PLANT BIODIVERSITY IN COASTAL DUNES BETWEEN WEST OF DERNA AND EAST OF BENGHAZI IN THE NORTHEAST PART OF LIBYA

2022
Ph.D. THESIS
DEPARTMENT OF GEOGRAPHY

Awad G. Ghieth YOUNES

Thesis Advisor
Prof. Dr. Mücahit COŞKUN

PLANT BIODIVERSITY IN COASTAL DUNES BETWEEN WEST OF DERNA AND EAST OF BENGHAZI IN THE NORTHEAST PART OF LIBYA

Awad G. Ghieth YOUNES

Thesis Advisor
Prof. Dr. Mücahit COŞKUN

T.C.
Karabuk University
Institute of Graduate Programs
Department of Geography
Ph.D. Thesis

KARABUK
November 2022

TABLE OF CONTENTS

THESIS APPROVAL PAGE

I certify that, in my opinion the thesis submitted by Awad G. Ghieth YOUNES titled "PLANT BIODIVERSITY IN COASTAL DUNES BETWEEN WEST OF DERNA AND EAST OF BENGHAZI IN THE NORTHEAST PART OF LIBYA" is fully adequate in scope and in quality as a thesis for the degree of PhD.

Prof. Dr. Mücahit COŞKUN .....

Thesis Advisor, Department of Geography

This thesis is accepted by the examining committee with a unanimous vote in the Department of Department of Geography as a PhD thesis. 18/11/2022

Examining Committee Members (Institutions)	Signature
Chairman : Prof. Dr. Ali ÖZÇAĞLAR (KBU)	.....
Member : Prof. Dr. Mücahit COŞKUN (KBU)	.....
Member : Prof. Dr. Duran AYDINÖZÜ (KU)	.....
Member : Prof. Dr. Ülkü Eser ÜNALDI (GU)	.....
Member : Assoc. Prof. Dr. Sevda COŞKUN (KBU)	.....

The degree of PhD by the thesis submitted is approved by the Administrative Board of the Institute of Graduate Programs, Karabuk University.

Assoc. Prof. Dr. Müslüm KUZU .....

Director of the Institute of Graduate Programs

DECLARATION

I certify that this letter is the result of my field and office work and that all information contained in it has been obtained and explained by the academic rules and ethical policy set forth by the Institute.

And that all data, results and materials that are not original to this thesis have been cited and referenced verbatim.

I accept all moral and legal consequences of any discovery contrary to the above statement without a time limit.

Name Surname: Awad G. Ghieth YOUNES

Signature:

ACKNOWLEDGEMENTS

The research area covers coastal dune plants between Derna and Benghazi in northeastern Libya. Plant species were collected, examined, and classified. The study aims to determine the degree of plant diversity of species in sandy habitats, evaluate the impact of human activities on the habitats and vegetation of coastal dunes, and provide suggestions and solutions. Changes in coastal habitats and species distribution and diversity were examined, prepared as a doctoral thesis entitled "Plant biodiversity in coastal dunes," This area is characterised by geomorphological and botanical diversity, making it a green island area. It was noted that the scraping and dredging of sand caused a sharp decline in plant diversity. The research was prepared in five chapters, except for the introductory part. The first chapter mentioned the characteristics of the climate and geomorphological features, and the nature of coastal dunes and their most important characteristics as plant habitats were explained. The second chapter describes the distribution of plant species in coastal dunes, the classification of plant communities, and their distribution in sandy habitats. In the third chapter, the diversity of coastal dune plants and the nature of this diversity in sandy habitats were clarified. The fourth chapter deals with human activities and their impact on coastal habitats. The final chapter included data assessment and proposals from a botanical and geographical perspective.

I thank Allah and my advisor, Prof. Dr. Mücahit COŞKUN, who enlightened my scientific and practical career with his experience and provided moral support and outstanding guidance in selecting and producing this research. Many thanks to the discussion committee members for their support, guidance, and valuable advice in the field of study. Thanks and appreciation to Prof. Dr. Ibrahim ATALAY for his guidance and direction that helped produce the work in a distinctive geographical manner. Thanks and gratitude to Assoc. Prof. Dr Sevda COŞKUN for your effort and time contributing to the work's excellence.

I want to thank the fieldwork team, Professor Mohammed GHAZI and my friend Hamdi AHMEIDA for their participation and support, and my heartfelt thanks to my friend Kamil TÜRK.

I dedicate this humble work to my country and my family. To my little homeland, my wife Jamela. My children are Lateefah, Alzubier, Renad, Aiham, Jana and Tim Allah.

ABSTRACT

Coastal dunes are not a random accumulation of grains of sand. They are a complex and dynamic structure to which various factors contribute. Coastal dune ecosystems provide diverse habitats for a wide range of organisms, and These habitats have been exposed to multiple types of threats due to human pressures.

The area between the El-Jabal El-Akhdar coast and the Benghazi plain constitutes the scope of this study. The subject scope of the research is the plant biodiversity of the coastal dunes in the specified area. In other words, Plant Biodiversity in Coastal Dunes between the West of Derna and East of Benghazi in the Northeast part of Libya was determined as the scope of the thesis. Field work was carried out four times in March and September 2018 and 2019. The Domain-Kregena/Braun-Blanquet 5x5 squaring method was applied to the plant abundance on the dunes. With this method, descriptive and quantitative data were obtained. The data obtained were expressed with cartographic materials and graphics prepared with the Arc Map 10.7.1 GIS program. The application of many methods while preparing the thesis was made with a mixed model because the thesis was created with more than one method, not one.

The results are as follows: there are 98 plant species in 36 families, of which 15 are annual and semi-annual, and 83 are perennial or more than two years. The number of trees was 9, shrubs 30, broadleaf and spiny species 8, and herbaceous species were predominant, with a total of 51 species.

The number of invasive species detected was 6, four exotic to Mediterranean plants and two natives to invading degraded sites. It also identified endemic and threatened species in the area.

On the coastal dunes can be distinguished three main vegetation areas; in the first zone (foreshore dunes), we find the leading herbaceous plants specialized in tolerating critical conditions. In the second zone (backshore dunes), mixed plant species adapted to natural needs, and in the third zone, we find species adapted to low salinity and the influence of the sea, mixed with trees and shrubs of the Maquis formation. However,

due to the impact of human activities, we rarely find a natural gradient of these plant species in the research area. The study reached a set of results related to plant species,

Euphorbia spreads; this type is a stingy species. It becomes a pioneer species after human destruction in the dunes and spreads quickly. The seed that comes in the first year grows rapidly, develops, and spreads in the second year. In the 3rd year, it spreads to the entire destroyed dune area.

Sporobolus pungen; It is a species that develops on shallow sand dunes and stops the mobility of the dunes by spreading to the surface. It is a threatened species in dune areas.

Sarcopoterium spinosum; It is an important species in dune vegetation. It is resistant to direct exposure to sea water. It likes direct radiation. Seeds scattered in the environment develop rapidly after rain.

Ecballium elaterium; It is an invasive species. It spreads over large areas by settling rapidly in destruction sites. It quickly settles on treated surfaces in areas destroyed by road construction.

Heliotropium curassavicum; It is a species native to the Americas. It is known as a weed of exotic origin that spreads rapidly in habitats degraded by disturbance.

Solanum elaeagnifolium Cav; It is a perennial herb native to the Americas but is a widely naturalised species outside its original habitat.

Thymelaea hirsute; It is an indicator of the degradation of coastal dune habitats. It is capable of rapid spread. Resistant to direct exposure to sea water.

After habitat degradation, some annual species return and complete their life cycle, while perennial species need more time to develop their root system and spread. When dune layers are destroyed, it takes time for the dune layer to re-form in the environment. When the dune formation occurs, perennial species find the environment to spread again.

Many plant species can adapt to critical conditions in the coastal dune environment, such as *Silene canescens, Vulpia fasciculata, Cutandia divaricate, Scrophularia ramosissima, Ephedra alata Decne, Crucianella maritima, Ephedra distachya, Cakile maritima - Ephorbia paralias - Ephorbia peplis - Eryngium bourgatii - Medicago marina - Ammophila toralis - Juncus maritimus - Artemisia campestris -*

Pancratium maritimum. The distribution pattern of species changes due to human intervention, so we find mixed species such as *Silene canescens, Vulpia fasciculata, Cutandia divaricate, Scrophularia ramosissima, Ephedra alata Decne, Crucianella maritima, Ephedra distachya.*

Important plants distributed in coastal dunes, such as *Salsola kali-Medicago marina,* have pale-coloured, stiff leaves and branches, a waxy layer and small hairs covering the plant as an adaptation to the harsh conditions in these environments.

Areas severely degraded due to human activities, especially sand extraction, have been identified with high accuracy on maps, and damage has been documented in photographs and videos. This activity is seen as the fastest and most dangerous factor for biodiversity. Because it negatively affects the environment by destroying coastal habitats. It is probably an important cause of desertification of coastal dunes.

The study recommends that three areas with diverse habitats consisting of coastal dunes, marshes and endemic plant species should be protected in terms of biodiversity and designated as biosphere reserves.

Keywords: Plant biodiversity - Coastal dunes - Maquis - Plant endemism - El-Jabal El-Akhdar.

ÖZ

Kıyı kumulları, rastgele oluşmuş kum tanelerinin bir birikimi değildir. Çeşitli faktörlerin katkıda bulunduğu kumullar karmaşık ve dinamik bir yapıdır. Kıyı kumul ekosistemleri, çok farklı organizmalar için çeşitli habitatlar sağlamaktadır. Bu habitatlar, insan faaliyetlerinin baskıları nedeniyle birden fazla tehdit türüne maruz kalmaktadır.

El-Jabal El-Akhdar kıyısı ile Bingazi ovası arası kesim çalışmanın alan kapsamını oluşturmaktadır. Araştırmanın konu kapsamını ise belirtilen alandaki kıyı kumullarının bitki biyoçeşitliliği meydana getirmektedir. Başka bir ifadeyle Kuzeydoğu Libya'da Derna'nın batısı ile Bingazi'nin doğusu arasındaki kıyı kumulları üzerindeki bitki biyoçeşitliliği tez çalışmasının kapsamı olarak belirlenmiştir. Araştırmanın ilk aşamasında arazi çalışmaları tamamlanmıştır. 2018 ve 2019 yılının mart ve eylül aylarında 4 kez arazi çalışması yapılmıştır. Kumullar üzerinde bitki bolluğu ile ilgili Domain-Kregena/Braun-Blanquet 5x5 kareleme yöntemi uygulanmıştır. Bu yöntem ile tanımlayıcı ve nicel veriler elde edilmiştir. Elde edilen veriler Arc Map 10.7.1 GIS programı ile hazırlanan kartografik malzemeler ve grafiklerle ifade edilmiştir. Tez hazırlanırken pek çok yöntemin uygulanması, tezin bir değil birden fazla yöntemle oluşturulması yüzünden karma modelle meydana getirilmiştir.

Sonuçlar aşağıdaki gibidir: 36 ailede, 15'i yıllık ve yarı yıllık, 83'ü çok yıllık veya iki yıldan fazla olmak üzere 98 bitki türü vardır. Ağaç sayısı 9, çalılar 30, geniş yapraklı ve dikenli türler 8 ve otsu türler toplam 51 türü baskın olanlardır.

