Photogrammetric Engineering and Remote Sensing* 62: 1025–36.

Chuvieco, E., M. Pilar Martin, and A. Palacios (ESRI). (2018). "Assessment of Different Spectral Indices in the Red-Near-Infrared Spectral Domain for Burned Land Discrimination." Remote Sensing of Environment 112 (2002): 2381-2396."

Cocke, Allison E., Peter Z. Fulé, e Joseph E. Crouse. (2005). «Comparison of Burn Severity Assessments Using Differenced Normalized Burn Ratio and Ground Data». *International Journal of Wildland Fire* 14, fasc. 2: 189. https://doi.org/10.1071/WF04010.

Costantino, D. (2009). La pianificazione paesaggistica siciliana dai vincoli ai livelli di tutela. Il progetto dell'urbanistica per il paesaggio. *XII Conferenza Nazionale Società degli Urbanisti.*

Delač, Domina, Ivica Kisić, e Paulo Pereira. (2022). «Temporal Impact of Mulch Treatments (Pinus Halepensis Mill. and Olea Europaea L.) on Soil Properties after Wildfire Disturbance in Mediterranean Croatia». *Agronomy* 12, fasc. 10: 2484. https://doi.org/10.3390/agronomy12102484.

De Simone, Walter, Michele Di Musciano, Valter Di Cecco, Giorgia Ferella, e Anna Rita Frattaroli. (2020). «The potentiality of Sentinel-2 to assess the effect of fire events on Mediterranean mountain vegetation». *Plant Sociology* 57: 11–22. https://doi.org/10.3897/pls2020571/02.

Di Mauro, L., & De Seta Cesare. (2009). I centri storici della provincia di Napoli: struttura, forma, identità urbana. Polis 1. Napoli: *Edizioni scientifiche italiane*. ISBN: 9788849517514.

Di Mauro, L., (2012). *Il viaggio a Napoli tra letteratura e arti*. Viaggio d'Europa 20. *Proceedings of the international conference The Journey to Naples between literature and arts.* Palazzo Zevallos Stigliano. Napoli: Edizioni scientifiche italiane, 2012. ISBN: 9788849525526.

Di Mauro, L., (2014). Pompei accessibile: per una fruizione ampliata del sito archeologico, Accessible Pompeii: for an extended fruition of the archaeological site. *Storia della tecnica edilizia e restauro dei monumenti 8*. Roma: «L'Erma» di Bretschneider. ISBN: 9788891306722.

Domina, Gianniantonio, Emilio Di Gristina, e Giulio Barone. (2022). «A new species within the Centaurea busambarensis complex (Asteraceae, Cardueae) from Sicily». *Biodiversity Data Journal* 10: e91505. https://doi.org/10.3897/BDJ.10.e91505.

Dutilleul, Pierre, Jason D. Stockwell, Dominic Frigon, e Pierre Legendre. (2000). «The Mantel Test versus Pearson's Correlation Analysis: Assessment of the Differences for Biological and Environmental Studies». *Journal of Agricultural, Biological, and Environmental Statistics* 5, fasc. 2: 131. https://doi.org/10.2307/1400528.

Fassnacht, Fabian Ewald, Ephraim Schmidt-Riese, Teja Kattenborn, e Jaime Hernández. (2021). «Explaining Sentinel 2-Based DNBR and RdNBR Variability with Reference Data from the Bird's Eye (UAS) Perspective». *International Journal of Applied Earth Observation and Geoinformation* 95: 102262. https://doi.org/10.1016/j.jag.2020.102262.

Filipponi, Federico. (2018). «BAIS2: Burned Area Index for Sentinel-2». In *The 2nd International Electronic Conference on Remote Sensing*, 364. MDPI. https://doi.org/10.3390/ecrs-2-05177.

García, M.J. López, e V. Caselles. (1991). «Mapping Burns and Natural Reforestation Using Thematic Mapper Data». *Geocarto International* 6, fasc. 1: 31–37. https://doi.org/10.1080/10106049109354290.

Gearey, Benjamin R., William Fletcher, e Ralph Fyfe. (2014). «Managing, Valuing, and Protecting Heritage Resources in the Twenty-First Century: Peatland Archaeology, the Ecosystem Services Framework, and the Kyoto Protocol». *Conservation and Management of Archaeological Sites* 16, fasc. 3: 236–44. https://doi.org/10.1179/1350503315Z.00000000084.

Goulson, D., G.C. Lye, e B. Darvill. (2008). «Decline and Conservation of Bumble Bees». *Annual Review of Entomology* 53, fasc. 1: 191–208. https://doi.org/10.1146/annurev.ento.53.103106.093454.

Fang, Lei, e Jian Yang. (2014). «Atmospheric Effects on the Performance and Threshold Extrapolation of Multi-Temporal Landsat Derived DNBR for Burn Severity Assessment». *International Journal of Applied Earth Observation and Geoinformation* 33: 10–20. https://doi.org/10.1016/j.jag.2014.04.017.

