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Morphometric and Morphological Analysis of Trindade Island, South Atlantic, Brazil

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Abstract
Despite being well established in continental watersheds, morphometric analysis is still incipient in oceanic islands. Our goal is to analyze the morphometry and morphologically classify the island of Trindade, located in the South Atlantic. The parameters we used were altitude, slope gradient and aspect, LS factor, Topographic Wetness Index (TWI) and the Geomorphons classification. Trindade island has an altimetric amplitude of 600m, with 34% of its area between 0-100m and 21.2% in the 100-200m range. The island's lower parts are gravel and sand beaches and alluvial fans. Ridgelines such as the Desejado and Verde peaks represent heights above 500m and occupy 2% of the island's area. Slope gradients vary from strongly undulated (20-45%) to hilly (45-75%), with both classes occupying half the island's area. Flatter areas (with slope gradients between 0-3% and 3-8%) occupy less than 4% of the island. The slopes more exposed to weather conditions (rainfall and winds) are the ones facing east and southeast, therefore being the most prone to evolutionary relief processes. The western and northwestern faces are steeper and more sheltered from the weather. The Geomorphons classification has shown that 57% of the island is composed by straight slopes, 19% are spurs (slightly convex slopes in plan and profile), and 18.6% are hollows. The TWI shows that the areas prone to saturation are relief concavities in medium to lower thirds of the slopes.

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INTRODUCTION

Ever since Robert E. Horton's article (1945), morphometric analysis has been an important relief analysis tool. After the 1950s, new parameters were presented by Strahler (1952; 1957) aiming to insert new variables for morphological and morphometric analysis. In Brazil, the studies of morphology and morphometrics began with Christofoletti (1969).

Since then, the quantitative and morphological analysis and interrelations between the physiography and the relief evolution dynamics were focused on geographical studies. After the pioneering work of Christofoletti (1969), other authors researched on the theme with a variety of goals, such as evaluation and analysis in watershed (TORRES et al., 2011; MOURA, 2013; SPANGHERO; MELIANI; MENDES, 2015; FERNANDEZ, 2016), support to territorial zoning and environmental sustainability (SANTOS; SOBREIRA, 2008; CLEMENTE et al., 2011; UMETSU et al., 2012), characterization and morphometric analysis (BARROS; STEINKE, 2009; STIPP et al., 2010; CARVALHO et al., 2014).

Those methodologies were developed primarily in continental watersheds, being still incipient in volcanic oceanic islands, such as the Trindade Island, in the South Atlantic region. Therefore, this work aims to analyze the morphometrical and morphological aspects from Trindade Island, as well as verify its relation with the Topographic Wetness Index (TWI).

STUDY AREA

The Trindade Island (20°29'S; 20°30'W), 1200km away from Vitória, Espirito Santo State's capital, and 1870km from Fernando de Noronha Island,

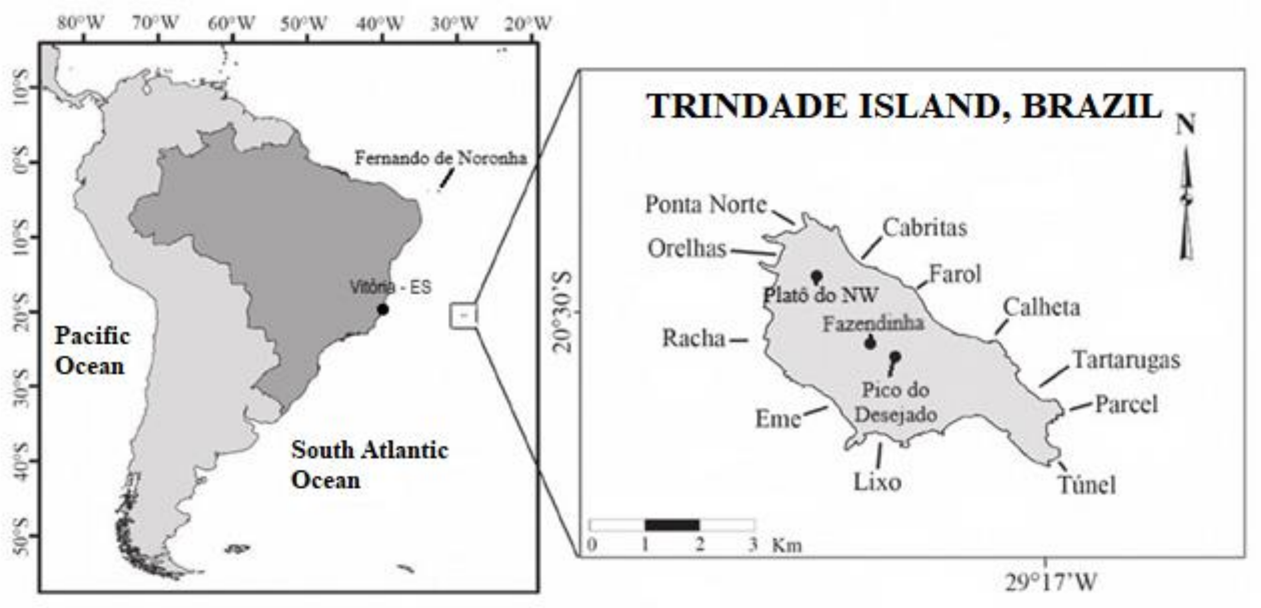
Figure 1.

It is a military island controlled by the Brazilian Navy and since 1957 it is solely occupied for the use of the military and the scientific community, with a scientific base called Posto Oceanográfico da Ilha da Trindade (POIT – Trindade Island's Oceanographic Post).

With perennial and temporary rivers (Figure 2) the island's characteristics favor the geological, geomorphological, biological, oceanographic and hydrosedimentological studies.

Due to its geographic isolation, Trindade Island favors the concentration of many endemic and endangered species. The island's singular characteristics have been attractive to scientists since the 19th century, including works of authors such as Charles Darwin and his expedition on the HMS Beagle ship (MURPHY, 1915).

Figure 1 – Trindade Island, South Atlantic, Brazil controlled by the Brazilian Navy since 1957.



Source: adapted by the authors, 2019.

Figure 2 – a) Captation river on eastside from Trindade (perennial) b) Vermelho hill river on eastside from Trindade (temporary).

Source: by the authors.

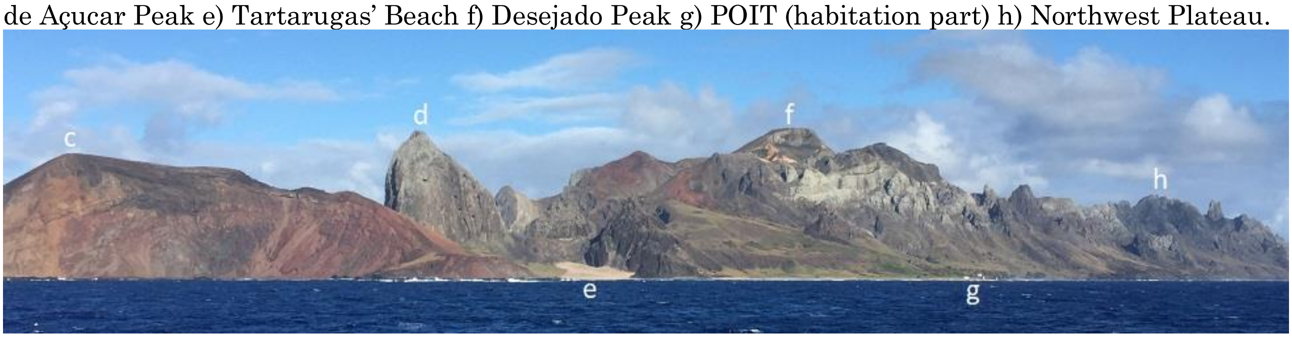
Due to its geographic isolation, Trindade Island favors the concentration of many endemic and endangered species. The island's singular characteristics have been attractive to scientists since the 19th century, including works of authors such as Charles Darwin and his expedition on the HMS Beagle ship (MURPHY, 1915).