Tespit edilen istilacı türlerin sayısı, 4'ü Akdeniz bitkilerine egzotik ve 2'si istilacı bozulmuş bölgelere özgü olan 6 türdür. Ayrıca çalışma sahasında endemik ve tehdit altındaki türler de tanımlanmıştır.

Kıyı kumullarında üç ana bitki alanı ayırt edilebilir; İlk bölgede (ön kıyı kumulları), kritik koşulları tolere etmede iyi olan otsu bitkiler yer almaktadır. İkinci bölgede (Ard kıyı kumulları), doğal şartlara uymuş karışık bitki türleri ve üçüncü bölgede, maquis oluşumu ağaççıkları ve çalıları ile karışmış, düşük tuzluluğa ve denizin etkisine adapte olmuş türler görülmektedir. Bununla birlikte, insan faaliyetlerinin etkisi nedeniyle, araştırma alanında bu bitki türlerinin doğal bir gradyanı nadiren

bulunmaktadır. Çalışmada, belirtilen bitki türleriyle ilgili bir dizi sonuçlara ulaştığı söylenebilir. Yani:

Euphorbia spreads; bu tür istacı bir türdür. Kumullarda insan tahribi olduktan sonra öncü tür olarak gelir ve çok hızlı olarak yayılır. İlk yıl gelen tohum hızla büyür ve 2. yılda gelişir ve yayılmaya başlar. 3. yılda ise tahrip edilen tüm kumul alanına yayılır.

Sporobolus pungens; sığ kumullar üzerinde gelişen bir tür olup yüzeye yayılarak kumulların hareketliliğini durdurmaktadır. Kumul alanlarında tehdit altında olan türler arasındadır.

Sarcopoterium spinosum; kumul vejetasyonunda önemli bir türdür. Deniz suyuna doğrudan maruz kalmaya karşı dayanıklıdır. Doğrudan radyasyonu sever. Çevreye saçılan tohumları yağmurdan sonra hızlı bir şekilde gelişir.

Ecballium elaterium; istilacı bir türdür. Tahrip sahalarına hızla yerleşerek geniş alanlara yayılır. Yol yapımı nedeniyle tahrip edilen yerlerde işlenmiş yüzeylere hızla yerleşir.

Heliotropium curassavicum; Amerika'ya özgü bir türdür. Tahrip nedeniyle bozulan habitatlarda hızla yayılan egzotik kökenli bir ot olarak bilinmektedir.

Solanum elaeagnifolium Cav*;* Amerika'ya özgü çok yıllık bir bitkidir ancak orijinal yaşam alanının dışında yaygın olarak doğallaştırılmış bir türdür.

Thymelaea hirsute; kıyılardaki kumul habitatlarının bozulmasının bir göstergesidir. Hızlı yayılış yeteneğine sahiptir. Deniz sularına doğrudan maruz kalmaya dayanıklıdır.

Habitat bozulmasından sonra, bazı tek yıllık türler geri döner ve yaşam döngülerini tamamlarken, çok yıllık türler kök sistemini geliştirerek yayılış yapmak için daha fazla zamana ihtiyaç duymaktadır. Kumul tabakaları yok olduğunda ortamda yeniden kumul tabakasının oluşumu zaman alır. Kumul oluşumu meydana geldiğinde çok yıllık türler tekrar yayılış ortamı bulur.

Silene canescens, Vulpia fasciculata, Cutandia divaricate, Scrophularia ramosissima, Ephedra alata Decne, Crucianella maritima, Ephedra distachya, Cakile maritima - Ephorbia paralias - Ephorbia peplis - Eryngium bourgatii - Medicago marina - Ammophila toralis - Juncus maritimus - Artemisia campestris - Pancratium maritimum gibi birçok bitki türü kıyı kumul ortamındaki kritik koşullara uyum

sağlayabilir. İnsan müdahalesi nedeniyle türlerin dağılım şekli değişir. Bu nedenle *Silene canescens, Vulpia fasciculata, Cutandia divaricate, Scrophularia ramosissima, Ephedra alata Decne, Crucianella maritima, Ephedra distachya* gibi karışık türler bulunur.

Kıyı kumullarında yayılış gösteren önemli bitkiler, *Salsola kali-Medicago marina'da* olduğu gibi, bu ortamlardaki zorlu koşullara adaptasyon olarak soluk renkli, sert yapraklı ve dallı, mumsu bir tabaka ve bitkiyi kaplayan küçük tüylere sahiptir.

İnsan faaliyetleri, özellikle kum kürümeleri (kum alımı) nedeniyle ciddi şekilde bozulan alanlar haritalarda yüksek doğrulukla tespit edildi, fotoğraflar ve videolar ile hasarlar tespit edilmiştir. Bu aktivite biyolojik çeşitlilik için en hızlı ve en tehlikeli faktör olarak görülmektedir. Çünkü kıyı habitatlarını tahrip ederek çevreyi olumsuz etkilemektedir. Bu durum muhtemelen kıyı kumullarının çölleşmesinde önemli bir nedendir.

Çalışma, kumullar, bataklıklar ve endemik bitki türlerinden oluşan çeşitli habitatların bulunduğu üç alanın biyoçeşitlilik açısından korunmasını ve biyosfer rezervi olarak belirlenmesini önermektedir.

Anahtar Kelimeler: Bitki biyoçeşitlilik - Kıyı kumulları - Maquis - Bitki endemizmi - El-Jabal El-Akhdar.

الملخص بالعربية

الكثبان الساحلية ليست تراكما عشوائيا لحبيبات الرمل. إنها بنية معقدة وديناميكية تساهم فيها عوامل مختلفة. توفر النظم الإيكولوجية للكثبان الساحلية موائل متنوعة لمجموعة واسعة من الكائنات الحية، وقد تعرضت هذه الموائل لأنواع متعددة من التهديدات بسبب الضغوط البشرية.

تشكل المنطقة الواقعة بين ساحل الجبل الأخضر وسهل بنغازي نطاق هذه الدراسة. نطاق موضوع البحث هو التنوع البيولوجي النباتي للكثبان الساحلية في المنطقة المحددة. وبعبارة أخرى، تم تحديد التنوع البيولوجي النباتي في الكثبان الساحلية بين غرب درنة وشرق بنغازي في الجزء الشمالي الشرقي من ليبيا كنطاق للأطروحة. تم تنفيذ العمل الميداني أربع مرات في مارس وسبتمبر 2018 و2019. تم تطبيق طريقة تربيع / Domain-Kregena Braun-Blanquet 5x5على وفرة النباتات على الكثبان الرملية. بهذه الطريقة، تم الحصول على بيانات وصفية وكمية. تم التعبير عن البيانات التي تم الحصول عليها باستخدام مواد رسم الخرائط والرسومات التي تم إعدادها باستخدام برنامج .Arc Map 10.7.1 GIS تم تطبيق العديد من الطرق أثناء إعداد الأطروحة بنموذج مختلط لأن الأطروحة تم إنشاؤها بأكثر من طريقة وليس طريقة واحدة.

النتائج هي كما يلي: هناك 98 نوعا نباتيا في 36 عائلة، منها 15 نوعا سنويا ونصف سنوي، و83 نوعا معمرا أو أكثر من عامين. كان عدد الأشجار 9، والشجيرات 30، والأنواع عريضة الأوراق والشوكية 8، وكانت الأنواع العشبية هي السائدة، بإجمالي 51 نوعا.

كان عدد الأنواع الغازية المكتشفة 6، أربع نباتات غريبة على البحر الأبيض المتوسط واثنين من السكان الأصليين لغزو المواقع المتدهورة. كما حددت الأنواع المتوطنة والمهددة في المنطقة.

على الكثبان الساحلية يمكن تمييز ثلاث مناطق نباتية رئيسية. في المنطقة الأولى (الكثبان الأمامية)، نجد النباتات العشبية الرائدة المتخصصة في تحمل الظروف الحرجة. في المنطقة الثانية (الكثبان الساحلية)، تتكيف الأنواع النباتية المختلطة مع الاحتياجات الطبيعية، وفي المنطقة الثالثة، نجد أنواعا تتكيف مع انخفاض الملوحة وتأثير البحر، مختلطة مع الأشجار والشجيرات من تكوين .Maquis ومع ذلك، نظرا لتأثير الأنشطة البشرية، نادرا ما نجد تدرجا طبيعيا لهذه الأنواع النباتية في مجال البحث. وتوصلت الدراسة إلى مجموعة من النتائج المتعلقة بالأنواع النباتية،

Euphorbia spreads يأتي كنوع رائد بعد تدمير الإنسان في الكثبان الرملية وينتشر بسرعة كبيرة. تنمو البذرة التي تأتي في السنة الأولى بسرعة وتتطور وتبدأ في الانتشار في السنة الثانية. وفي السنة الثالثة، ينتشر إلى منطقة الكثبان الرملية المدمرة بأكملها.

Sporobolus pungens إنه نوع يتطور على الكثبان الرملية الضحلة ويوقف حركة الكثبان الرملية عن طريق الانتشار إلى السطح. إنه نوع مهدد بالانقراض.

Sarcopoterium spinosum نوع مهم في تثبيت الرمال ، مقاوم للتعرض المباشر للبحر ، ينمو بعيدا عن مناطق الظل ، وتنتشر بذوره وتنمو بكثافة بعد المطر.

Ecballium elaterium يغزو المواقع المضطربة وحواف الطرق، ويغطي مساحات واسعة، وهو مؤشر على الأنشطة البشرية.

Heliotropium curassavicum نوع موطنه الأمريكيتان ، يظهر كحشائش تنتشر بسرعة في المناطق المتدهورة.

***Solanum elaeagnifolium* Cav** نبات معمر، موطنه الأمريكيتان ولكنه الآن متجنس على نطاق واسع خارج نطاقه الأصلي.

Thymelaea hirsuta نوع يُعد مؤشراً على تدهور الموائل الرملية الساحلية، ينتشر بسرعة ، ويقاوم التعرض المباشر للبحر.

بعد تدهور الموائل، تعود بعض الأنواع السنوية وتكمل دورة حياتها، بينما تحتاج الأنواع المعمرة إلى مزيد من الوقت لتطوير وإصلاح نظام الجذر، ثم بناء ركيزة والعودة إلى النمو.

تملك العديد من الأنواع النباتية قدرة على التكيف مع الظروف الحرجة في بيئة الكثبان الساحلية مثل *Cakile maritima - Ephorbia paralias - Ephorbia peplis - Eryngium bourgatii - Medicago marina - Ammophila littoralis - Juncus maritimus - Artemisia campestris - Pancratium maritimum* يتغير نمط توزيع الأنواع بسبب التدخل البشري، لذلك نجد أنواعا مختلطة مثل *Silene canescens, Vulpia fasciculata, Cutandia divaricate, Scrophularia ramosissima, Ephedra alata Decne, Crucianella maritima, Ephedra distachya.*

النباتات الهامة الموزعة في الكثبان الساحلية، مثل *Salsola kali-Medicago marina*، لها أوراق وفروع شاحبة اللون وصلبة وطبقة شمعية وشعر صغير يغطي النبات للتكيف مع الظروف القاسية في هذه البيئات.

