



Diversity and Distribution of Flora and Vegetation of the Wind Farm of Sal Island

Final Report

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Associação Projeto Biodiversidade

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1. Introduction

Cabeólica, S.A., the company responsible for the wind farm on Sal Island, as well as other similar installations on other islands, requested a technical and financial proposal for the preparation of a study on the diversity of flora and vegetation cover within the wind farm territory. This study will serve as a basis for elaboration of the Environmental Impact Assessment for the expansion of the wind farm with the installation of a set of batteries.

The wind farm is located in Lajedo da Ribeira de Tarrafe, with an area of approximately 45ha ($\approx 0.45 \text{ km}^2$) and lies outside the National Protected Areas Network of Sal Island.

The environmental impact is defined as the set of favourable and unfavourable changes (positive impact and negative impact) produced in environmental and social parameters, within a certain area, during a certain time period, resulting from the implementation of a certain project, in comparison to the situation that would occur, under the same conditions, if the project in question had not taken place.

In this context, its implementation may give rise to positive and negative impacts as a direct consequence of its execution, which should be enhanced, mitigated, or corrected, respectively, through appropriate measures.

To assess those possible impacts and to propose a set of mitigation actions, it is important, therefore, to have the better knowledge possible regarding biodiversity and ecosystems dynamics in the area where the project is projected. This report answers to this need with the study of the diversity and distribution of all species of flora in the area.

This is the first of two reports of the surveys that will be conducted in the same area by the team of Associação Projeto Biodiversidade. The two surveys will cover the different traditional seasons in the archipelago: the dry season (current) and the rainy season.

2. Methodology

Two surveys were conducted in the area requested by Cabeólica, the first during the dry season and the second after the rainy season. Given the geographical location of the islands of Cabo Verde, there are two well defined seasons: the dry season period (November – July) and the rainy season (August – October), with a high level of variability between years. The native flora of Cabo Verde has specialised to resist long dry periods, and some plants, including endemic and endangered species, only appear after the first rains. This is why is crucial to perform two surveys during the different season to capture all the plant diversity of the area.

The first survey was conducted on April 17th, 18th and 20th, and the second survey was carried out on November 13th and 14th. The team took special care to avoid any harm of the plant species within the study area. The field technicians walked in clear areas with no plants to avoid trampling the vegetation and destroying the plants.



Figure 1: Biologist and study leader, Vânia Tavares, collecting data in the study area during the first day of the first surveys (dry season).



Figure 2: Biologist and study leader, Vânia Tavares, with an international internship, collecting data in the study area in the second survey.

Stage 1: Identification of species present within the wind farm area.

The objective was to identify the plant species found within the wind farm territory and, therefore, increase the knowledge on the environmental value of the area. With this objective we used a list of plants present in the island of Sal, from publications, previous surveys conducted by our team and general guides on flora of the country.

- I. The entire territory of the wind farm was covered on foot by a two-person team walking in a north to south direction.
- II. In order to cover more ground, the minimum distance between team members was three meters.
- IV. For each plant species encountered, the scientific name (genus and species) and/or common name was recorded.
- VI. Plants encountered that were not on the guide were photographed, and their GPS location was recorded. In the field, these species were assigned a number until they could be identified later using the photos taken.

VIII. At the end of stage 1, a final list was made with all plant species found in the wind farm (*Figure 13 and 14 from*).



*Figure 3: View of the south-eastern part of the wind farm territory, an area with high presence of the endemic and Critically Endangered *Limonium brunneri*.*

Step 2: Distribution and occupation area of the species found.

The objective was to record the distribution of each species found within the wind farm.

- I. Primarily, GPS and distribution of species with the smallest populations were recorded.
- II. For more abundant species, the GPS points were taken around the area containing a group of plants of the same species, continuing to cover the entire area until the full perimeter was completed.
- III. Each species found was recorded in the field sheet "Species distribution".
- IV. GPS location was taken as one point if the species occupied a single small place or as a perimeter (polygon) of the occupied area when the species distribution covered several meters or a much larger area.
- V. We recorded the GPS coordinates of each of the populations, differentiating the areas (A) from the points (P). Both areas and points were numbered (for example: A1, A2, A3, P1, P2).