Such studies contributed to the creation of the island's management plan (a Brazilian document to rule the use and occupation of land in preservation areas), in accordance with pertinent laws. According to the current legislation, the management plan must be concluded until five years after the creation of protected areas. Therefore, on the decree No. 9.312 from March 9th, 2018, the Conservation Unit and Natural Monument of Conservation of Trindade Island was created with the purpose of preserving I- remnants of the Tropical Forest ecosystem; II – scenic beauty and III – Natural resources and marine biodiversity on submerse mountain chains (BRASIL, 2018).

Geology

The classic geological description of Trindade was made by (ALMEIDA, 1962). He recognized five volcanogenic successions in distinctive ages: the Trindade Complex (TC) and the Desejado (DF), Morro Vermelho (MV), Valado (VF) and Paredão (PF) formations, composed of nephelinitic to phonolitic effusive-pyroclastic deposits, dykes and necks (Figure 3).

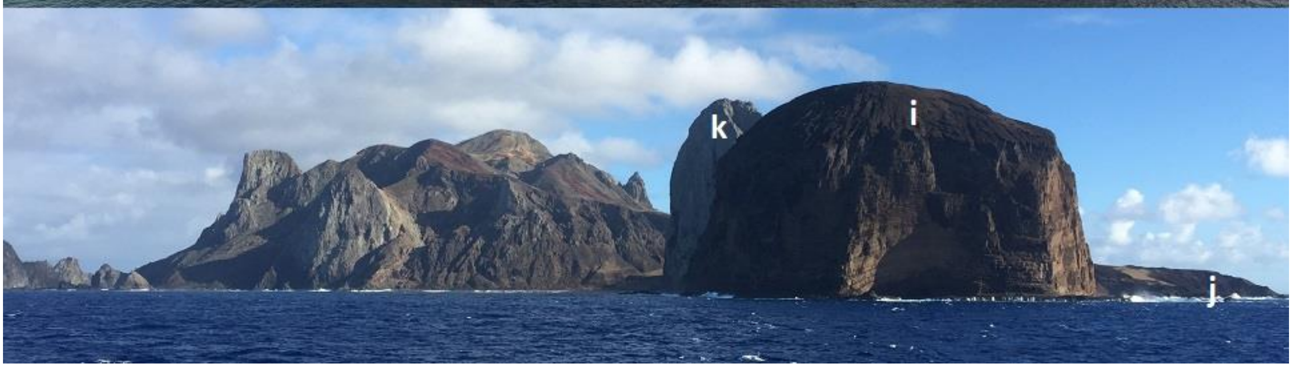
Figure 3 – Perspective as of ocean to east side from Trindade Island. c) Paredão Volcano (Extinct) d) Pão de Açucar Peak e) Tartarugas' Beach f) Desejado Peak g) POIT (habitation part) h) Northwest Plateau.



Source: by the authors.

Geochronological data placed the peak of the volcanic activity between 3.9 and 2.5 Ma (i.e. Lower Pliocene to Lower Pleistocene), however, the volcanic activity in Trindade was ceased completely at ca. 0.25 Ma, event registered in the uppermost volcanic deposits of the Paredão Volcano and that represents the last volcanic activity in the Brazilian territory which corresponds to the largest volume of volcanic deposits preserved in the island (PIRES et al., 2016). The Paredão Volcano is the last place in Brazil where debris of an extinct volcano can be recognized (CORDANI, 1970) (Figure 4). The geological environment of the island consists of basic and alkaline rocks, as well as Pleistocene Holocene sediment deposits (CASTRO, 2010).

Figure 4 – Southernmost tip from Trindade Island: i) part of extinct Paredão Volcano j) Parcel of Tartarugas k) Pão de Açúcar peak l) Tartarugas' beach.



Climate

Trindade Island has (mainly) a Tropical Oceanic climate (MOHR et al., 2009). The average annual temperature is 25.3°C and the prevailing winds are from the East (Figure 5).

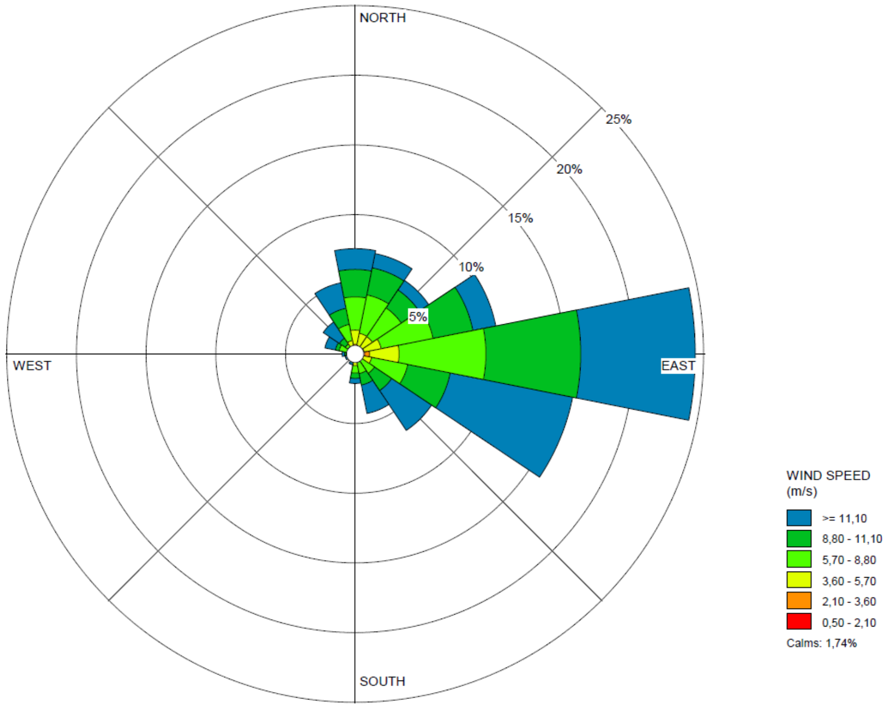
According to Pedroso et al. (2018), November is the rainiest month (with mean precipitation of 215mm), followed by October (mean precipitation of 186mm). January and February are the driest months, with precipitation averages of 64 mm. The orographic rainfalls are important on the island (called Pirajá by the locals, which means fast rain in the indigenous language).

Soils

The predominant soil in Trindade is the Neosoil. With approximately 55%, it can vary between Litolic and Regolitic. Followed by Haplic Cambisol with 30% and Folic Organosol with 10%, being the remaining 5% of the area of the island composed by rocky outcrops (SÁ, 2010).

With the description from Sá (2010), Machado et al. (2017) indicating that in Trindade, due to peculiarities such as the cloud forest, the materials from unusual origin, such as young volcano rocks and bioclastic carbonate sediments, are influenced by orographic humidity; and the specific interactions between substrates and biological activities with avifaunal colonization, ontogenesis and phosphatization, are the potential soils producers.