تم تحديد المناطق المتدهورة بشدة بسبب الأنشطة البشرية، وخاصة استخراج الرمال، بدقة عالية على الخرائط، وتم توثيق الأضرار في الصور ومقاطع الفيديو. ينظر إلى هذا النشاط على أنه العامل الأسرع والأكثر خطورة للتنوع البيولوجي. لأنه يؤثر سلبا على البيئة من خلال تدمير الموائل الساحلية. ربما يكون سببا مهما لتصحر الكثبان الساحلية.

اقترحت الدراسة ثلاثة مواقع كمحميات طبيعية مهمة للغاية من حيث التنوع البيولوجي، حيث توجد موائل متنوعة من كثبان رملية ومستنقعات وبحيرات وأنواع نباتية متوطنة.

الكلمات المفتاحية: التنوع الحيوي النباتي - الكثبان الساحلية - تكوين الماكي - التوطن النباتي - الجبل الأخضر

ARCHIVE RECORD INFORMATION

Name of Thesis	Plant biodiversity on dunes in the west of Derna and east Benghazi in north-eastern Libya
Author of Thesis	Awad G. Ghieth YOUNES
Advisor of Thesis	Prof. Dr. Mücahit COŞKUN
Degree of Thesis	Ph. D.
Date of Thesis	18/11/2022
Field of Thesis	Geography
Place of Thesis	UNIKA / IGP
Number of Pages	288
Keywords	Plant biodiversity; Coastal dunes; Maquis; Plant endemism; El-Jabal El-Akhdar

ARŞİV KAYIT BİLGİLERİ

TezinAdı	Libyanın Kuzeydoğusunda Derne Batısı ile Benghazi Doğusu Arasındaki Kıyı Kumullarında Bitki Biyoçeşitliliği
TezinYazarı	Awad G. Ghieth YOUNES
TezinDanışmanı	Prof. Dr. Mücahit COŞKUN
TezinDerecesi	Doktora
TezinTarihi	18/11/2022
TezinAlanı	Coğrafya
TezinYeri	KBÜ/LEE
TezinSayfaSayısı	288
AnahtarKelimeler	Bitki biyoçeşitliliği; Kıyı kumulları; Maki; Bitki endemizmi; El-Jabal El-Akhdar

ABBREVIATIONS AND TERMS

Some of the terms mentioned in the research have been explained in their scientific meaning to deal with them systematically and avoid misunderstandings due to incorrect interpretations of terms across different languages or scientific research centres.

Native species: When species originate in or access a particular area without direct or indirect human intervention, and this access is from a native area.

Alien (introduced) species: A species that exists in an area due to intentional or accidental human activity.

Exotic (random) species: Species that breed in an area, and these groups need human support to survive (not homogeneous).

Invasive (competition) species: species that reproduce in large numbers at a distance from mother plants (more than 100 m in less than 50 years for species that reproduce seeds, and more than 6 m in 3 years for species that reproduce vegetatively (by creeping roots and stems) invade natural or semi-natural ecosystems. For clarification, see David Richardson et al., 2000.

Endemic species: limited to a specific geographical area. The endemism of a place or region means that it exists only in that part of the world and nowhere else.

Common (non-endemic): species are universal species with biological characteristics that make them more widespread at different levels of ecosystems.

Geographical separation (separation): It is the prevention or obstruction of communication between plant communities using geographical barriers, which is one of the factors of ancient and modern endemism, and one of its results is the isolation of a group of species geographically due to a natural phenomenon or human intervention with a broad impact.

Broadleaf: includes all perennial, annual and semi-annual species with large leaves.

Psammophilous plants: plants that grow on sand.

USGS: It is an abbreviation for the United States Geological Survey.

Ann: Annual.

Per: Perennial.

Mar: March.

Sep: September.

INTRODUCTION

The introductory part of the thesis covers the topic, field of research, objectives, relevance, methodology and analysis of previous studies.

Research Scope

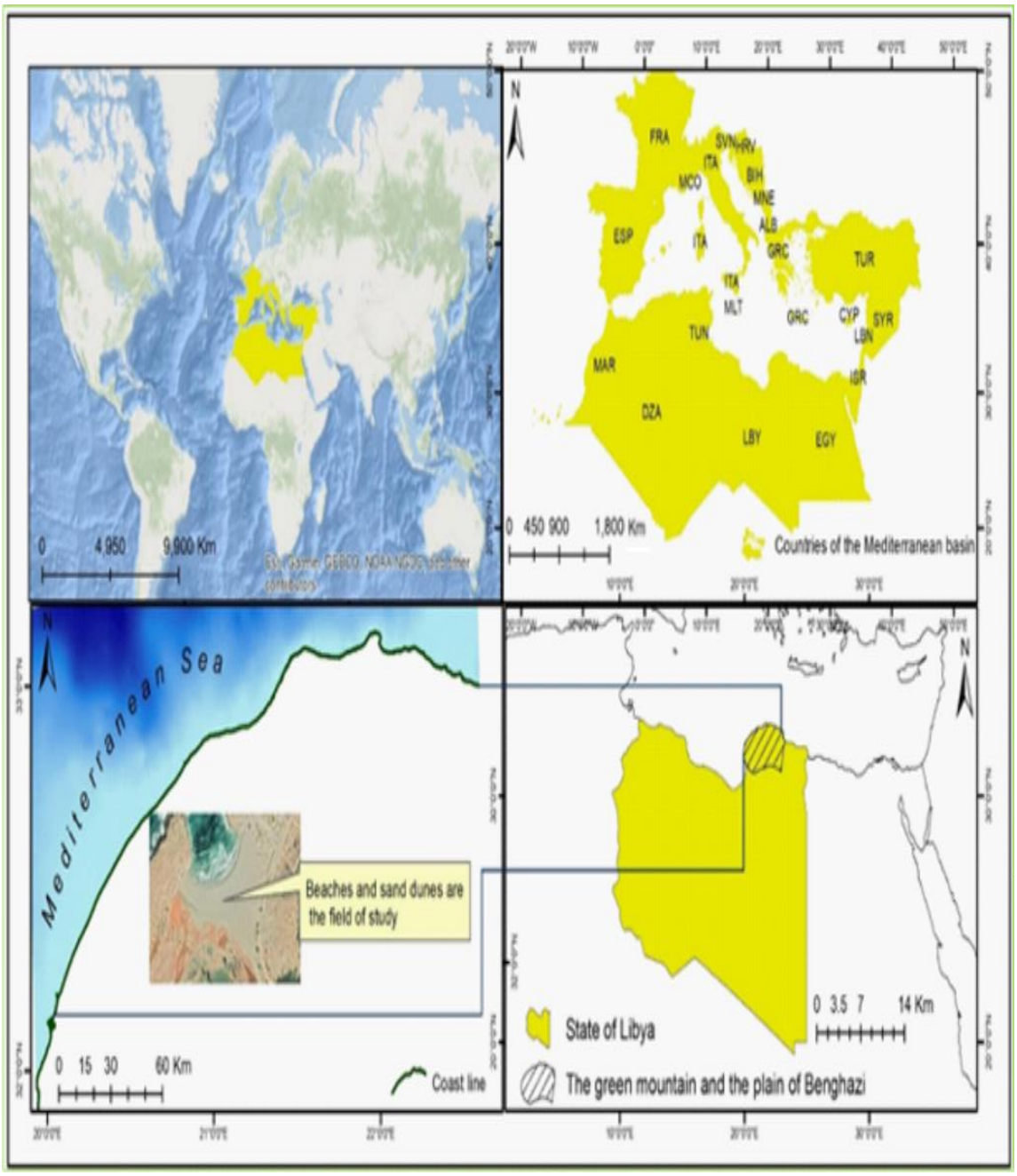
The research was conducted in Biogeography, the branch of vegetation geography in the Department of Physical Geography. The range between the study was prepared as plant biodiversity in the coastal dunes of the El-Jabal El-Akhdar coast and the Benghazi plain in northeastern Libya. In defining this area as an area of study, the objective was to identify the diversity and ecological characteristics of the environment, identify types of natural and anthropogenic pressures, detect and assess impacts, and identify possible measures.

The Field Range Of Research

It is located in the northeastern part of Libya on the coast of Jabal Akhdar and the Benghazi Plain, within the vegetation area of the Mediterranean Sea, and is located astronomically between N32° 10'00.41" and E020° 05'38.36", N32° 48'01.91" and E022° 31'55.92"

Geographically located between the city of Derna and Benghazi in northeastern Libya and extends over a coastline of 300 km, map 1 shows the geographical and astronomical location. The vegetation line represents the northern boundary of the area and the outer range of ancient dunes, the southern boundary.

Dunes make up 20,463,013.26 m^2, and swamps 29,543,913.28 m^2. Some sandy beaches range in width from 20 to more than 750 meters.



Map 1. Location of North El-Jabal El-Akhdar and Benghazi Plain

Scope Of The Research Topic

Coastal dunes represent attractive environments from an ecological perspective. They are diverse terrestrial and water-water biological systems through the occupation of transition zones between terrestrial and marine ecosystems, their complex systems, composition, and interactions over long periods. Due to their sensitivity, botanists and ecologists have devoted more attention to particular ecosystem species (Kavgaci, 2007). Dunes are one of the most sensitive ecosystems, and although they are located in a very narrow area of the world, they have higher biodiversity than other natural ecosystems.

The boundaries of the botanical community are a mosaic of suitable local spots colonized by different species at different times. The boundaries of the plant community are not fixed and show a constant exchange of species (Castillo & Casasola, 1996). Due to their particular nature, plants are a good indicator of biodiversity in general and the ecosystem health of coastal dune environments.

In coastal dunes, strong ecological gradients determine the coexistence of different plant communities in a relatively small area; one of the essential features of coastal dunes is their high biodiversity in ecological heterogeneity and diversity of species formation. The dunes are home to many rare plants (Avcı, 2005).

However, all over the world and especially in the Mediterranean, coastal ecosystems are under severe threat. In the Southern Mediterranean, 75% of IPAs were endemic in one country. 60% contain minimal species; major endemic sites containing more than 20 species have been found in Algeria, Morocco, Lebanon, Syria and Libya (Catullo et al., 2011).

These marginal habitats are essential for ecosystem functioning because they provide sanctuary for wildlife, so meadows, roadsides, field boundaries, and other marginal habitats may act as connecting corridors (Cakan, 2011). Coastal dunes are complex systems in terms of vegetation growth. The vegetation of coastal dunes is quite different from other species. This distinction arises due to the characteristics of the dunes and their location as a habitat (Avcı, 2017).

The presentation and analysis of previous literature showed a lack of specialized studies on coastal dunes as diverse habitats from a botanical point of view. In the present study, a field survey was conducted on the part of the Libyan coast, namely the El-Jabal

El-Akhdar and the Benghazi plain in northeastern Libya, to determine the plant biodiversity in this natural environment, which is the environment of coastal dunes. It describes patterns of spatial variation in species diversity along the coastal slope of dunes. It identifies vegetation ranges in this environment, essential to the region's richness, especially El-Jabal El-Akhdar, which represents Libya's most important and prosperous vegetation area.