- VI. When multiple species were found within the same area the area was recorded and each species of plant was recorded as found within that area. Here, care was taken to ensure points were recorded for plant specimens with low distribution.
- VII. During stage 2 new plant species were found which were not recorded during stage 1. In this case the same protocol was followed than stage 1 where a photograph was taken, GPS coordinates recorded, and the plant was later identified.
- VIII. Once data collection was complete, a distribution map of each of the species was made.



Figure 4: Southeast view of the wind farm and we can see the abundance of Sueda caboverdeana, which is the most abundant species found in the wind farm.

3. Results

Plant diversity within the study area

During the first census, **37 plant species were found, eight of which are endemic** to Cabo Verde. In the second census, **42 plant species were found, with the same eight endemic plants** to Cabo Verde found during the first surveys: *Polycarpaea caboverdeana*, *Asparagus squarrosus*, *Pulicaria diffusa*, *Sueda caboverdeana*, *Lotus brunneri*, *Frankenia pseudoericifolia*, *Limonium brunneri* and *Kickxia elegans*. *Limonium brunneri* was found in abundance in the upper area of the wind farm, a significant find as it is listed on the IUCN Red List Endangered Species as a **Critically Endangered** species, and is a species exclusive of Sal Island. *Pulicaria diffusa*, *Frankenia pseudoericifolia* and *Kickxia elegans* are the other endemic plants listed as Endangered. In addition, *Lotus brunneri* is listed as Data Deficient, meaning that there is not enough information in the literature that allows a good assessment of its conservation status. Two other endemic species, *Polycarpaea caboverdiana* and *Asparagus squarrosus* are listed as Near Threatened by the IUCN. Finally, another species, the *Cistanche phelipaea*, although not endemic, is listed as Vulnerable by the IUCN.

In the second survey we found 5 plant species that we did not find in the first survey (*Andrachne telephioides*, *Cleome brachycarpa*, *Cyperus bulbosus*, *Indigofera cordifolia* and *Tephrosia uniflora*). These species are not endemic species, nor listed as protected by the national legislation. However, this finding shows the relevance of conducting regular surveys, preferable after the rainy season, as the diversity of plant species could still increase.

From the 37 species identified in the first survey, ten are under special national protection, listed on the recent Decree-law n° 8/2022 of April 6 (page n° 928), that describes the special protection regime, the applicable exceptions, and the sanctions, of all endemic species and those listed on the Annex I of the same diploma. The species protected under the umbrella of this regime are the eight endemic species plus *Cistanche phelipaea* and *Tamarix senegalensis*, the last one being the only shrub-like plant species in the study area. Of the 42 species found in the second census, the same ten (10) are on the list of species protected at national level under Decree-Law no. 8/2022 of April 6 (page n° 928).



Figure 5 - Limonium brunneri, a critically endangered endemic species



Figure 6 - Kickxia elegans, and endemic species of Cabo Verde and listed as Endangered by the IUCN.



Figure 7 - *Cistanche phelipaea*, native species listed as Vulnerable and protected by the recent Decree-law nº8/2022.



Figure 8 - *Frankenia pseudoericifolia*, and endemic species of Cabo Verde and listed as Endangered by the IUCN



Figure 9 - *Lotus brunneri*, one of the endemic plants found in the study area.



Figure 10 – Some of the other species found in the area: (A) *Senna italica*, (B) *Cucmis anguria*, (C) *Rinchosia minima* and (D) *Zygophyllum creticum*.



Figure 11 - *Asparagus squarrosus*, endemic species that are Near Threatened



Figure 12 - New plants found in the second survey in the wind farm: (A) *Indigofera cordifolia*, (B) *Tephrosia uniflora*, (C) *Andrachne telephioides*, (D) *Cleome brachycarpa*.