Figure 5 – Wind direction at Trindade Island, South Atlantic. Records from 2008 to 2018. Elaborated with data from the Meteorological Station of Trindade Island, MSTI.



Source: Brazilian Navy, 2018. Org.: by the authors.

Land Use and Land Cover

Until the 17th century, 80% of the island was covered by forests (ALVES, 1998). These forests were alive and robust in 1700, when the island was visited by the English astronomer Edmund Halley (1656-1742) (MURPHY, 1915). However, in two visits in 1881 and 1889, Sir Edwar Knight (1852-1925) described a dead forest (ALVES; SILVA, 2016 apud KNIGHT, 1884; 1892). The reasons of degradation can be safely attributed to successive attempts at occupations by humans, including the insertion of exotic animals.

Publications and manuscripts of Trindade, Alves and Silva (2016) argue that the occupation and devastation of Trindade Island occurred before the first records of flora and fauna. The authors also add that the human occupation that introduced the goats, pigs and other exotic animals have caused negative environmental impact.

METHODOLOGY

An extensive bibliographic review of works developed on the island was carried out for the elaboration of this article, as well as scientific expeditions, necessary given the geographic isolation of the place. The scientific expeditions occurred in 2018. In April, with approximately 3 days on the island and, between May and June, in a period of 45 days for validation of the maps.

Area Data

The shapefiles were obtained through vectorization of Nautical Chart No. 21, Ilhas ao Largo – Ilha da Trindade in *raster* format, made available by the Brazilian Navy (1:15.000).

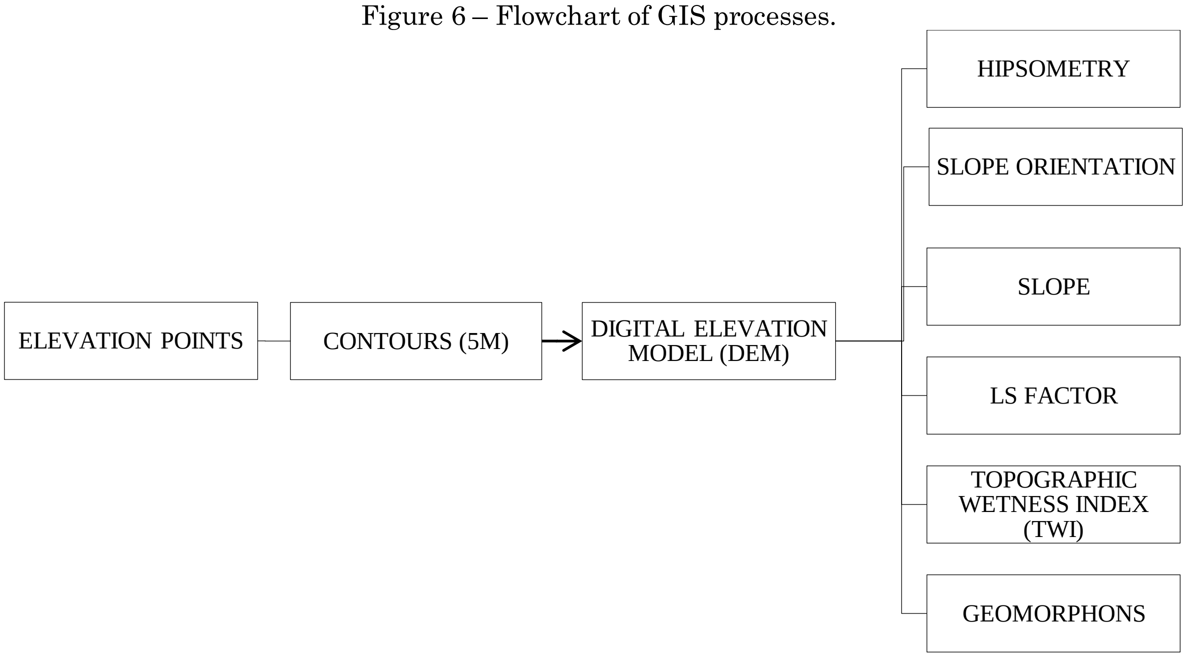
In 2018, to improve the accuracy of topographic data, a topographic survey was carried out on the island with the Global Position System (GPS) – Real Time Kinematic (RTK).

To validate the maps, we did a scientific expedition. For inaccessible areas (due to topographic issues) we used orthophoto mosaics with a scale of 1:6.000, UTM projection – 26S (WGS-84) from the year 2012 made available by the Brazilian Navy (2017).

Geoprocessing Operations

The maps were created with the software SAGA GIS 6.4.0, available for free download at <*https://sourceforge.net/projects/saga-gis-br/*> and ArcMap™ 10.3.2 from ESRI™. The SAGA GIS software was chosen because it is an open source software. Figure 6 shows a flowchart of all GIS processes performed for this paper.

Figure 6 – Flowchart of GIS processes.



Org.: by the authors.

To generate the Digital Elevation Model (DEM), geoprocessing was performed with the pixel at 5 meters (contour lines), scale of 1:10.000, using the *Topo to Raster* tool in *3D Analyst* from ArcMap™. The final maps have a scale of 1:10.000.

The DEM was imported into SAGA GIS and with the *Terrain Analysis* tool the processing of data was generated (Figure 7). After processing, they were exported to ArcMap™, where the maps were made.

Figure 7 – Work sequence in SAGA GIS to generate maps for the analysis.

Org.: by the authors.

Elevation map

The elevation map was generated from the DEM. The classes were sliced in 25m intervals until 250m, after which the classes were sliced in 100m intervals.

Slope map

The slope map was classified accordingly with the proposed by Embrapa (1999), the Brazilian Agricultural Research Corporation (Table 1).

Table 1 - Slope classifications proposed by Embrapa (1999).

CLASSES	SLOPE (%)
Flat	0 – 3
Gently Undulated	3 – 8
Undulated	8 – 20
Highly Undulated	20 – 45
Mountainous	45 – 75
Cliff	> 75

Org.: adapted by the authors.

LS-factor Map from USLE

The Map of Slope Length and Steepness factor (LS-factor) is part of the universal soil loss equation (USLE), made in SAGA GIS software, with the methodology proposed by Desmet and Govers (1996). They developed an algorithm to calculate the L factor, based on the equation of Foster and Wischemeier (1974), in which they considered the flux accumulation as an estimate of slope length. The L factor represents the ratio of soil losses between slope length and length of the plot of 25m of the same soil, rainfall, hillslope degrees, cover land and management factors. The S factor deals with the ratio of soil losses between any slope and a 9% slope, and with an equation for possible adjustments to local characteristics (BESKOW et al., 2009).

The classification for the LS factor map was done by Natural Breaks, using 5 classes, as follows: 0 – 4.186 (Very low); 4.186 – 8.152 (Low); 8.152 – 11.897 (Average); 11.897 – 16.303 (High) e 16.303 – 56.180 (Very High).