Purpose And Sub-Objectives Of The Research

The study aims to document the vegetation cover of coastal dunes on the Jabal Akhdar and the Benghazi Plain and reveal the vegetation diversity and distribution of vegetation cover in sandy habitats. Provide assessment of coastal dunes using various analyses aimed at providing a better understanding of the structure and composition of plant communities and the successive stages of gradation of plant communities in the interior. Classify coastal dunes and identify the most critical factors affecting the region's natural distribution and plant biodiversity. Including monitoring and evaluation of human activities and their impacts on coastal dune ecosystems as plant habitats and the extent to which species can be restored, preserved and developed as a result of activities such as severe dredging and sand stratification, a sharp decline and change in the composition and number of species in plant communities have been revealed.

To achieve these goals, we will look for answers to the following questions:

- How does the distribution of dunes affect the distribution and diversity of plant species?
- What is the distribution pattern of plant species in coastal dunes?
- What are the main factors affecting plant diversity in sandy habitats?

The Jebel Akhdar region in northeastern Libya is one of the most critical areas for biodiversity, containing the only natural forest from the borders of Tunisia in the west to the borders of Palestine in the east. It is among Libya's top 4 plant endemic centres, with an area of 23,000 km2 or 1% of the total 1,760,000 Km^2.

In terms of topography and rainfall, this unique region has produced a Mediterranean island of the ever-green Maquis forest, surrounded by desert to the south and east, overlooking the Mediterranean coast to the north and west.

Climatically, Jabal Akhdar is the wettest region in the country, characterized by cyclonic winter weather. Average annual rainfall ranges from 300 mm in the coastal zone to 560 mm in some areas of the second edge of Jebel Akhdar (Al Hanafi & Nooh, 2012).

Its soil is diverse, containing more than 11 central taxonomic units, which include about 1,750 species of natural plants, including plants endemic to Libya, and about 4,590 species of wild (Environment Public Authority, 2010) according to surveys. They are incomplete and outdated, with unrecorded plant species and wildlife.

In Libya, coastal dunes have not been studied as plant habitats, these habitats are part of plant diversity, and although they are located in a very narrow area of the world, they have higher biodiversity than natural ecosystems.

Coastal dune plant species are declining as human activities continue with such a rapid capacity for change and specialized research results in the discovery of new plant species, the distribution of plant species and communities, the characteristics of these habitats, and provides a better understanding.

Search Boundaries

The coastal dunes area from the west of Derna City to the east of Benghazi City represents the boundaries of the search area.

Botanically, from the vegetation of the drift line, through the swamps to the outer range of ancient dunes and the emergence of the Maquis community or coastal forest; in other words, the leading annual vegetation that characterizes the coastal zone from the shore to the juniper-dominated shrub formations on the stationary dunes.

The Conceptual Background Of The Research

Microclimate affects species' morphology and plant communities' geographical distribution. Plant biodiversity is influenced by geomorphology and invasive species. Urban areas, resorts, sand scraping, various forms of trampling, swamp demolition, waste of all kinds, and grazing threaten plant diversity and promote the spread of invasive species.

To illustrate further, variables, factors and conditions affecting coastal dune biodiversity can be formulated as follows: Figure 1 illustrates human activities that threaten coastal habitats, and Figure 2 shows the effect of distance from the sea and substrate stability on plant diversity in coastal habitats, and Figure 3 shows the spread of invasive species as a result of coastal habitat degradation.

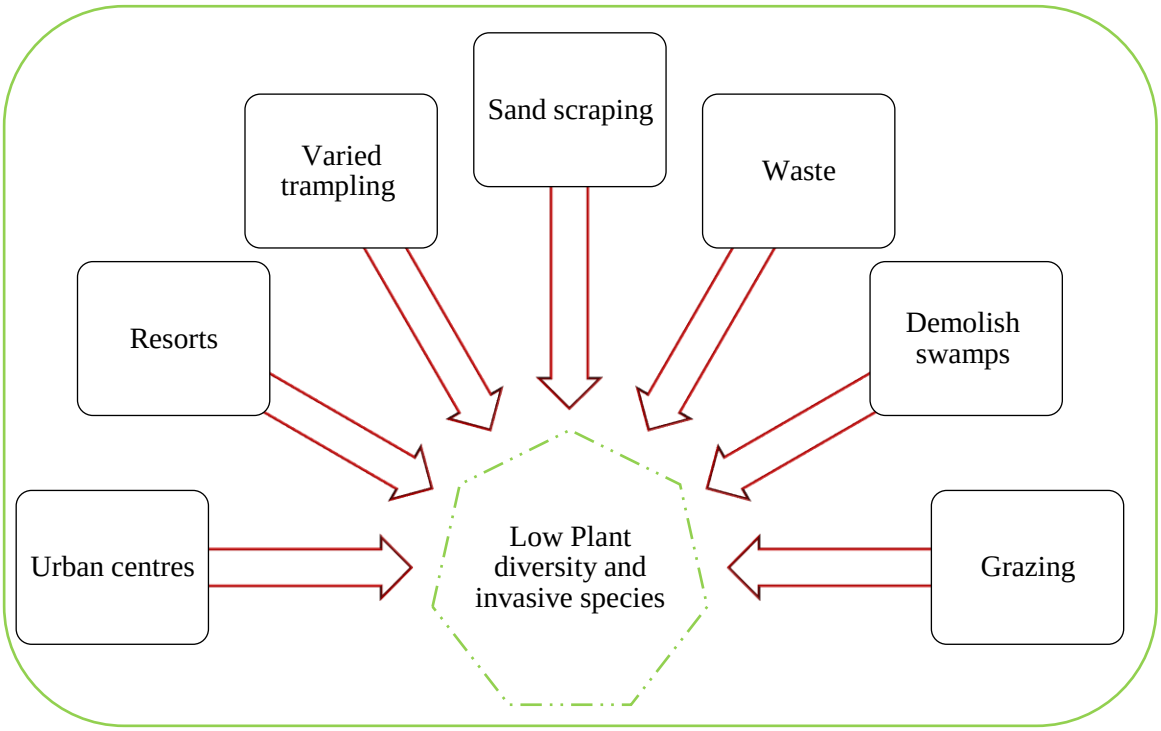


Figure 1. Human activities are the most threatening to coastal habitats

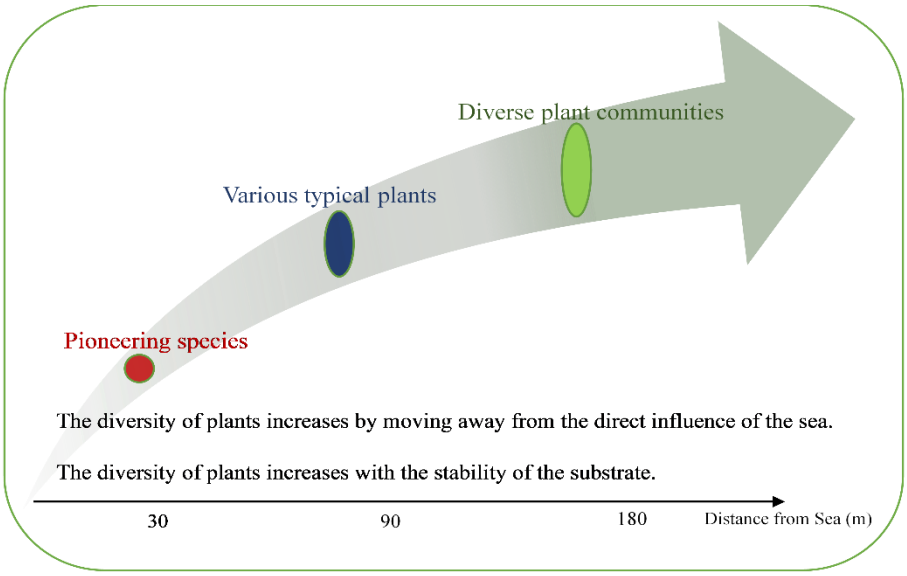


Figure 2. Distance from the direct influence of the sea and stability of the substrate are factors that increase plant diversity

Swamps, lakes and valleys near the sea are sites of plant diversity and endemic to species.

When the substrate is thin sand with a layer of rock, we find woody species with solid roots.

Sites flooded in winter have a botanical community with distinctive characteristics.

The destruction of sandy habitats distorts the mosaic of plant communities regarding spatial distribution and the number of species.

After the degradation of sand habitats, the dunes begin to grow again, invasive plant species emerge and spread rapidly, and some notable species may not reappear at these sites.

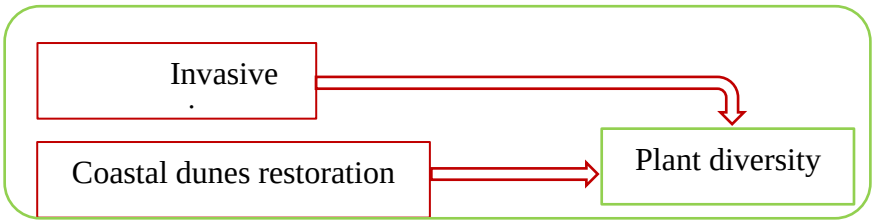


Figure 3. The disintegration of coastal habitats increases the spread of invasive species

Coastal dunes exist in all latitudes and all climatic systems and are very diverse , comprising forests, grasslands and shrubs, all of which share a response to environmental constraints such as temperature, drought and nutrient deficiencies (L. M. Martínez et al., 2013).

Coastal sand ecosystems include terrestrial beaches, spitting and dunes where sand is the dominant substrate. They contain ecological communities characterized by scattered grasses, forests and wetlands.

Three zones can be distinguished:

A low beach area with scattered vegetation.

Upper beach area, with grassy beach communities.

Dune areas with no stable vegetation (Page et al., 2011).

When discussing the factors affecting plant life in the dune environment, it is appropriate to classify them into weathering, hydrodynamic, structural, topographical, and historical (Olsson-Seffer, 1909).

Coastal dunes are complex systems in terms of vegetation growth. Some factors that limit growth are the lack or absence of nutrients and organic matter, high permeability, exposure to direct sunlight, exposure to wind, substrate movement, and salt spray (Avcı, 2017).

The effect of temperature, drought and salt on *Phleum sardoum*, an endemic species of Sardinia that grows exclusively on coastal dunes, showed that germination was better during autumn and winter when water was available under a Mediterranean climate (Santo et al., 2014).

Focus on physical environmental factors such as strong winds, intense insolation, and extensive summer heat from the sand surface. In response to these conditions, some species, like desert plants, modify their structure to protect themselves from excessive water loss through transpiration (Kearney, 1904).

The geographical composition of endemic species on the slopes towards the Mediterranean Sea was analyzed. In the subspecies *Pseudoscabiosa limonifolia*, it is an endemic species from Sicily (Italy) whose general distribution has been determined by

field observations, habitat descriptions and conservation status assessment, also taking into account the geographical relationships of the closest species (De Simone, 2021).

Coastal areas are sensitive systems that suffer from natural and anthropogenic stress, and geomorphological changes show a relationship between the formation of native species and local environmental features (Lomba et al., 2008). In mid-latitudes, Turkey is one of the wealthiest regions in plant diversity, with about 12,000 species. Several factors contribute, the most important of which are climate, geomorphology, and soil diversity. The endemic rate is also high. The number of endemic species in Turkey is more than 3000 (Avcı, 2005).