Table of plant species found on April 2023

Family	Gender	Species	Common name	Synonym	Endemic	Global Red List
Aizoaceae	<i>Aizoon</i>	<i>canariense</i>				
Amaranthaceae	<i>Aerva</i>	<i>javanica</i>	Florzinha	<i>Aerva persica</i>		
	<i>Chenopodium</i>	<i>murale</i>				
	<i>Polycarpaea</i>	<i>caboverdeana</i>		<i>Polycarpaea nivea</i>	yes	Near Threatened (NT)
Asclepiadaceae	<i>Calotropis</i>	<i>procera</i>	Bombardera			Least Concern (LC)
Asparagaceae	<i>Asparagus</i>	<i>squarrosus</i>	Espargos		yes	Near Threatened (NT)
Asteraceae	<i>Launaea</i>	<i>intybacea</i>				
	<i>Pulicaria</i>	<i>diffusa</i>	Pulicaria		yes	Endangered (EN)
Boraginaceae	<i>Heliotropium</i>	<i>ramossisimum</i>				
Caryophyllaceae	<i>Gymnocarpus</i>	<i>sclerocephalus</i>	Brodxe	<i>Sclerocephalus arabicus</i>		
Chenopodiaceae	<i>Suaeda</i>	<i>caboverdeana</i>	<i>Fninga</i>	<i>Suaeda vermiculata</i>	yes	
Cucurbitaceae	<i>Citrullus</i>	<i>colocynthis</i>	Melon brob			
	<i>Cucumis</i>	<i>anguria</i>	Maxixe			
Euphorbiaceae	<i>Euphorbia</i>	<i>iniquilatera</i>				
Fabaceae	<i>Lotus</i>	<i>brunneri</i>			yes	
	<i>Prosopis</i>	<i>juliflora</i>	Spinhera			
	<i>Rynchosia</i>	<i>minima</i>				
	<i>Senna</i>	<i>italica</i>		<i>Cassia italica</i>		
Frankeniaceae	<i>Frankenia</i>	<i>pseudoericifolia</i>			yes	Endangered (EN)
Malvaceae	<i>Abutilon</i>	<i>pannosum</i>				
	<i>Corchorus</i>	<i>depressus</i>				
	<i>Corchorus</i>	<i>trilocularis</i>				
Orobanchaceae	<i>Cistanche</i>	<i>brunneri</i>		<i>Cistanche phelipaea</i>		Vulnerable (VU)
Plantaginaceae	<i>Kickxia</i>	<i>elegans</i>	Agrião d'rotxa		yes	Endangered (EN)
Plumbaginaceae	<i>Limonium</i>	<i>brunneri</i>	Carqueja		yes	Critically Endangered (CR)
Poaceae	<i>Chloris</i>	<i>virgata</i>				
	<i>Dactyloctenium</i>	<i>aegyptium</i>				
	<i>Sporobolus</i>	<i>spicatus</i>				
Portulacaceae	<i>Portulaca</i>	<i>oleracea</i>	Bordolega			Least Concern (LC)
Resedaceae	<i>Caylusea</i>	<i>hexagyna</i>				
Tamaricaceae	<i>Tamarix</i>	<i>senegalensis</i>	Tarrafe			Least Concern (LC)
Zygophyllaceae	<i>Zygophyllum</i>	<i>creticum</i>		<i>Fagonia cretica</i>		
	<i>Zygophyllum</i>	<i>mayanum</i>		<i>Fagonia latifolia</i>		
	<i>Tribulus</i>	<i>cistoides</i>				
	<i>Tetraena</i>	<i>fontanesii</i>		<i>Zygophyllum fontanesii</i>		
	<i>Tetraena</i>	<i>simplex</i>		<i>Zygophyllum simplex</i>		
	<i>Tetraena</i>	<i>waterlotii</i>		<i>Zygophyllum waterlotii</i>		

Figure 13 - List of the first census of plant species found in the study area.