Slope Orientation map

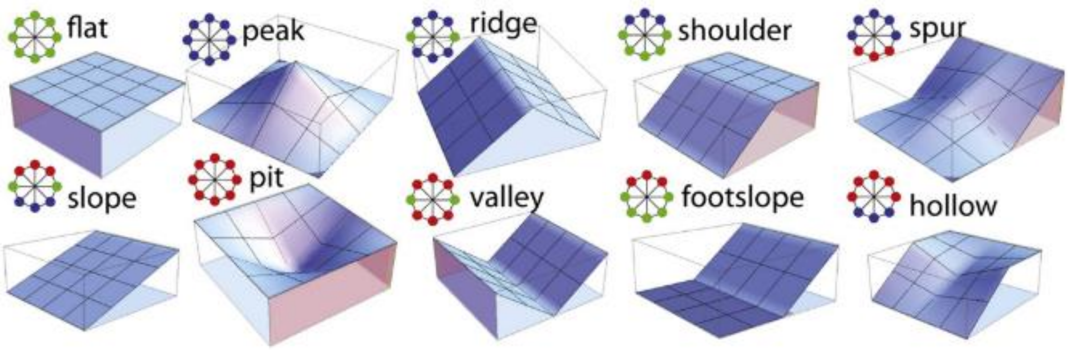
To obtain the Slope Orientation map we used the Raster Surface – Aspect tool from ArcMap™. The results were classified at every 27,5° interval from degree 0 as north.

Geomorphons Morphological Map

Geomorphons is a morphology classification method proposed by Jasiewicz and Stepinski (2013). The textural similarity analysis is performed on the DEM, considering the variations of grey level between a central cell (center pixel) and the neighboring cells. Considering the central cell, it assumes positive values as "higher", negative values as "lower" and 0 as "same".

To calculate the zenith and nadir angles of a central cell, eight elevation profiles starting at the central cell and extending along the principal directions up to the "lookup distance" L are extracted from the DEM (Figure 8).

Figure 8 – Symbolic 3D morphologies and their corresponding geomorphons (ternary patterns) for the 10 most common landform elements.



Source: Jasiewicz and Stepinski (2013).

To process the DEM and generate the .TIF geomorphons file, we used the online tool available at <http://sil.uc.edu/geom/app>. The code is available for use in GIS software tools. The parameters used to prepare the map were: 10 cells of search radius (totaling 50m radius) and leveling of 0.3° for the flat areas.

Topographic Wetness Index map (TWI)

The TWI is defined by the natural logarithm of the ratio between the specific contribution area (As, in units of orthogonal to front line of flux (m2 m-1)) and the tangent of slope (ß, in radians), (TWI = In (As/tan ß)) where As corresponds to the specific area contribution. The equation shows that the TWI is a function of ß. Therefore, the constraints arise: 0º < ß < 90°, because if ß = 0, tan ß = o and 1/tan ß is infinite and if ß = 90°, 1/tan 90 = 0, In 0 is infinite.

The TWI provides an index of relative saturation in watersheds, and hydrological similarity between areas with same index value is assumed (BEVEN; KIRKBY, 1979).

In the elaboration of the TWI map for Trindade, we sliced the results in qualitative segments using the Natural Breaks classification from ArcMap™ in 5 classes of saturation possibilities: Very low; Low; Average; High and Very High.

RESULTS

Morphometric Analysis

Trindade Island Hypsometry

The altimetric amplitude of Trindade Island (Figure 9) is roughly 600 meters, with 34% of the island's area ranging between 0-100m and 21.2% with altitudes ranging from 100-200m, as shown in

Table **2**. The interval between 200-300m corresponds to 16.8% of the island, and only 2.1% of Trindade heights are above 500m.

Figure 10 shows the waterheads with the peaks Desejado, Verde, São Bonifácio and Trindade. This sequence was named by Almeida (1962) as Sequência do Desejado.

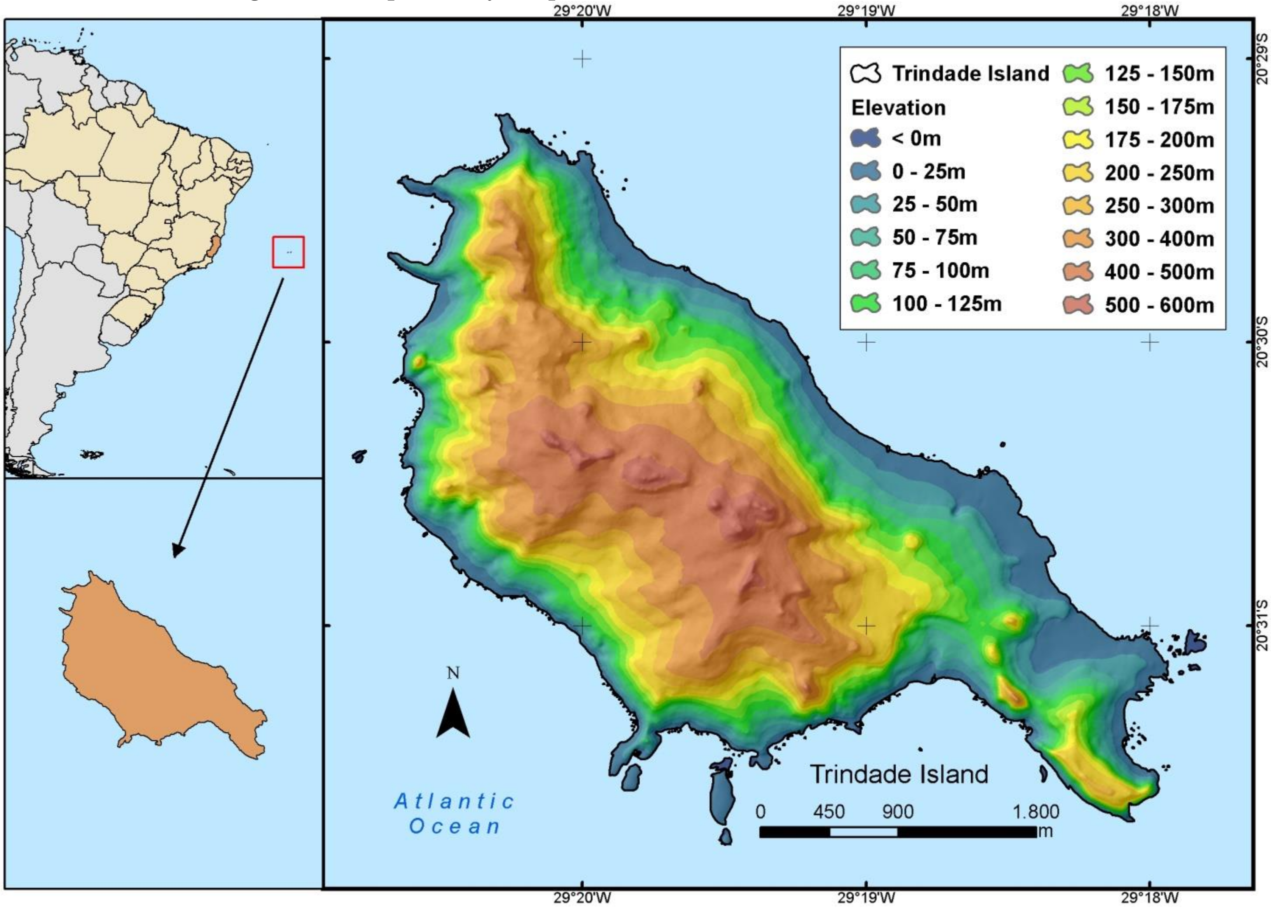
The areas with lower altitudes correspond to regions classified by Angulo et al. (2018) as sand and gravel beaches and alluvial fans, concentrated mainly in the East and Southeast parts of the island, such as Tartarugas` Beach , Paredão Beach, among others.

Table 2 – Morphometric characterization from Trindade Island, South Atlantic.