About 10% of Turkey's coastline is coastal dunes, habitats for endemic plant species. The negative impact of populations on coastal dunes is increasing and threatening essential plant species (Avcı et al., 2015).

There are many human pressures on sandy beaches, and their biodiversity contains a unique variety of species. Such habitats are widely used. Many wildlife species, such as birds, turtles and fish, rely on beaches and dunes for nesting and feeding (Schlacher et al., 2013).

The primary role in vegetation disturbance is due to harmful human activities such as land misuse, coal burning and overgrazing (Elshatshat & Mansour, 2014). Since there is no uniform vegetation taxonomy in Europe and the Mediterranean basin, a database of 30,759 coastal vegetation fragments from the Atlantic, Baltic, Mediterranean and Black Sea coasts of Europe has been compiled, resulting in 18 coastal dune vegetation alliances, including the newly described *Centaureo unifoliate-Verbascion pinnatifid* from the Aegean region (Marcenò et al., 2018).

The study revealed descriptions of some newly identified and semi-defined entities and changes in the nomenclature and taxonomic order of other entities, including *Sedum cyrenaicum, Sedum laconicum* and *Salsola siberi Presl ssp. Cyrenaica* (Brullo & Furnari, 1979). Investigation of species diversity and floral analysis of the Poaceae family in Libya Based on data provided by the Flora of Libya series, the Poaceae family in Libya consists of 229 species belonging to 92 genera. The geographical distribution of the species showed that the highest percentage (31.88%) was for the Mediterranean region (Al-Sghair, 2019).

Pumice fragments of various sizes and circular mixed with modern coastal deposits of limestone sand, lime grains, and shells have been found in the southwest of Benghazi and the coastal area of Qasr, Libya and El-Jabal El-Akhdar in northeastern Libya. The pumice must have travelled at least 1,000 km across the Mediterranean Sea as a pontoon. The recent coastal sediments in the Jabal Akhdar region are mainly derived from two different sources: a nearby southern source, consisting of a well-exposed series of bicarbonate rocks that produced well-sorted sand-sized fragments, and a northern source that produced gravel-sized fragments of pumice (Elzouki & Elfigih, 2020).

The lack of updating or revision since 1989 means that Libyan plants are obsolete and require re-evaluation using modern methods. Initial efforts are reported here to provide an updated checklist covering 43 out of 150 families of plants published in Libya, including 138 genera and 411 species (Gawhari et al., 2018).

Research Materials and Method

The study is based on field surveys to understand and analyze coastal dune habitats from a geographical, geomorphological and botanical point of view and assess the status of plant communities in sand habitats in terms of plant diversity and species abundance. The area was divided into three main parts: due to the tremendous geomorphological diversity and to facilitate field work. The materials used in research, literature and studies conducted in sandy habitats have been reviewed from various sources. Sources of geomorphological data include the study and analysis of maps and satellite images and direct data from fieldwork. Data from detailed maps and topographic maps were used to prepare sites and work points, correlation of coordinates and organization field visits.

The focus was on two main points. Use vegetarian community-level landscaping to determine the size and location of sandy habitats and monitor plant families, genera, species, and age. The perceived human impact on sandy habitats was monitored and calculated. Changes in dune areas were observed using different remote sensing software, followed by on-site documentation and measurement.

Geomorphologically, the area was divided into ranges from the near-sea vegetation line to the interior, and descriptive and quantitative data on plant species were

collected, using 5 × 5 square meters, to measure plant abundance according to the Domain-Kregena/Braun-Blanquet method as illustrated in Table 1.

Table 1. Measurement of plant abundance according to the composite scale method (Domain-Krajina/Braun-Blanquet)

Brawn - Blnquet	Domain - Krajina	cover%
5	10 multiple types complete overlap	100
4	9 Many types and cover more than 3/4 and less than the total cover	75
	8 Several types overlap 1/2 to 3/4	50 - 75
3	7 Medium-large number 1/3 to 1/2	33 - 50
2	6 Too many 1/4 to 1/3	25 - 33
1	5 A large number of 5 types of interference 1/10 to 1/4	10 - 25
*	4 Types of large numbers overlap from 1/20 to 1/10	5 - 10
	3 Several species overlap less than 1/20	1 - 5
r	2 Scattered overlap less	1
	1 Rare types, cover case uncertain	
*	A few individuals cover very little	
r	One individual with minimal cap	

The vegetation area in sandy habitats has been identified, classified and evaluated, and an attempt has been made to explain the factors that have influenced plant diversity.

The study produced maps showing plant species distribution and spread using GIS software, locations of severe degradation in coastal habitats, and maps of proposed nature reserve locations.

Organizing and Scheduling Data

The climate data used in the study are data produced from temporary stations used by scientific research companies in the region, and experts in the climate of El-Jabal El-Akhdar were consulted regarding the data and their results and the climatic classification of the region, as defined by Noah and Al-Hanafi 2012, for further clarification see (Al Hanafi & Nooh, 2012) and (Nooh, 2007).

As for the plant data, samples were collected, measurements, observations, photos and videos were taken, with the organization and arrangement of plant species and families in the area.

Plant Sample Collection and Identification

The phases of fieldwork were carried out in four phases in two consecutive seasons, the first phase in March and April, the second phase in August and September 2018, the third phase in February and March, and the last phase in July and August 2019.

Samples of plants were collected in the field, with data on the geographic and astronomical location (unpublished data) of these habitats. Then they produced maps showing the distribution of families, species, and highly degraded areas.

Working Software and Tools

ArcGIS Earth - USGS Map - QGIS 3.10.13 A - ArcMap 10.7.1 - Terra incognita 2.45 - Google Earth Engine -Landsat 8 satellite images - Paint Net - PlantNet - PaInkscape -PhotoPad Image Editor - maps 1: 250,000 - GPS - Nikon D3500 a camera - Metric wheel - Measuring meter reel - Colored ribbons 50 m pegs - Atlas of coastal dune vegetation in Libya (in preparation).

Difficulties Encountered in the Study

The most serious difficulty that the study faced was the lack of climatic data (especially the local climate) due to the nature of the research field. So we relied on data from previous studies of companies and research centres analyses and rankings by the best climate experts in El-Jabal El-Akhdar and Benghazi Plain, The study is the first scientific treatise on plant biodiversity in the coastal dunes of Libya, and this has resulted in many difficulties, such as the severe lack of data. The botanical library database is outdated. There is a severe lack of data on plant species in general and on plant species in the coastal dune environment.

Previous Search

Kearney (1904), in his study "Are the Plants of Seashores and Dunes Halal Plants?" He explained that factors of the physical environment other than the excessive concentration of a soil solution must be considered to explain the typically dry character of sandy plants (strong wind, solar radiation, surface temperature). These factors lead to particular adaptations of plant species.

Olsson-Seffer (1909), in his study "The Relationship between Soils and Plants on Sandy Sea Shores," referred to the factors affecting plant life, categorized into meteorological, hydrodynamic, structural, topographical, and historical factors. It is necessary to know the impact of human activities in studying vegetation cover on coastal sands; Then, some biological agents come from plants.

DE Molenaar (1974), in his manuscript entitled "Vegetation of the Angmagssalik District, Southeast Greenland. I. Littoral vegetation" The composition of coastal plant communities depends on the physical characteristics of the coast, the most important of which are climate, characteristics of open water, substrate, phytogeographical, and historical factors.

Brullo and Furnari (1979), in their study "Taxonomic and Natural Observations on the Plants of Cyrenaica (Libya)", Some specific and subspecific new entities are described. Besides, the nomenclature and the taxonomic rank of other entities are changed. *Salsola sieberi* Presl ssp. *cyrenaica*.

Castillo and Casasola (1996), in a study "Coastal dune vegetation: an extreme case of species invasion", analysed the distribution of plant groups over 44 sites to understand the differences in floral composition and richness found along the coast. Ruderal or species are frequently found inland, common in disturbed areas such as roadsides, abandoned fields, or part of secondary growths.

Avcı (2005), in a study entitled "Diversity and endemism in Turkey's Vegetation", plant species, including halophytes, and that plant endemism rates in Turkey are more significant than in European countries that plant diversity is under serious threat from human activities such as harvesting.

Yılmaz and Serbest (2005), in a study " Investigation of Environmental Impacts on the Saros Bay Coastal Dunes ", most dune plants cannot continue their lives anywhere

except in dune areas. Their environmental impacts on them have been identified and evaluated by various criteria. The illegal extraction of sand is a critical threat to the dunes and, in particular, destroys dune meadows; the negative impact of grazing on plants indirectly damages the dune ecosystem.

Acosta, Ercole, Stanicki, Pilar & Blasey (2007), in a study entitled "Coastal vegetation zone and dune morphology in some Mediterranean ecosystems", analysis of coastal vegetation at some best-preserved sites on the coast of Lazio (Central Italy). To determine whether societal differences are related to slope and side, the results showed that no societal sequence is perfect.

Kavgaci (2007), in a study, "Sand Dune vegetation of Igneada coast in the Thracian part of Turkey", three communities were defined. These communities are *Otho-Leymetum fabulous, Medicago rigidula-Cionura erecta* basal community and meadow behind the dune; behind it is a vegetation belt of universal species or characteristics of meadow plants.

Lomba, Alves and Honrado (2008), in a study entitled "Endemic Sand Dune Vegetation of the Northwest Iberian Peninsula: Diversity, Dynamics, and Significance", coastal systems are affected by natural and human geomorphological changes and show a link between the composition of local species and local environmental features.

Gamper, Filesi, Buffa and Sburlino (2008) published a study titled "Phytogenetic diversity of north-Adriatic coastal dunes 1-Phanerophytic communities". The high originality of the vegetation is due to its bioclimatic and phytogeographical characteristics. Spread of *Juniperus communis* ssp. The community presence that contributes to its more significant differentiation from other shrubs concerning the background of Mediterranean dune forests dominated by oak trees is due to the characteristics of this species.

Woodward (2009), in the book "The Physical Geography of the Mediterranean", wrote that Urban sprawl is a significant threat to coastal dunes along the coast of Egypt, especially between Alexandria and El Alamein. One of the most exciting features of many of the coastal dunes on the shorelines of the Mediterranean is the formation of lithified carbonate-rich dunes or aeolianites. Overgrazing, trampling, and other human interference have destabilized them, leading to wind erosion problems. Almost 75 per cent of the Mediterranean's coastal dunes had been damaged or destroyed in the

preceding thirty years, primarily due to tourism. The gradual disappearance of the dunes means that sandy beaches are also vanishing at an increasing rate.

Hand and Hadjikyriakou (2009), in a study entitled "*Cynara makrisii* (Asteraceae, Cardueae), a new artichoke species in Cyprus", confirmed this a new type of artichoke in Cyprus, the clan of wild artichoke discovered in 1997 in the western part of Cyprus turned out to be a new species, *Cynara makrisii*. Morphologically, it is similar to *C. Cyrenaica*, which occurs in Libya and Crete.

El-Darier and El-Mogaspi (2009), in a study entitled "Ethnobotany and Relative Importance of Some Endemic Plant Species at El-Jabal El-Akhdar Region (Libya)", The total number of endemic species surveyed in the region was 44 species, belonging to 28 families and 41 genera.