Table of plant species found on November 2023

Family	Gender	Species	Common name	Synonym	Endemic	Global Red List
Aizoaceae	<i>Aizoon</i>	<i>canariense</i>				
Amaranthaceae	<i>Aerva</i>	<i>javanica</i>	Florzinha	<i>Aerva persica</i>		
	<i>Chenopodium</i>	<i>murale</i>				
	<i>Polycarphaea</i>	<i>caboverdeana</i>		<i>Polycarphaea nivea</i>	yes	Near Threatened (NT)
Asclepiadaceae	<i>Calotropis</i>	<i>procera</i>	Bombardera			Least Concern (LC)
Asparagaceae	<i>Asparagus</i>	<i>squarrosus</i>	Espargos		yes	Near Threatened (NT)
Asteraceae	<i>Launaea</i>	<i>intybacea</i>				
	<i>Pulicaria</i>	<i>diffusa</i>	Pulicaria		yes	Endangered (EN)
Boraginaceae	<i>Heliotropium</i>	<i>ramosissimum</i>				
Capparaceae	<i>Cleome</i>	<i>brachycarpa</i>				
Caryophyllaceae	<i>Gymnocarpos</i>	<i>sclerocephalus</i>	Brodxe	<i>Sclerocephalus arabicus</i>		
Chenopodiaceae	<i>Suaeda</i>	<i>caboverdeana</i>	<i>Fninga</i>	<i>Suaeda vemiculata</i>	yes	
Cucurbitaceae	<i>Citrullus</i>	<i>colocynthis</i>	Melon brob			
	<i>Cucumis</i>	<i>anguria</i>	Maxixe			
Cyperaceae	<i>Cyperus</i>	<i>bulbosus</i>				Least Concern (LC)
Euphorbiaceae	<i>Euphorbia</i>	<i>iniquilatera</i>				
Fabaceae	<i>Indigofera</i>	<i>cordifolia</i>				
	<i>Lotus</i>	<i>brunneri</i>			yes	
	<i>Prosopis</i>	<i>juliflora</i>	Spinhera			
	<i>Rynchosia</i>	<i>minima</i>				
	<i>Senna</i>	<i>italica</i>		<i>Cassia italica</i>		
Legomninusae	<i>Tephrosia</i>	<i>uniflora</i>				
Frankeniaceae	<i>Frankenia</i>	<i>pseudoericifolia</i>			yes	Endangered (EN)
Phyllanthaceae	<i>Andrachne</i>	<i>telephioides</i>				
Malvaceae	<i>Abutilon</i>	<i>pannosum</i>				
	<i>Corchorus</i>	<i>depressus</i>				
	<i>Corchorus</i>	<i>trilocularis</i>				
Orobanchaceae	<i>Cistanche</i>	<i>brunneri</i>		<i>Cistanche phelipaea</i>		Vulnerable (VU)
Plantaginaceae	<i>Kickxia</i>	<i>elegans</i>	Agrião d'rotxa		yes	Endangered (EN)
Plumbaginaceae	<i>Limonium</i>	<i>brunneri</i>	Carqueja		yes	Critically Endangered (CR)
Poaceae	<i>Chloris</i>	<i>virgata</i>				
	<i>Dactyloctenium</i>	<i>aegyptium</i>				
	<i>Sporobolus</i>	<i>spicatus</i>				
Portulacaceae	<i>Portulaca</i>	<i>oleracea</i>	Bordolega			Least Concern (LC)
Resedaceae	<i>Caylusea</i>	<i>hexagyna</i>				
Tamaricaceae	<i>Tamarix</i>	<i>senegalensis</i>	Tarrafe			Least Concern (LC)
Zygophyllaceae	<i>Zygophyllum</i>	<i>creticum</i>		<i>Fagonia cretica</i>		
	<i>Zygophyllum</i>	<i>mayanum</i>		<i>Fagonia latifolia</i>		
	<i>Tribulus</i>	<i>cistoides</i>				
	<i>Tetraena</i>	<i>fontanesii</i>		<i>Zygophyllum fontanesii</i>		
	<i>Tetraena</i>	<i>simplex</i>		<i>Zygophyllum simplex</i>		
	<i>Tetraena</i>	<i>waterlotii</i>		<i>Zygophyllum waterlotii</i>		

Figure 14: List of the second census of plant species found in the study area, with the new species highlighted in yellow.

Distribution and abundance

The distribution of the different species is presented in a map with all points and polygons of distribution well identified. Each colour represents a species. Analysing the map, we can see which is the most abundant and which is the least abundant. For example, *Sueda caboverdeana*, was found in a great abundance in the wind farm (Figure 16) in relation to other endemic species, such as *Kickxia elegans*, which was found in little quantity within the study region (Figure 24).

The distribution and abundance of the species found in the wind farm in both the first and second surveys is the same, we have not seen the appearance of new endemic species or an increase in the abundance of these species, for example the *Limonium brunneri* which is an endemic species that is critically endangered continues to have a wide distribution in the central and southern sectors of the study area, with some also present in the north, and the *Sueda vermiculata* continues to be the most abundant species in the wind farm with a wide distribution in all the places where it has vegetation