Fontana, P.; Zanotelli, L. (editor(s)) (2021). Api e biodiversità : tutela delle sottospecie autoctone di Apis mellifera Linnaeus, 1758. San Michele all'Adige (TN): Fondazione Edmund Mach: 206 p. ISBN: 9788878430556 handle: http://hdl.handle.net/10449/69432.

Hølleland, Herdis, Joar Skrede, e Sanne Bech Holmgaard. (2017). «Cultural Heritage and Ecosystem Services: A Literature Review». *Conservation and Management of Archaeological Sites* 19, fasc. 3: 210–37. https://doi.org/10.1080/13505033.2017.1342069.

Huvila, Isto, e Jeremy Huggett. (2018). «Archaeological Practices, Knowledge Work and Digitalisation». *Journal of Computer Applications in Archaeology* 1, fasc. 1 : 88–100. https://doi.org/10.5334/jcaa.6.

Ireland, Gareth, e George P. Petropoulos. (2015). «Exploring the Relationships between Post-Fire Vegetation Regeneration Dynamics, Topography and Burn Severity: A Case Study from the Montane Cordillera

Ecozones of Western Canada». *Applied Geography* 56: 232–48. https://doi.org/10.1016/j.apgeog.2014.11.016.

Jiang, Wei, Yuan Ni, Zhiguo Pang, Xiaotao Li, Hongrun Ju, Guojin He, Juan Lv, Kun Yang, June Fu, e Xiangdong Qin. (2021). «An Effective Water Body Extraction Method with New Water Index for Sentinel-2 Imagery». *Water* 13, fasc. 12: 1647. https://doi.org/10.3390/w13121647.

Key, C. H., & Benson, N. C. (2006). Landscape Assessment: Ground Measure of Severity, the Composite Burn Index; and Remote Sensing of Severity, the Normalized Burn Ratio. In D. C. Lutes, R. E. Keane, J. F. Caratti, C. H. Key, N. C. Benson, S. Sutherland, & L. J. Gangi (Eds.), *FIREMON: Fire Effects Monitoring and Inventory System*. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station, Gen. Tech. Rep.

Kuveždić Divjak, Ana, Almin Đapo, e Boško Pribičević. (2020). «Cartographic Symbology for Crisis Mapping: A Comparative Study». *ISPRS International Journal of Geo-Information* 9, fasc. 3: 142. https://doi.org/10.3390/ijgi9030142.

La Rosa, A., Salvatore Cambria, e Salvatore Brullo. (2019). «Considerazioni tassonomiche sulle popolazioni sicule di Trifolium isthmocarpum (Fabaceae)» *Atti riunioni scientifiche*. Notiziario della Società Botanica Italiana, 3.

Llorens, Rafael, José Antonio Sobrino, Cristina Fernández, José M. Fernández-Alonso, e José Antonio Vega. (2021). «A Methodology to Estimate Forest Fires Burned Areas and Burn Severity Degrees Using Sentinel-2 Data. Application to the October 2017 Fires in the Iberian Peninsula». *International Journal of Applied Earth Observation and Geoinformation* 95: 102243. https://doi.org/10.1016/j.jag.2020.102243.

Liu, Sicong, Yongjie Zheng, Michele Dalponte, e Xiaohua Tong. (2020): «A Novel Fire Index-Based Burned Area Change Detection Approach Using Landsat-8 OLI Data». *European Journal of Remote Sensing* 53, fasc. 1: 104–12. https://doi.org/10.1080/22797254.2020.1738900.

Maes, Joachim, Camino Liquete, Anne Teller, Markus Erhard, Maria Luisa Paracchini, José I. Barredo, Bruna Grizzetti, et al. (2016). «An Indicator Framework for Assessing Ecosystem Services in Support of the EU Biodiversity Strategy to 2020». *Ecosystem Services* 17: 14–23. https://doi.org/10.1016/j.ecoser.2015.10.023.

Mannoni, Chiara. (2014). «"Marmi inutili da vendere o riutilizzare"». PDF. *MDCCC 1800*, 2014. https://doi.org/10.14277/2280-8841/20P.

Mannoni, C. (2021). Legislation on the Heritage Protection and Restoration of Antiquity. The Case of the Acropolis of Athens in the Nineteenth Century. *SSRN Electronic Journal*. https://doi.org/10.2139/SSRN.3841388.

Martín, M.P., & Chuvieco, E. (1998). Cartografía de grandes incendios forestales en la Península Ibérica a partir de imágenes NOAA-AVHRR. *Serie Geográfica*, 7, 109-128.

Murphy, Karen A., Joel H. Reynolds, e John M. Koltun. (2008). «Evaluating the Ability of the Differenced Normalized Burn Ratio (DNBR) to Predict Ecologically Significant Burn Severity in Alaskan Boreal Forests». *International Journal of Wildland Fire* 17, fasc. 4: 490. https://doi.org/10.1071/WF08050.

Olivito, Riccardo, e Emanuele Taccola. (2014). «3D Modelling in the agora of Segesta: techniques and data interpretation». *Archeologia e Calcolatori* 25: 175–88.