ELEVATION	AREA (m²)	%
< 0m	76750	1%
0 - 25m	1350000	11.8%
25 - 50m	853000	7.4%
50 - 75m	785400	6.8%
75 - 100m	797700	7.0%
100 - 125m	704200	6.1%
125 - 150m	652700	5.7%
150 - 175m	567300	4.9%
175 - 200m	520800	4.5%
200 - 250m	1018000	8.9%
250 - 300m	910700	7.9%
300 - 400m	1654000	14.4%
400 - 500m	1336000	11.7%
500 - 600m	240500	2.1%
Totals	11467050	100%

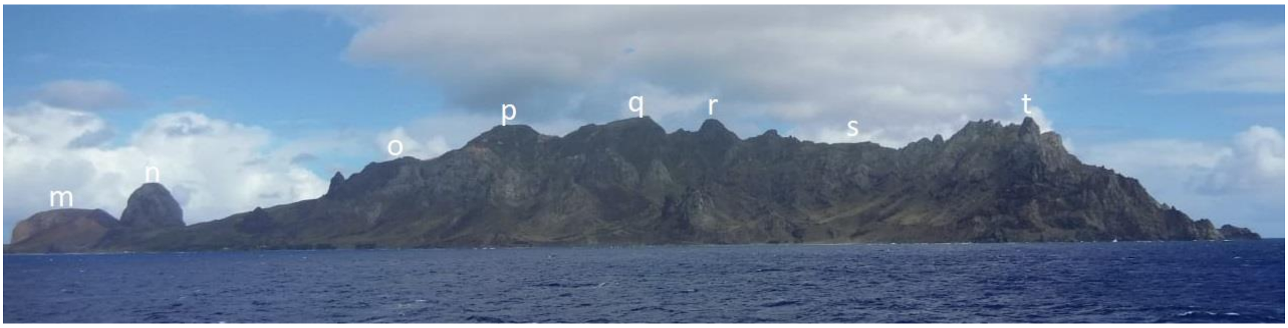
Org.: by the authors.

Figure 9 – Hipsometry map from Trindade Island, South Atlantic.



Org.: by the authors.

Figure 10 – East side of Trindade Island seen from the sea: m) Paredão Volcano n) Pão de Açúcar Peak o) Grazinas Peak p) Vermelho Hill q) Desejado Peak r) Fazendinha Peak s) Monumento Peak t) Obelisco Plateau's.



Source: by the authors.

Trindade Island's slopes

The following relief classes are predominant: highly undulated (31.2% of the island's area) and mountainous (28.8% of the island's area), totaling 60% of the island's relief (Table 3). The cliffs occur in 24.3%, while the flat, gently undulated and undulated are in 13.4% of Trindade Island's area (Figure 11).

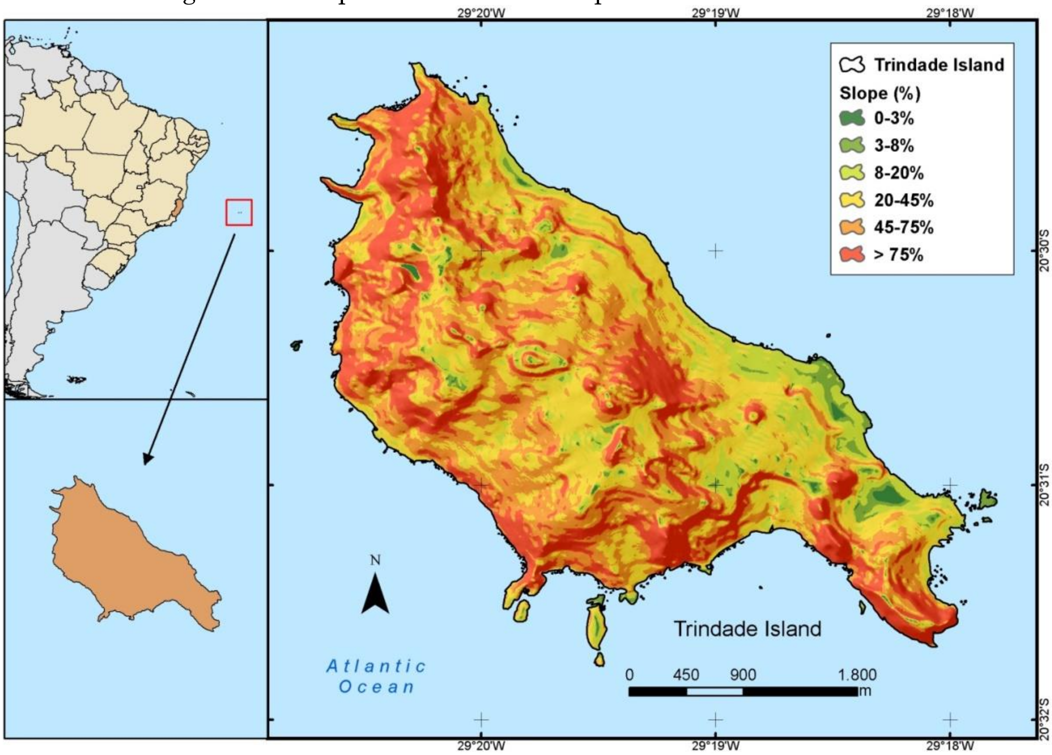
The mountainous and the cliffs classes were in all slopes on the Northwest and West (Figure 12) occurring in some parts of upper and middle slopes from the East.

Table 3 - Slope classifications in the classes proposed by Embrapa (1999).

CLASSES	Area (m²)	%
Flat (0 – 3%)	98550	0.9%
Gently Undulated (3 – 8%)	294200	2.6%
Undulated (8 – 20%)	1135100	9.9%
Highly Undulated (20 – 45%)	3578225	31.2%
Mountainous (45 – 75%)	3576475	31.2%
Cliff (>75%)	2784000	24.3%

Org.: by the authors.

Figure 11 - Slope classifications Map from Trindade Island.



Org.: by the authors.

Figure 12 – Perspective from the sea to the extreme north of Trindade Island and also the Monument peak.

Source: by the authors.

The highly undulated and mountainous classes are present mainly on slopes to the West part of Trindade, especially on slopes facing the Northwest (

Figure 13). These characteristics suggest that these slopes are protected from winds, which come from the East through most of the year, as well as protected from air masses from the South, which occur between April and September.

The slope map shows that slopes facing the Northeast, East and Southeast (Figure 12) have lower inclinations in relation to winds coming from the East, which altogether transport more humidity to Trindade during most of the year, causing more weathering and erosion of the slopes.

Figure 13 - Perspective as of Verde peak to western side from Trindade Island. In the center of the pic, EME beach.

Source: by the authors.

Figure 14 - Perspective eastern side from Trindade Island (from Vermelho Hill to Valado) as of EMIT.

Source: by the authors.

LS-factor from USLE

Table 4 shows the area of Trindade presented as m² and as a percentage of LS Factor results. The highest percentage of the LS Factor was classified as Low, represented by clear green (4.186 – 8.152), totaling 30% of Trindade, followed by the average class in yellow (8.152-11.897), with 26% of area, and the class very low, in dark green, with 22% of Trindade's area. The classifications high (11.897 - 16.303), in orange, had 17% and very high (16.303 - 56.180), in red, had 5% of the total area.

Table 4 – Trindade slopes' classification based on the results of the LS Factor.