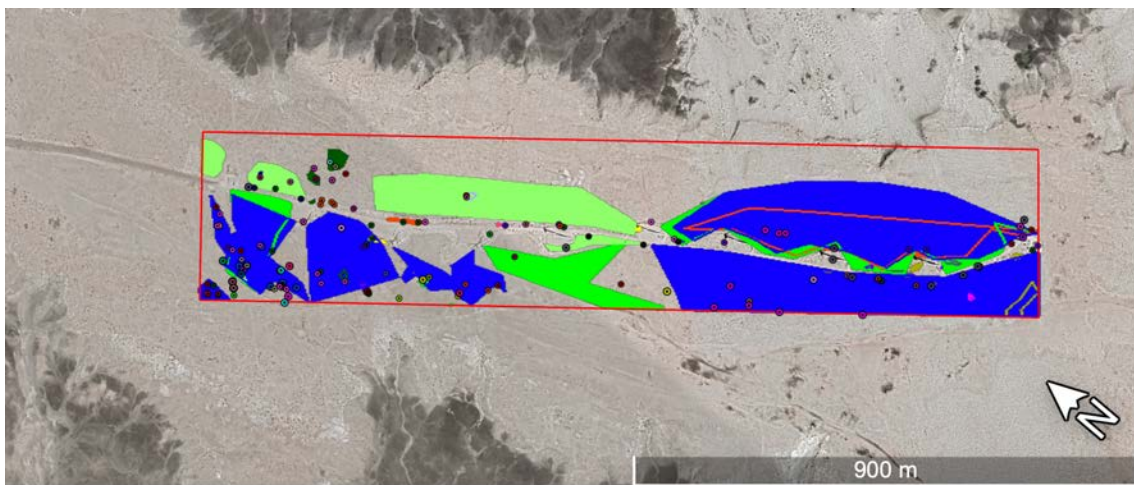


Figure 15 - Example of distribution a cover map of the study area. The information was recorded using commercial GPS devices and the points and polygons were created using Google Earth platform.

Sueda caboverdeana is one of the most abundant species in the wind farm and it was the species we found almost everywhere where there was vegetation - we can see in figure 16 its distribution in the wind farm.



Figure 16 - Distribution of the endemic *Sueda caboverdeana*, one of the most abundant species in the area.

In the following figure 17 we can see the comparison between two endemic species, *Limonium brunneri* and *Kickxia elegans*), with the first more abundant. *Kickxia elegans*, an endangered species, it is only some found in a few spots in the initial part of the park, while *Limonium brunneri*, which is a critically endangered species, is found on larger areas.

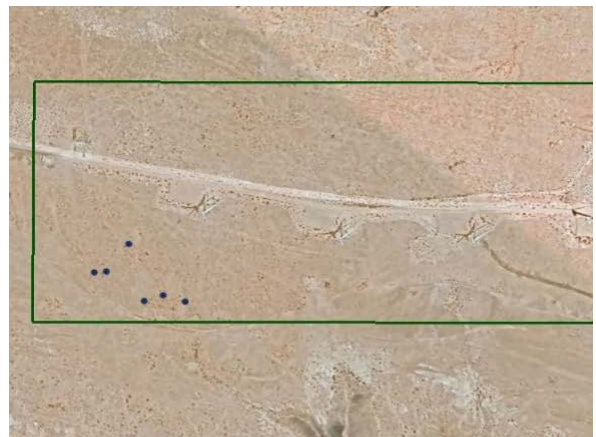


Figure 17 - Distribution of two different endemic species. *Limonium brunneri* (left) is found covering large areas, while only few specimens of *Kickxia elegans* (right) can found near the entrance of the park.

In the following maps we show the distribution of all the species protected by the Decree-law n° 8/2022.

Polycarpaea caboverdeana – Near Threatened



Figure 18 - Distribution and cover of *Polycarpaea caboverdeana*, present in the southern part of the study area.

Asparagus squarrosus – Near Threatened



Figure 19 - Distribution of *Asparagus squarrosus*, with some larger areas in the northern section and a few individuals found in the centre and southern sections of the study area.

Pulicaria diffusa – Endangered



Figure 20 - Distribution of *Pulicaria diffusa*, present mainly in the northern section, with few individuals in the south of the study area.

Lotus brunneri – Data Deficient



Figure 21 - *Lotus brunneri* is distributed along the study area, with few individuals and no large cover area.

Frankenia pseudoericifolia – Endangered



Figure 22 - *Frankenia pseudoericifolia* can be found, mainly, in the northern section, with some individuals in the centre.