Environment Public Authority, Libya (2010), in "the 4th National Report on the Convention on Biological Diversity", the discovery of the Libyan natural plants dates back to 1703. The coastal strip is within the vegetation of the Mediterranean Sea. Libyan coast is 5.5% of the country's area; it is the longest in African countries and sixth in the Mediterranean countries. The diversity in Libya is poor compared to the area of the country. It recorded 1,750 plants and 4590 animals, which are old and inaccurate due to preliminary surveys and specialized studies. The number of plants was 744 genera, distributed over 118 families, 4% endemic, as in the genus *Pachyctenium.*

De Natale and Pollio (2012), in the study "A forgotten collection: The Libyan ethnobotanical exhibits (1912-14) by A. Trotter at the Museum O. Comes at the University Federico II in Naples, Italy", The information collected by Trotter from the Libyan lands between 1912 and 1924 is an essential contribution in tracing the use of plants in Libyan folk medicine, the ethnographic and pharmacological data about 80 flowering plants and 4 lichens. The plants are mainly in Mediterranean or sub-Saharan habitats and belong to 37 families.

Martínez, Fernández and Hesp (2013), in a study entitled "Restoration of Coastal Dunes", a compendium of studies, shows that coastal dune restoration has many definitions and thus leads to many actions, especially in conservation ecology, biology, coastal dune dynamics and geomorphology, coastal management, and others.

Shibutani, Matsubara and Kuroiwa (2013), in a study, "Effect of coastal conservation due to beach nourishment of the Totori dune coast", In the beach recharge project for coastal line restoration, the sedimentation sand was moved to the erosion area and injected into the marine erosion area and the beach area. The beach recharge was adequate, and the large amount of sediment in the land area quickly recovered the shoreline.

Lithgow, Martínez, Gallego-Fernández, Hesp and Flores (2013), in a study entitled "Linking restoration ecology with coastal dune restoration", that Human activities alter natural processes and coastal dynamics, eliminate topographic variance, fragment, degrade or remove habitats, reduce diversity and threaten endemic species. Ecological succession is a desirable approach in coastal dune restoration procedures, with natural dynamics and disturbances as part of the restored system, to improve ecosystem integrity and sustainability.

Elshatshat and Mansour (2014), in a study "Disturbance of flora and vegetation composition of Libya by human impacts: Coastal Region of El-Jabal El-Akhdar area as the model" Negative interactions between human activities (land abuse, charcoal burning, overgrazing).

Santo, Mattana, Frigau and Bacchetta (2014), in a study entitled "Light, temperature, dry after-ripening, and salt stress effects on seed germination of Phleum stardom", found that this species has its optimum germination during autumn and winter when soil salinity levels are minimal.

Mucina, Price and Kalwij (2014), in the book "Biodiversity and Vegetation: patterns, processes, conservation" Research paper submitted by **Kuroda and Sawada** ", Factors influencing plant species richness in sandy coasts: A case study in the Sanin Kaigan National Park, western Japan" Due to various anthropogenic factors such as land reclamation and recreational activities, sandy coastal vegetation has decreased. A total of 229 species, 35 of which belonged to the group of local coastal plants. The species were classified into native coastal plants, native indoor plants and exotic plants. The study showed that expansive sandy coastlines with more developed dunes have an incredible richness of coastal plant species.

Mahklouf (2016), in a study entitled "Flora of *Solanum rostratum* Dunal (Family-Solanaceae) in Libya: A New Record ", A new invasive species, *Solanum*

rostratum (*Solanaceae*) This species was added to the flora of Libya as the first recording. The specimens were collected from Gabes, about 80 km east of Tobruk city in the North-East part of the Libyan coast.

Cuccuini, Nepi, Abuhadra, Banfi and Domina (2016), "The Libyan Collections in FI (Herbarium Centrale Italicum and Webb Herbarium) and Studies on the Libyan Flora by R. Pampanini – Part 2" In this second part, a total of 113 names have been indexed and 91 typified, Correctly took the names published in the entire work to 353 species.

Cuccuini, Nepi, Abuhadra, Banfi, Domina (2016), Published **Pampanini 1933** work on plants of Libya, "Libyan groups in FI (Herbarium Centrale Italicum and Webb Herbarium) and studies on Libyan plants," 113 names are catalogued, and 91 names are classified. With the names published correctly, the entire issue reached 353, classified as 286, and was published online on December 16, 2016.

García-Romero, Hernández-Cordero, Hernández-Calvento and Hesp (2017), in a study entitled "Long-term analysis of the role of *Traganum moquinii* plants in the foredune formation of an arid dune field (Maspalomas, Gran Canaria, Canary Islands)" suggested that the species *Traganum moquinii* a critical species in the restoration of the front dunes.

El-Mokasabi, Al-Sanousi and El-Mabrouk (2018), A study titled "Taxonomy and Ethnobotany of Medicinal Plants in the Eastern Region of Libya" surveyed 179 species from 166 genera and 72 families in the region.

Marcenò, Guarino, Loidi, Herrera and Isermann (2018), in a study entitled "Classification of European and Mediterranean coastal dune vegetation", formalized the classification of this vegetation in dunes and identified the main factors driving its plant species composition at a continental scale, the influence of geographic, topographic, and climatic gradients on coastal dune vegetation.

Gawhari, Jury and Culham (2018), in a study entitled "Towards an updated checklist of the Libyan flora", The lack of an update or revision since 1989 means that the Libyan Flora is now out of date and requires a reassessment using modern approaches. Here we report initial efforts to provide an updated checklist covering 43

families out of the 150 in the published flora of Libya, including 138 genera and 411 species.

Marzialetti, Giulio, Malavasi, Sperandii, Acosta, and Carranza (2019), in a study "Capturing Coastal Dune Natural Vegetation Types Using a Phenology-Based Mapping Approach: The Potential of Sentinel-2" we tested the strength of a phenology-based vegetation mapping approach and statistically compared results with previous studies. We identified five accurate land cover classes in three hierarchical levels.

Saaed, El-Barasi and Rahil (2019), in a study entitled "Our present knowledge about the history and composition of the vegetation and flora of Libya", The Libyan flora is not fully understood. The number of Libyan plants recorded is about 2082 species in the interior lands, southern mountains, desert valleys, depressions, and northern valleys. The ease of recording new species demonstrates the need to document the flora bibliography and conduct more detailed investigations.

Akyel (2019), in a study on the coastal dunes of the second-largest delta in Turkey Yeşilırmak, Identified many plant species, distribution of vegetation cover, climate, and topography revealed demonstrate their influence on vegetation distribution and the potential impacts of farms, dams, and other activities, which are a threat to coastal dunes despite their economic benefits. Such developments are decreasing plant diversity.

Yilmaz (2021), in a study entitled "filyos deltasi kumul vejetasyonu" in northern Turkey on the coasts of the Black Sea, the study showed a reduction in the distribution of dunes as a result of human interventions. Many plant species were recognized; some adapted to the changes, others not, and others spread out in place.

The presentation of previous studies, especially in Libya, did not highlight the plant diversity in the coastal dune environment. These distinct plant habitats do not appear in more comprehensive studies. Coastal dunes, although small, are characterized by high plant diversity; this study attempts to monitor, classify and interpret plant biodiversity in the coastal dune environment in a small part of northeastern Libya.

1. GROWING CONDITIONS OF DUNE VEGETATION

This section covers some elements of climate, provides data on the climatic classification of the coastal area, and presents some geomorphological features directly related to the research topic. It then explains the nature of coastal dunes and their most important characteristics as a plant habitat.

1.1. The Climate

The climate of El-Jabal El-Akhdar and the Benghazi plain reflects the relationship between dry semi-desert conditions in the south and Mediterranean conditions in the north. El-Jabal El-Akhdar is a distinctive and unique area in northeastern Libya, as it is the rainiest and most moderate due to its height, proximity to the sea, and prominence to the north.

Most studies agreed, in general, that a temperate climate, with hot and dry winters in most parts of the summer, characterizes the region. January is the coldest month, and August is the hottest. Rainfall falls from October to April, with the highest rainfall of over 600 mm (year). At the edge of the second, the number of rainy days is 32 days in areas of 300 mm, within which the coastal plain area is located, and the average annual temperature is 16 °C.

1.1.1. Temperature Conditions

In mountainous regions where the surface appearances are complicated, we notice that there are significant differences between the climate of a single mountain and the daily temperature regime differs clearly from one side to the other, depending on the degree of inclination on which the sun’s rays fall and the different heights of its fall on different sides of the mountain.

We find that the air of the foothills of some heights facing the sun's rays is warmer than the air of the slopes that are evident to the rays of the sun, and in the high areas, the air temperature decreases while it rises in the plains, valleys, and depressions during the day.

The valley floor is warmer during the day than its sides, and at night the opposite happens (Hilal, 1996). This fact is also evident concerning slopes, where the lower parts are more relaxed than the upper parts; the valley breeze and the mountain breeze represent the daily air cycle.

The temperatures are affected by several factors, including altitude and proximity to the sea. This effect is evident when observing the difference between the average temperatures in the interior and coastal regions and the daily and seasonal systems for their distribution. Its temperature and small daily and seasonal thermal range; even though the Derna station is on the eastern coast of El-Jabal El-Akhdar, marine influences appear in its moderate temperature.

We notice the closeness between the annual average of this station and the Benina station, located inland away from the influence of the sea at 17 km and an altitude of 132 meters above sea level, which affects the annual average temperature.

It is evident from Table 2, figure 4 that there is a convergence between the annual temperature averages for both stations with the difference in location and altitude.

The data in Table 3 shows that the averages in winter do not fall below 13 °C. Because of the marine influences, January is the coldest month of the year, and the average winter temperatures range between 13.6 and 13.7 °C in Derna and Benina stations, respectively.

The averages are also very close in the summer; the average temperature is 25.5 °C, and August is considered the warmest month. Table 3 shows that the average minimum temperature decreases in Benina station due to the continental influences, represented in the Benghazi Plain from the east and, from the south, a semi-desert region. While this average increases in Derna station due to the influence of the sea, the average maximum temperature rises to 24.4 °C at Benina station while it is 22.7 °C at Derna station due to the marine influences on the temperature.