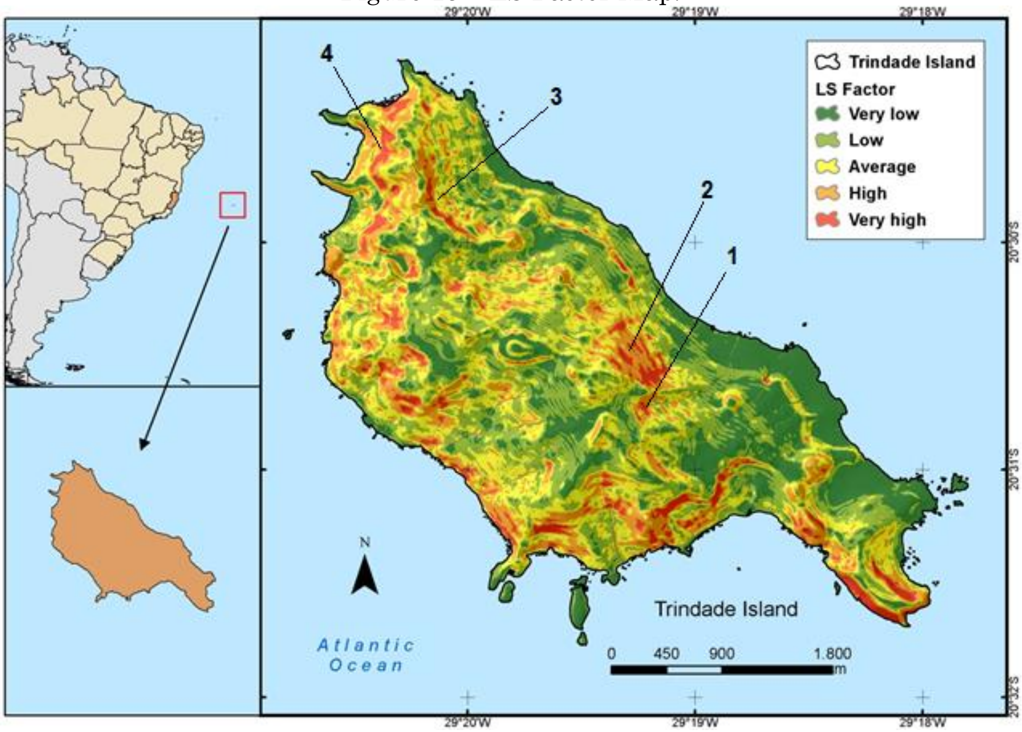
CLASSES	AREA (m²)	%	COLORS
VERY LOW	2556100	22%	DARK GREEN
LOW	3464900	30%	CLEAR GREEN
AVERAGE	2928175	26%	YELOW
HIGH	1895225	17%	ORANGE
VERY HIGH	593750	5%	RED

Org.: by the authors.

In all thirds of the slopes facing the Northwest and West, there is predominance of higher LS Factor results, suggesting short-length Slopes and steeper inclinations, when compared to slopes facing the East (which had the lower results of LS Factor, suggesting long slopes and with mild inclinations) (Figure 15 and Figure 16).

The high values of LS Factor found in the Northwest and West indicate high susceptibility to soil erosion as they have steeper inclinations and short lengths of slopes when compared to the East slopes.

Figure 15 – LS Factor Map.



Org.: by the authors.

Figure 16 - 1) Grazina peak seen from Desejado peak 2) Vermelho Hill on east side 3) Track to Plateau from NE 4) Perspective to West side from Trindade as of NE plateau and the Monument peak in the center.

Source: by the authors.

Morphological Analysis

Slope Orientation

Table **5** presents the slope orientations of Trindade Island. The slopes facing the Northeast and Southeast directions have predominance over the others, with the percentage of 24.8% and 16.1%. The slopes with lower results are the North-facing ones with 6.5% followed by the Southeast, with 7.7% and Northwest, with 7.8% of the total area (

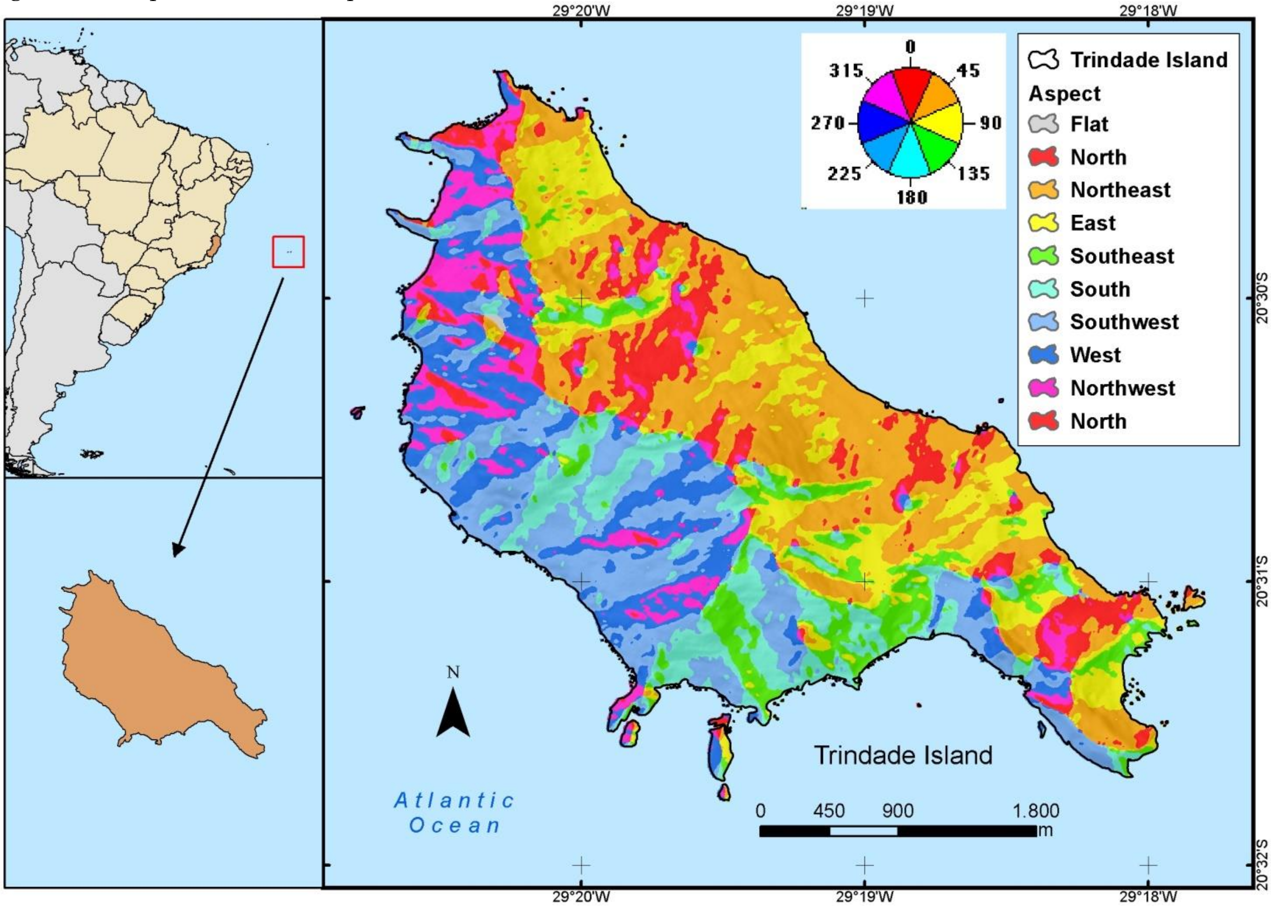
Figure 17).

Table 5 – Percentage of the slopes orientations from Trindade Island.