Ortiz, J. D., e A. C. Mix. (1997). «Comparison of Imbrie-Kipp Transfer Function and Modern Analog Temperature Estimates Using Sediment Trap and Core Top Foraminiferal Faunas». *Paleoceanography* 12, fasc. 2: 175–90. https://doi.org/10.1029/96PA02878.

Özden, S., (2019). The Economic Analysis of The Mastic Tree (Pistacia lentiscus L.) Cultivation Projects. *Anatolian Journal of Forest Research* 5(2): 93-100.

Parks, Sean, Gregory Dillon, e Carol Miller. (2014): «A New Metric for Quantifying Burn Severity: The Relativized Burn Ratio». *Remote Sensing* 6, fasc. 3, 1827–44. https://doi.org/10.3390/rs6031827.

Patel, S.B., & Bhavsar, C. (2013). Analysis of pharmacokinetic data by wilk 's lambda. An important tool of manova.

Pausas, J. G., Llovet J., Rodrigo A, and Vallejo R. (2008). «Are Wildfires a Disaster in the Mediterranean Basin? - A Review». *International Journal of Wildland Fire* 17, fasc. 6: 713. https://doi.org/10.1071/WF07151.

Rivera-Marin, Daniela, Jadunandan Dash, e Booker Ogutu. (2022). «The Use of Remote Sensing for Desertification Studies: A Review». *Journal of Arid Environments* 206: 104829. https://doi.org/10.1016/j.jaridenv.2022.104829. desertificazione.

Saaty, Thomas L. (2003). «Decision-Making with the AHP: Why Is the Principal Eigenvector Necessary». *European Journal of Operational Research* 145, fasc. 1: 85–91. https://doi.org/10.1016/S0377-2217(02)00227-8.

Santer Richard, Argans Lise. (2010). Sentinel-3 Optical Products and Algorithm definition. Theoretical Basis Document Rayleigh Correction Over Land. (Technical document). ARGANS.

Schepers, Lennert, Birgen Haest, Sander Veraverbeke, Toon Spanhove, Jeroen Vanden Borre, e Rudi Goossens. (2014): «Burned Area Detection and Burn Severity Assessment of a Heathland Fire in Belgium Using

Airborne Imaging Spectroscopy (APEX)». *Remote Sensing* 6, fasc. 3, 1803–26. https://doi.org/10.3390/rs6031803.

Silvestro, Roberto, Luigi Saulino, Carla Cavallo, Emilia Allevato, Stefania Pindozzi, Elena Cervelli, Paola Conti, Stefano Mazzoleni, e Antonio Saracino. (2021). «The Footprint of Wildfires on Mediterranean Forest Ecosystem Services in Vesuvius National Park». *Fire* 4, fasc. 4: 95. https://doi.org/10.3390/fire4040095.

Tarquini S., Vinci S., Favalli M., Doumaz F., Fornaciai A., Nannipieri L., (2012). Release of a 10-m-resolution DEM for the Italian territory: Comparison with global-coverage DEMs and anaglyph-mode exploration via the web, *Computers & Geosciences* , 38, 168-170. doi: doi:10.1016/j.cageo.2011.04.018.

Thompson, Corey N., Wenxuan Guo, Bablu Sharma, e Glen L. Ritchie. (2019). «Using Normalized Difference Red Edge Index to Assess Maturity in Cotton». *Crop Science* 59, fasc. 5: 2167–77.

Thukral, A. K. (2017). A review on measurement of Alpha diversity in biology. *Agricultural Research Journal,* 54(1), 1. https://doi.org/10.2135/cropsci2019.04.0227.

Troia, Angelo, Patrizia Campisi, Maria Dia, Vincenzo Ilardi, A. La Rosa, Pasta Salvatore, e Leonardo Scuderi. (2016). «The temporary wetland complex of Anguillara and its key role for the botanical heritage of western Sicily».

Trigg, S., e S. Flasse. (2001). «An Evaluation of Different Bi-Spectral Spaces for Discriminating Burned Shrub-Savannah». *International Journal of Remote Sensing* 22, fasc. 13: 2641–47. https://doi.org/10.1080/01431160110053185.

Tucker, Compton J. (1979). «Red and Photographic Infrared Linear Combinations for Monitoring Vegetation». *Remote Sensing of Environment* 8, fasc. 2: 127–50. https://doi.org/10.1016/0034-4257(79)90013-0.

Vargas, R. V. (2010). Using the analytic hierarchy process (ahp) to select and prioritize projects in a portfolio. Paper presented at *PMI® Global Congress* 2010—North America, Washington, DC. Newtown Square, PA: Project Management Institute

Volpe, G,, e Cambi F.. (2015). a c. di. Storia e archeologia globale. *Insulae Diomedeae* 25–26. Bari: Edipuglia.

Wilson, Andrew. (2021). «The Use of Remote Sensing and Digital Tools for Cultural Heritage Management and Archaeological Research». *Levant* 53, fasc. 3: 384–