Limonium brunneri – Critically Endangered

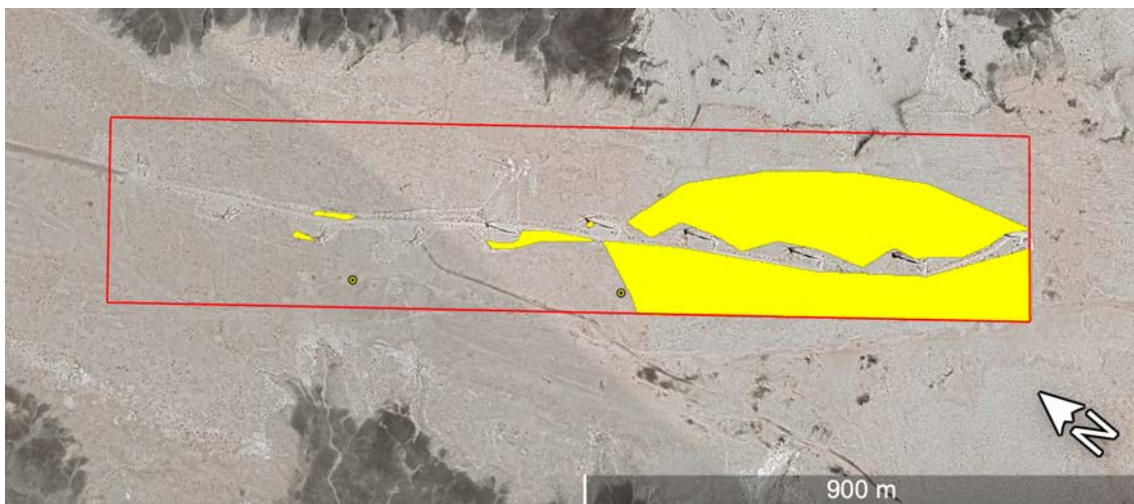


Figure 23 - *Limonium brunneri* present a wide distribution in the central and southern sectors of the study area, with some present also in the north.

Kickxia elegans – Endangered



Figure 24 - The distribution of *Kickxia elegans* is restricted to the norther corner of the study area, with only six individuals detected.

Cistanche phelipaea – Vulnerable



Figure 25 - *Cistanche phelipaea* is found along the access path, with higher density in the southern section.

Tamarix senegalensis – Least Concern



Figure 26 - Only one individual of *Tamarix senegalensis* can be found on the area.

The distribution of the new species found in the second survey of the wind farm shows that all the species were in the northwest part of the wind farm and did not show a great abundance. And even though these species are not endemic and do not have a great abundance, it is relevant to present their distribution in the wind farm to consider them even during the dry season, when most probably they will not appear visible to a normal sight.

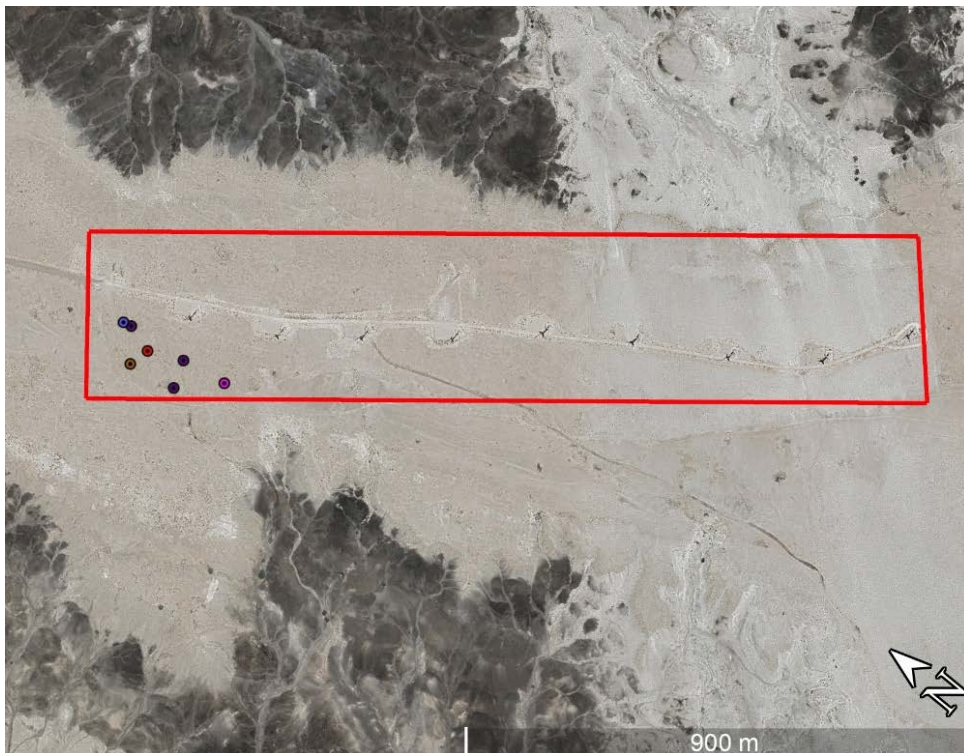


Figure 27: Distribution of new species found in the second survey.