ORIENTATION	AREA (m²)	%
FLAT	8975	0.1%
NORTH	713400	6.5%
NORTHEAST	2739000	24.8%
EAST	1612000	14.6%
SOUTHEAST	847900	7.7%
SOUTH	1151000	10.4%
SOUTHWEST	1770000	16.1%
WEST	1319000	12.0%
NORTHWEST	864000	7.8%

Org.: by the authors.

Figure 17 - Slope orientation map from Trindade Island.



Org.: by the authors.

The slopes facing East can be associated with greater morphogenesis processes, as it is explained by the East wind's hot and humid prevalence throughout the year, coming from the Equator line.

The island's northwestern portion has slopes protected from winds coming from the East during most of the year, and also the air masses coming from the South between June and September. Therefore, the slopes were mostly of the Cliff class (inclination higher than 75%) (Figure 11) and the results from the LS Factor are High and Very High (Figure 15).

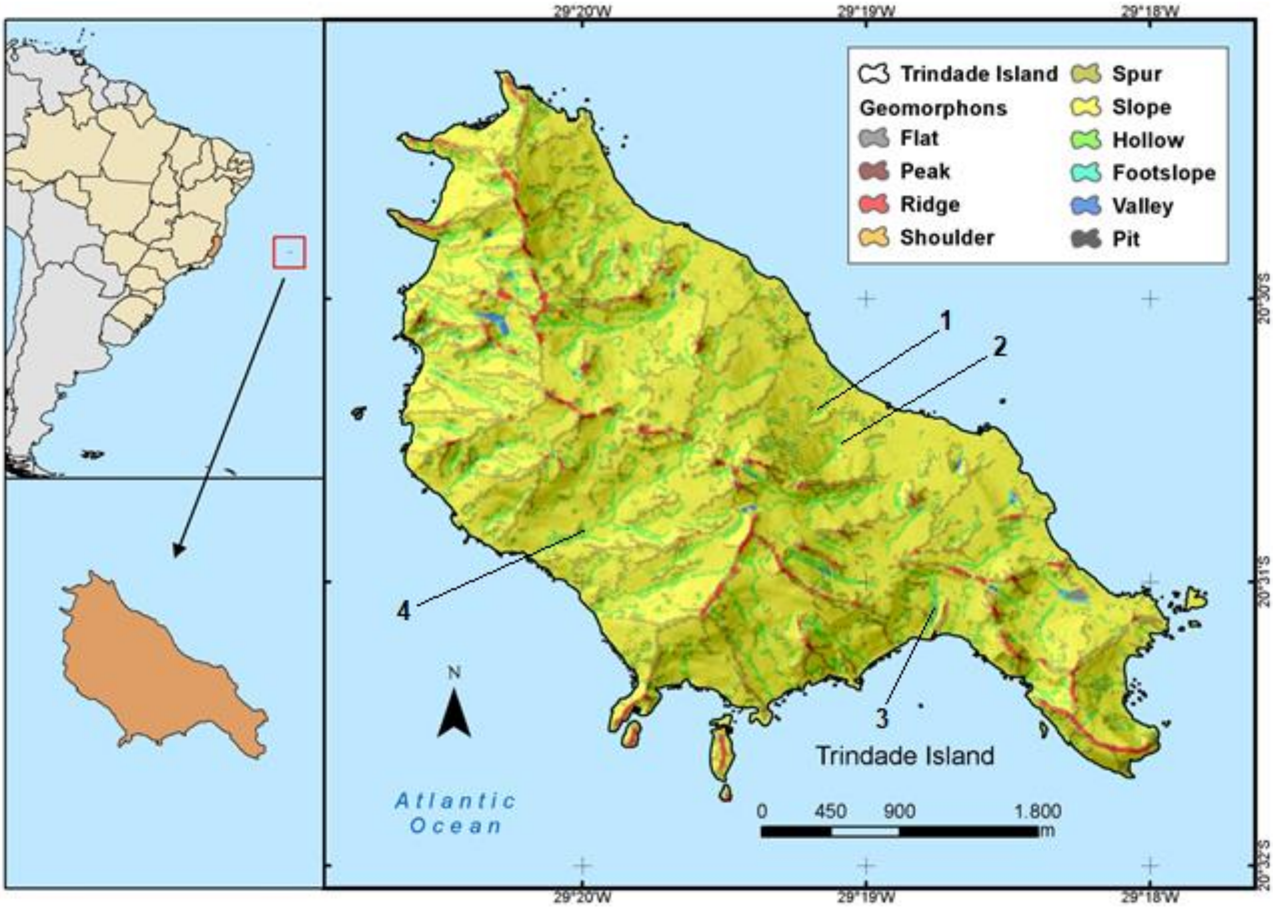
The West, Southwest and South facing slopes also have particular characteristics, due to these parts receiving Polar air masses coming from the south mainly between June and September, when the South Atlantic Subtropical Anticyclone moves towards the Equator (ANGULO et al., 2018). These parts had a predominance of slopes classified as Mountainous (45% - 75%) and Cliff (>75%), and also had the LS Factor classified as Average and High, indicating smaller morphogenesis in comparison to the Northeast part and, greater when compared to the East part.

Geomorphons Morphological Map

The morphological class with the highest percentage was Slope with 51.1%, followed by the Spur class, 19.1% and Hollow, with 18.5% of the total area (Table 6). The lowest percentage was accounted for the Flats and Peaks (each with only 0.3%). The Shoulders had 0.1% and the Pit hardly anything (

Figure 18).

Figure 18 - Trindade Island's morphological classification by Geomorphons methodology.



Org.: by the authors.

Table 6 – Morphological classification from Trindade Island.

RELIEF SHAPES	AREA (m²)	%
Flat	25175	0.3%
Peak	30075	0.3%
Ridge	240450	2.4%
Shoulder	8700	0.1%
Spur	1932025	19.1%
Slope	5768650	57.1%
Hollow	1874700	18.6%
Footslope	107200	1.1%
Valley	112675	1.1%
Pit	400	0.0%

Org.: by the authors.

The Hollow zones concentrate the fluvial courses, most of them temporary. Among the perennial rivers on Trindade, the Captação river stands out, being the one that is used for human consumption. Also, the Hollow class in some slopes have the form of amphitheatres, mainly on the East part, and with minor occurrence on the West part, being inexpressive on the Northwest side (

Figure 19).

The presence of alluvial fan deposits on the outlets of those perennial streams corroborates the association of hollows and fluvial streams, as shown by Angulo et al. (2018). Therefore, the erosion and sediment transportation processes carried out by streams in Trindade stand out (Figure 20).

The Spurs (Figure 21) occur in 19.1%, corresponding to buttresses or secondary water divisors. They are important because they allow the formation of small headwater drainages as described by Marques et al. (2017).

Figure 19 – 1) Temporary river on eastern side from Trindade near POIT 2) Perennial river on eastern side from Trindade (Captation river) 3) Waterfall Pedra da Garoupa on southwest from Trindade (perennial) 4) EME river west side from Trindade (perennial).

Source: by the authors.

Figure 20 - Rainfall event in June 2018, formed a temporary river coming from Vermelho Hill and flowing into Calheta Beach, Eastern Trindade.

Source: by the authors.

Figure 21 - Perspective as of Fazendinha Peak to Eastern Trindade.

Source: by the authors.

The Peaks and Ridges occur in only 2.7% of the area of Trindade (

Figure 22). Their importance lies in determining flux direction, functioning as topographic divisors. The Flat areas occur in just 0.3% of the island and are associated with the coastal plain, sand and gravel beaches and alluvial fan deposits.