Table 2. Monthly and annual averages of temperatures (1987- 2010)

station		Derna			Benina		
temperatures °C		Maximum	Minimum	Average	Maximum	Minimum	Average
Months	1	16.9	11.9	14.4	16.8	9.1	12.95
	2	17.1	10.9	11.1	17.1	9.3	13.2
	3	18.9	11.8	15.35	18	10.9	14.5
	4	22	15	18.5	21	13.8	17.4
	5	22.9	17.6	20.25	25.9	17.2	21.6
	6	25.8	21	23.4	29	19	24.0
	7	27.6	23.9	25.75	31	21.1	26.1
	8	29	25.8	27.4	31.9	21.7	26.8
	9	28.2	23.1	25.65	31.1	21	26.1
	10	27.3	21.1	24.2	27.8	18.2	23.0
	11	23.9	17.2	20.55	22.9	13.8	18.4
	12	19	11.8	15.4	20	10.3	15.2
Annual average		22.7	17.6	**20.2**	24.4	15.5	**19.9**

Source: Libyan National Meteorological centre climate (LNMC, 2010)

Table 3. The average seasonal temperature (1987 – 2010)

station	winter	spring	summer	autumn
Derna	13.6	18	25.5	23.4
Benina	13.7	17.8	25.6	22.4

Source: (LNMC, 2010)

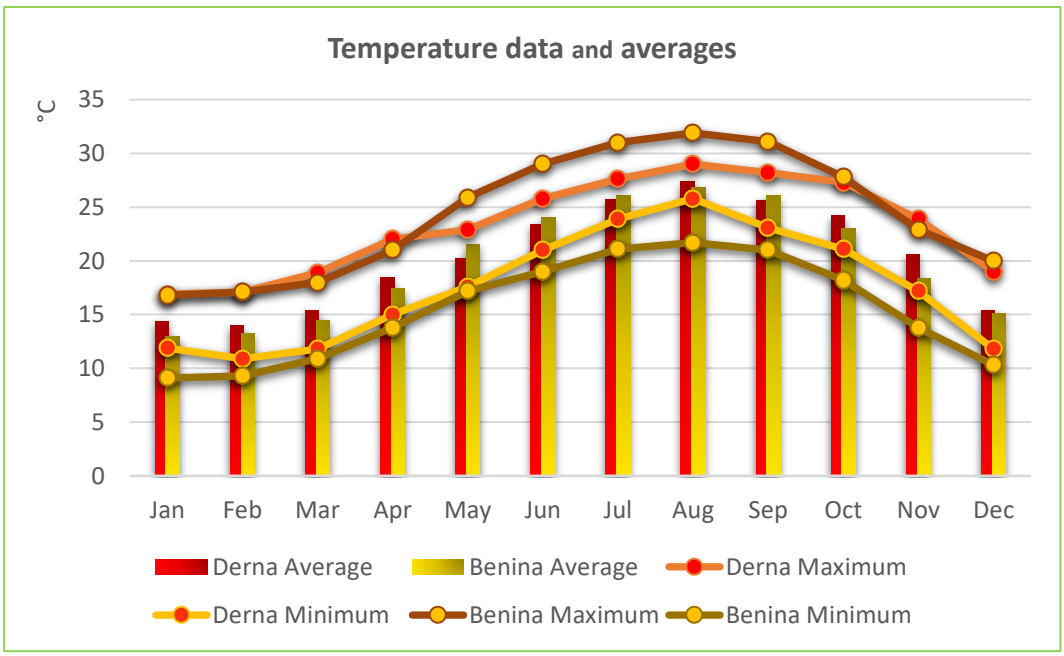


Figure 4. Temperature data and averages (1987 – 2010)

It is noted from the previous presentation that the average temperatures are similar in winter, and January is the coldest month. We also find a convergence of averages in summer and August, the year's warmest month. Continental influences reduce the average temperature, shown in the western region at the Benina station.

In contrast to the marine influences that raise the average temperature, as it is in the eastern part of the region at the Derna station, this affects the vegetation cover, its distribution, and the composition of plant communities.

1.1.2. Humidity and Precipitation Conditions

It is evident from Table 4 that the average relative humidity in Derna station decreases in winter (67%), compared with Benina station (72.8%), while it increases in summer and reaches (72.1%) in Derna station and decreases (63.1%) in Benina station. The average humidity has been rising since May because the Derna station is located on a more advanced coast to the north and is, therefore, more vulnerable to marine influences; Table 4 shows the average temperature and relative humidity. The relative humidity is the amount of water vapour in the air compared to the maximum capacity for the air to hold. It is measured as a percentage and expressed as a monthly or annual mean.

Table 4. Monthly seasonal and annual mean relative humidity (%) 1987 - 2010

Station		**Derna**	**Benina**
seasons	12	68.9	72.1
	1	70.5	73.4
	2	61.7	72.9
	winter	67	72.8
	3	65.1	67.3
	4	69	59.1
	5	70.9	57
	spring	68.3	61.1
	6	71.9	59.2
	7	73.3	66.1
	8	71.1	64.1
	summer	72.1	63.1
	9	71.9	60.7
	10	69.1	65.9
	11	64.9	64.8
	autumn	68.3	63.8
Annual average		69	65.2

Source: (LNMC, 2010).

Relative humidity depends on temperature, indicating how close air is to saturation and directly affecting plant life distribution and diversity; people tend to feel more comfortable when the relative humidity is between 30% and 50%. The ideal range for plants is around 40% to 60%.

Table 5, Figures 5 and 6, compares the average temperature and the average relative humidity. It is noted that the average relative humidity rises between June and August and records the highest rate in July. At the same time, the lowest percentage is recorded between December and February, which are the months of the winter season, due to the inverse relationship between temperature and relative humidity.

Table 5. Average temperature and relative humidity (1987 - 2010)

Station	**Derna**		**Benina**	
Months	temperatures °C	humidity (%)	temperatures °C	humidity (%)
Jan	14.4	70.5	12.95	73.4
Feb	11.1	61.7	13.2	72.9
Mar	15.35	65.1	14.5	67.3
Apr	18.5	69	17.4	59.1
May	20.25	70.9	21.6	57
Jun	23.4	71.9	24.0	59.2
Jul	25.75	73.3	26.1	66.1
Aug	27.4	71.1	26.8	64.1
Sep	25.65	70.9	26.1	60.7
Oct	24.2	69.1	23.0	65.9
Nov	20.55	64.9	18.4	64.8
Dec	15.4	68.9	15.2	72.1

Source: Libyan National Meteorological centre climate (LNMC, 2010).

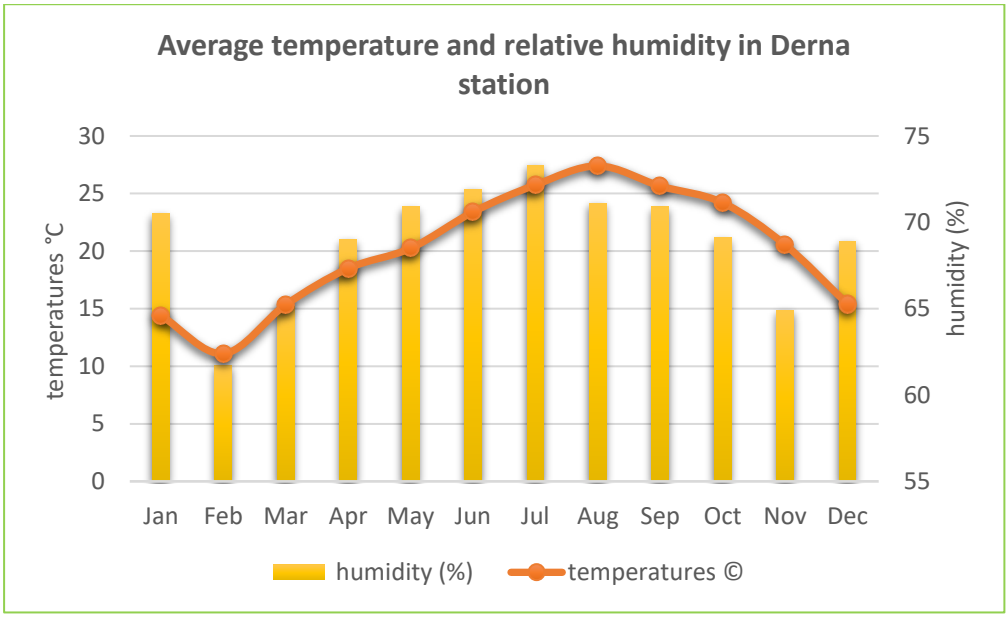


Figure 5. Average temperature and relative humidity in Derna station (1987 – 2010)

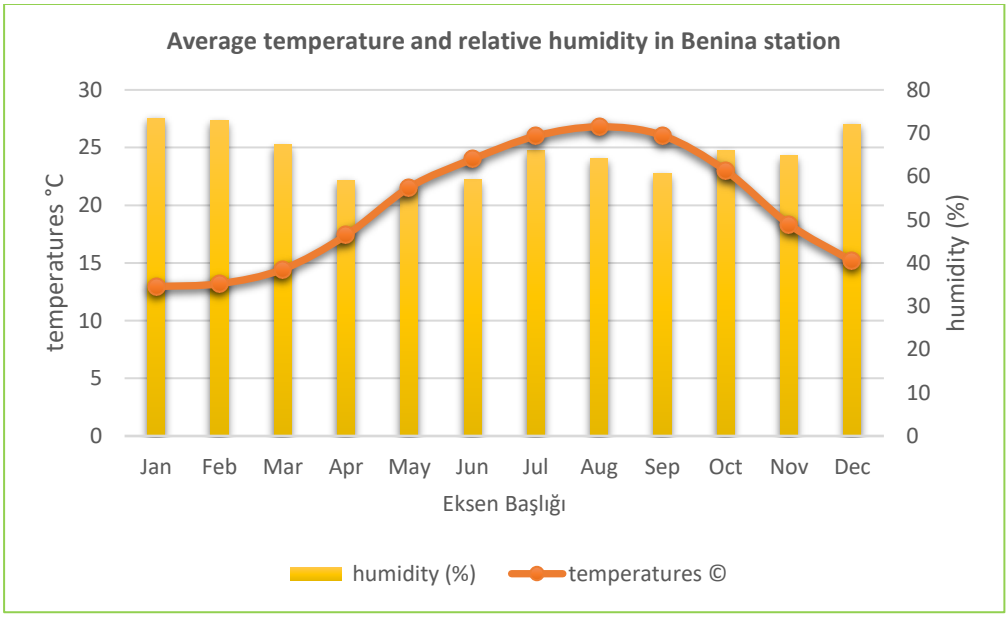


Figure 6. Average temperature and relative humidity in Benina station (1987 – 2010)

It is noted that the average relative humidity rises and records its highest rate in July, while the lowest percentage is recorded in the winter months due to the inverse relationship between temperature and relative humidity, a comparison between the annual mean humidity of the two stations reveals no significant differences between these averages, as depicted in Figure 7.

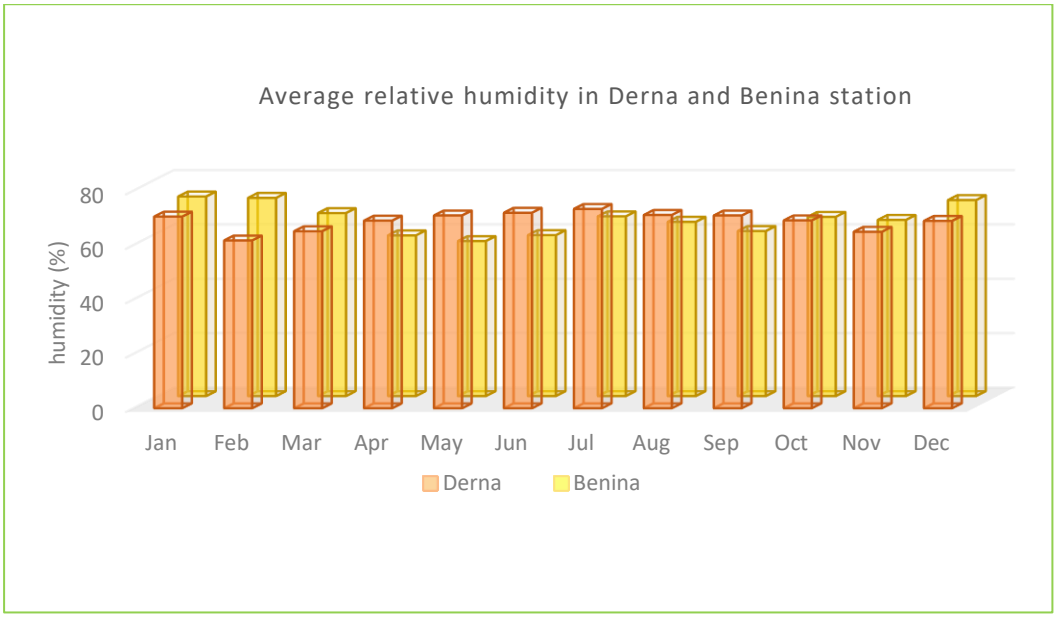


Figure 7. Average relative humidity in Derna and Benina station (1987 – 2010)

El-Jabal El-Akhdar region is the rainiest in Libya, its privileged location as a unique island surrounded by the Sahara Desert in the south and the Mediterranean Sea from the north, east and west forms unique and distinct climatic conditions.