The distribution, abundance, and cover of the all of species can be found in the document delivered with this report (Censo Flora Novembro 2024.kmz), which allow the individual selection and visualization of each species present on the area from both the first and second surveys (i.e: Figure 28 and 29).

The distribution and abundance of the first and second census are practically the same, only there has been an increase in the number of plant species.

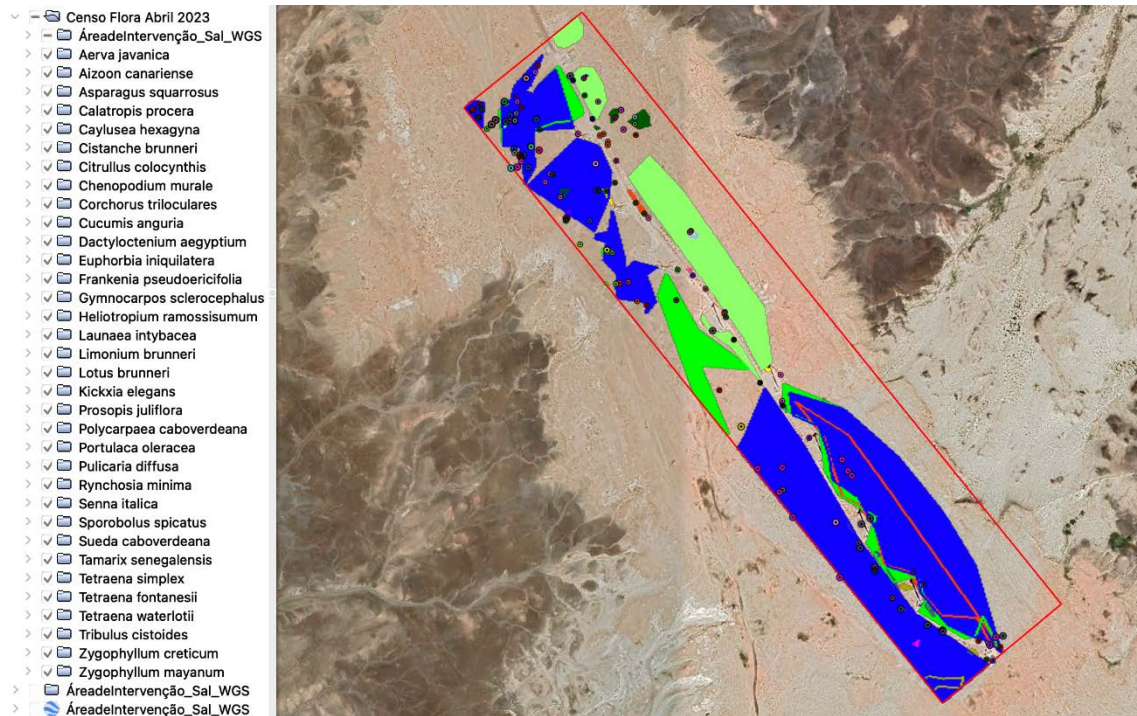


Figure 28 - Visualization of the list of species in the Google Earth platform from the first survey. On the left side, a list of all species is shown, allowing the user to select specific plant species. Opening the menu of each species shows the number of individuals (points) and cover areas (polygons), with a numbered order as described in section 2 of this report.