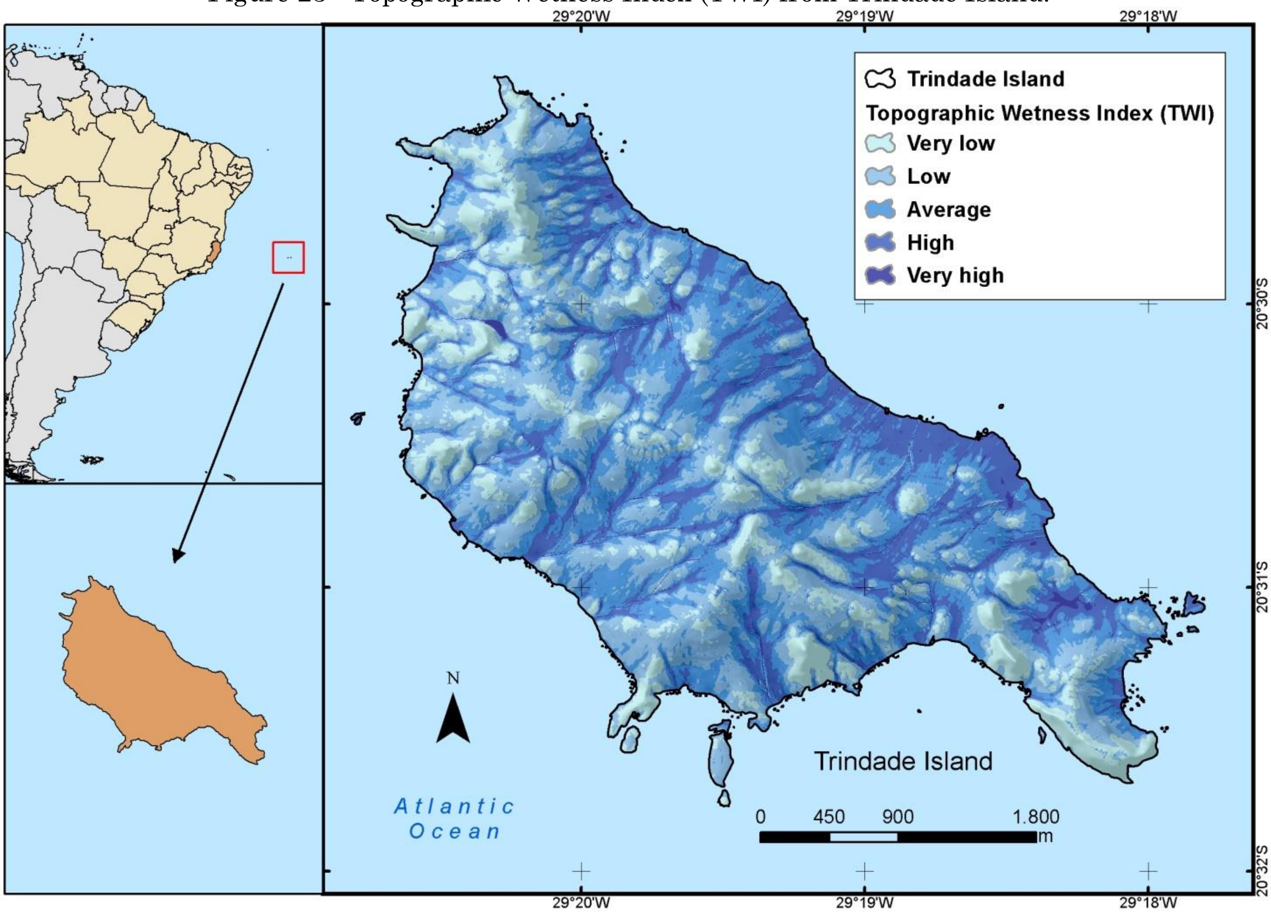
Topographic Wetness Index (TWI)

The topographic wetness index (TWI) shows the following percentages of the total area: very low (17.5%); low (33.6%); average (30.6%); high (16.9%) and very high (16.9%), as shown in Figure 23.

Figure 22 - Perspective as of Desejado Peak to Fazendinha Peak and Northeast from Trindade Island: u) Cabritas beach v) Fazendinha peak w) Crista do Galo, northern tip of Trindade.

Source: by the authors.

Figure 23 - Topographic Wetness Index (TWI) from Trindade Island.



Org.: by the authors.

The TWI High and Very High classes stand out at the East part of Trindade, following the lower results of the LS-Factor in this region, when compared to the West and Northwest parts (Figure 24). Also, in this part, it has concave slopes with the formation of areas of convergence fluxes, as shown in dark blue on the map. This is beneficial for the formation of perennial streams like the one of the Captação River.

The fluvial streams are concomitant with areas of the Hollow morphological class, areas of convergence of fluxes and are represented on the map in dark blue color, such as the watershed of the Captação River.

Figure 24 - Perspective as of EMIT to eastern slopes from Trindade Island: x) Desejado peak. y) Part of watershed of the Captation river.

Source: by the authors.

The Northwest part of Trindade had mainly a TWI classification of very low, with the exception of some areas concomitant with morphological aspect of the Hollow class, indicating the fluvial streams. This land is mainly composed by steep and abrupt rocky walls (Figure 25) a factor that is not favorable to the occurrence of fluvial streams.

In this part, the slope class that stood out was the Cliff type and the LS-Factor results were classified as High and Very High, reinforcing the indications of the TWI. These slopes are protected from the hot and humid winds coming from the East for the majority of the year and also from the air masses coming from the South between June and September.

Figure 25 - Perspective from North to South at Trindade Island.

Source: Google Earth.

As pointed by Clemente et al. (2018), the morphological class Peak, in Trindade, is a pedoclimate, colder and more humid. These and the Ridge are lumped together in the central parts of Trindade, with the vast Desejado Sequence standing out (ALMEIDA, 1962). Furthermore, they are areas where the TWI results had mainly classifications of the type Very low and act as water flow dividers.

CONCLUSIONS

The analysis made from thematic maps corroborates the relationships between the morphometry and morphology of Trindade Island and to associate them with its evolution over time. As an example, we observed that the East part has higher morphogenesis when compared with the other parts of the island.

The higher morphogenesis at the eastern portion of Trindade is evidenced by the lower values of slope inclination, indicating a flat and gently undulated relief, as well as with the lower results of LS-Factor when compared to the western portion, which had higher values of slope inclination. This relief has its slopes undulated and mountainous along with higher results of LS Factor. We claim that the higher morphogenesis in the East part of the island is due to the climate (i.e. winds, rainfall and temperature), more prominent during the majority of the year and with winds coming from the East.

In the Geomorphons classification, the

slopes from the East part are peculiar for having lots of concave areas that are denominated Hollow, which favors water flow concentration. The West part has some convergence zones of water flow, with less expression than in the East part but with greater altimetric amplitude, given that most of its relief is made of cliffs. On the Northeast part of the island, the slopes show cliffs and smaller occurrence of convergence flux zones.

The topography wetness index's higher classes are found mainly in the eastern portion of Trindade, associated with headwater drainages, in hollow types of morphology. These indexes reinforce the higher possibility of water in the East part of the island instead of the other parts, an important fact to geomorphologic evolution. However, Trindade lacks complementary studies about hydro-sedimentology in order to assess the quantitative and qualitative hydric availability.

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