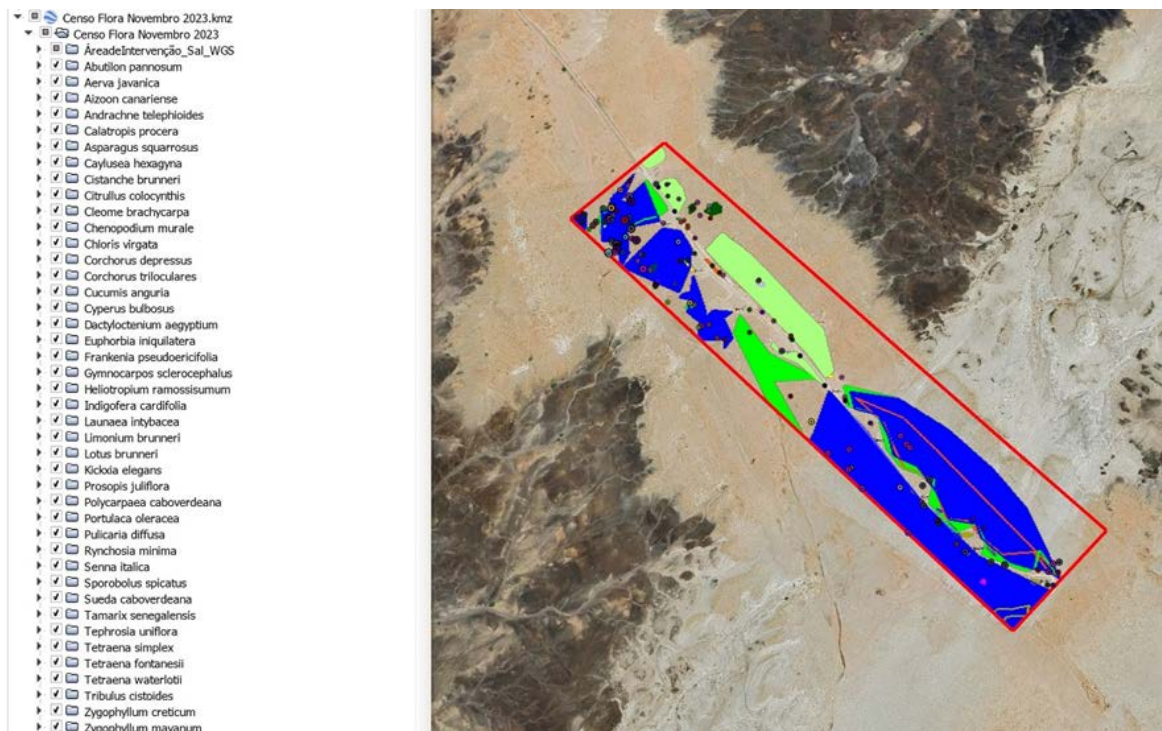


Figure 29: Visualization of the species list on the Google Earth platform for the second survey. On the left-hand side, a list of all the species found in the second survey is displayed, allowing the user to select specific plant species.

4. Conclusion

An ordinary visitor to the study area would think, at first glance, that there is no biodiversity. This is a common misconception for the rest of the island and for similar semi-desert habitats. However, the study found a surprising diversity of plants, totalling 42 different species during both surveys, with 5 different species only found during the second survey. This fact is even more relevant if we take into account that the first survey was carried out during the dry season and the second after a small rainy season, which prompt us to believe that with more rain, the abundance and even the diversity could be higher.

There are **ten species that need to be highly considered** during the planning, execution and running of the project. Those are either endemic species, or native species listed as protected by the government of Cabo Verde. Special attention needs to be taken for the species listed as endangered by the ICUN Red List of Threatened Species. This also include the *Lotus brunneri*, listed as Data Deficient.

During the second survey we saw an increase in the number of negative impacts on the wind farm's area, such as the passage of vehicles over vegetation, causing the destruction of individual plants and the degradation of the area. Several roads were found throughout the territory that passed directly over the vegetation. On one occasion, we recorded the flattening of an area with the material piled up at the end. The removal of stones and sand that have accumulated over the years makes it difficult for plants to establish themselves, which also considerably **reduces the soil's resistance to erosion** caused by natural events (rain and wind).



Figure 30 – Different examples identified in the area of study. The ecosystem, which is already stressed due to the lack of rain, is very fragile to human activity. The cover of the territory by rocks, sand and plants is important to reduce the erosion of the area.

5. Recommendations

After visiting the area of the wind farm and with better knowledge of the plant diversity and distribution existing there, the following recommendations are made:

- Adopt measures to reduce the circulation of cars and quad bikes to prevent driving over the vegetation. Circulation should be kept to the minimum areas needed.
- Avoid “clearing” areas and accumulating material with no obvious reason. This will only eliminate plants and speed up the degradation of the soil.
- The site has many plant species, some of which are endemic and/or protected, therefore, at least the areas with presence of those species should be targeted to prevent degradation.
- Raise awareness and informing staff and visitors about the existence of endemic species within the wind farm.
- Consider the distribution of the vegetation during the planning and installation of new batteries, both in terms of location of the new infrastructure and the installation process.