Winter cyclonic rains are prevalent and are associated with the formation of Mediterranean and Atlantic depressions, which begin to affect the region in late autumn. Its quantity varies significantly from place to place (Nooh, 2007).

Regarding precipitation rates, coastal dunes are sandy ecosystems near the coast, and most of them receive more than 250 mm of precipitation annually (McLachlan, 1991).

Figure 8 presents rainfall station data, and Tables 6 and 7 show the average annual rainfall. There is an increase in the averages in the eastward direction to Ras Al-Hilal station, while it decreases in Derna station and reaches (246.6 mm). The highest rate recorded by Ras Al Hilal station is located west of Derna station, about 37 km away, due to its advanced location towards the north, and the proximity of the edge of El-Jabal El-Akhdar to the south, which allows for further condensation.

Susa, El-Haniyah, and Tolmeta stations are located on the part of the coast, advancing northerly in a southwest-northeast direction, which makes them receive rainy northwest winds. Hence, the annual averages rise and converge in these stations.

By comparing the annual rates between Derna and Tocra stations with the rest of the stations, we find that the rate is lower due to the deflection of the coast to the south, reducing the chances of condensation. The chance of condensing air arriving is slight, or it arrives with an unloaded portion of its cargo on the coastline east of Derna (Nooh, 2007).

In the monthly and seasonal rainfall distribution, December and January represent the peak rainfall. January is considered the essential rainy month in all stations, with its highest level in Ras Al-Hilal and Tocra stations.

From mid-May to early September is the least rainy period. Due to the high levels of rainfall in December and January, winter rains are the highest, followed by autumn rains distributed between October and November, with average rainfall in October at Susa station of 44.6 mm and in November (43 mm) at Tolmeta station.

Autumn rains fall at Derna and Tocra stations while rising in the rest of the stations. Figure 9 shows the average monthly and annual rainfall, and the average seasonal rainfall is shown in Figure 10. The distribution of average rainfall on the northern coast of El-Jabal El-Akhdar in the Benghazi plain is shown in Map 2.

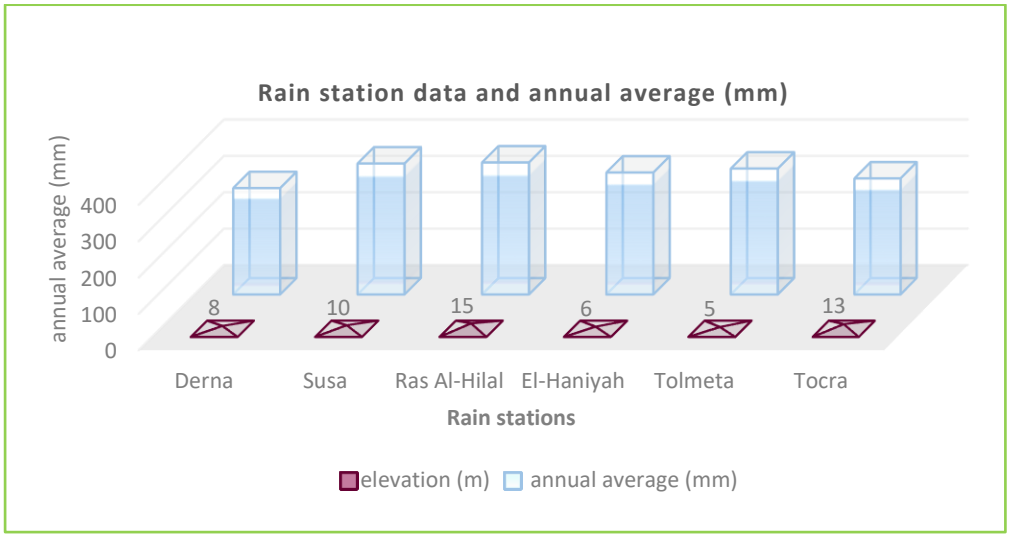


Figure 8. Rain station data and annual average between (1960 – 2000)

Table 6. Monthly and annual averages of rainfall

Station	Tocra 60 -1976	Tolmeta 60 -2000	El-Haniyah 60 -2000	Susa 61-1990	Ras Al-Hilal 61-1976	Derna 60-2000(*)
elevation (m)	13	5	6	10	15	8
Jan	92.6	88.8	86.5	83.7	92.7	59
Feb	58.5	47.6	55	58.4	54.3	40
Mar	26.4	28.7	28.8	33	43.6	21.5
Apr	7.3	9.2	13.7	11.1	16	10
May	3	1.3	2.4	2.3	0.6	4.4
Jun	0	0.29	1.3	0.55	0.4	3.2
Jul	0	0	0.1	0	0	0
Aug	0.4	0	1.1	0	0	0
Sep	4.5	6.9	4.2	10.6	10	3.5
Oct	25	29.8	31.2	44.6	40.7	30
Nov	32.6	43	42.2	40.9	35.4	26
Dec	67.9	86	68.3	60.5	85	49
annual average (mm)	318.2	341.6	334.8	345.6	378.7	246.6

Source: After (Nooh, 2007). (*) The difference in the history of the stations is due to a lack of data means this is the only period recorded for them.

Table 7. The seasonal average of rainfall

Station (*)	Seasons				annual
	winter	spring	summer	autumn	average (mm)
Tocra 60 -1976	73	12.2	0.1	20.7	26.5
Tolmeta 60 -2000	74.1	13.1	0.1	26.6	28.5
El-Haniyah 60 -2000	69.9	15	0.8	25.9	27.9
Susa 61-1990	67.5	15.5	0.2	32	28.8
Ras Al-Hilal 61-1976	77.3	20.1	0.1	28.7	31.6
Derna 60-2000	49.3	12	1.1	19.8	20.6

Source: After (Nooh, 2007). (*) variation in years of monitoring due to the unavailability or incompleteness of data at the station

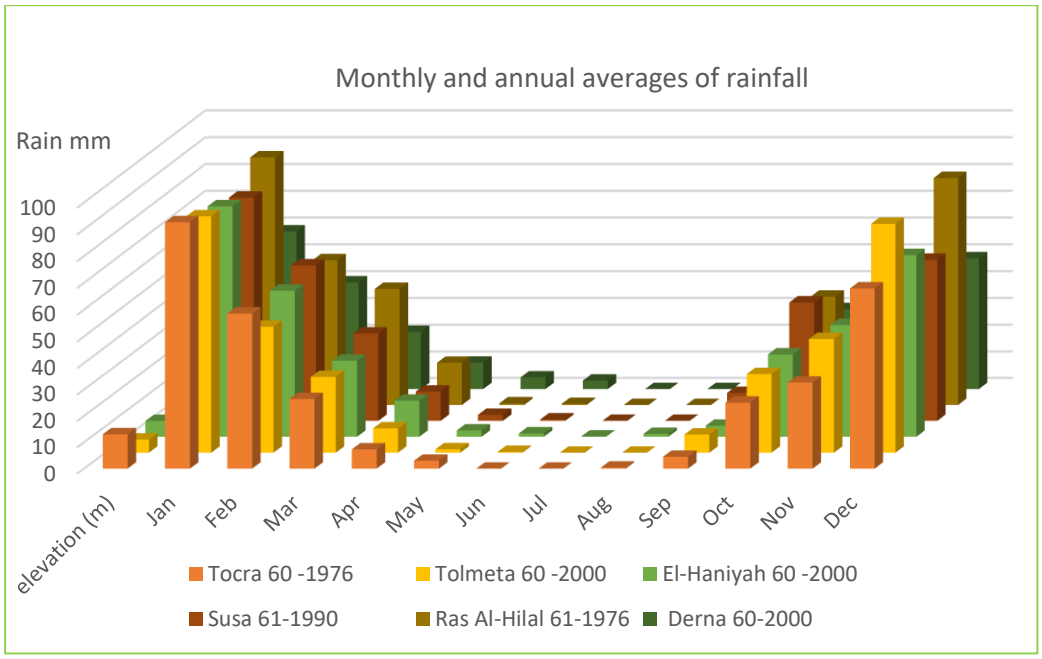


Figure 9. Monthly and annual averages of rainfall between (1960 – 2000)

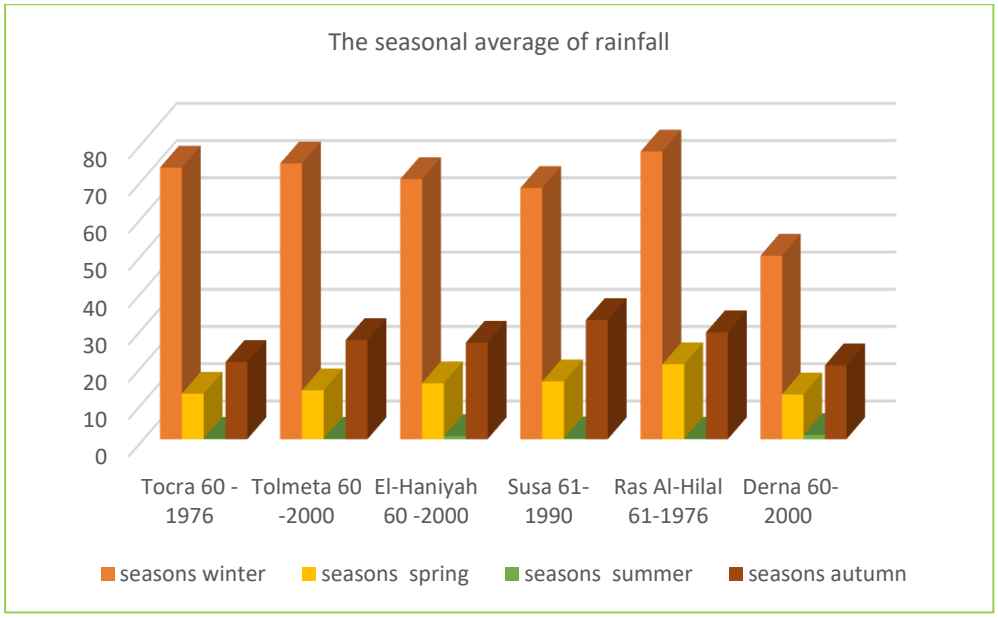
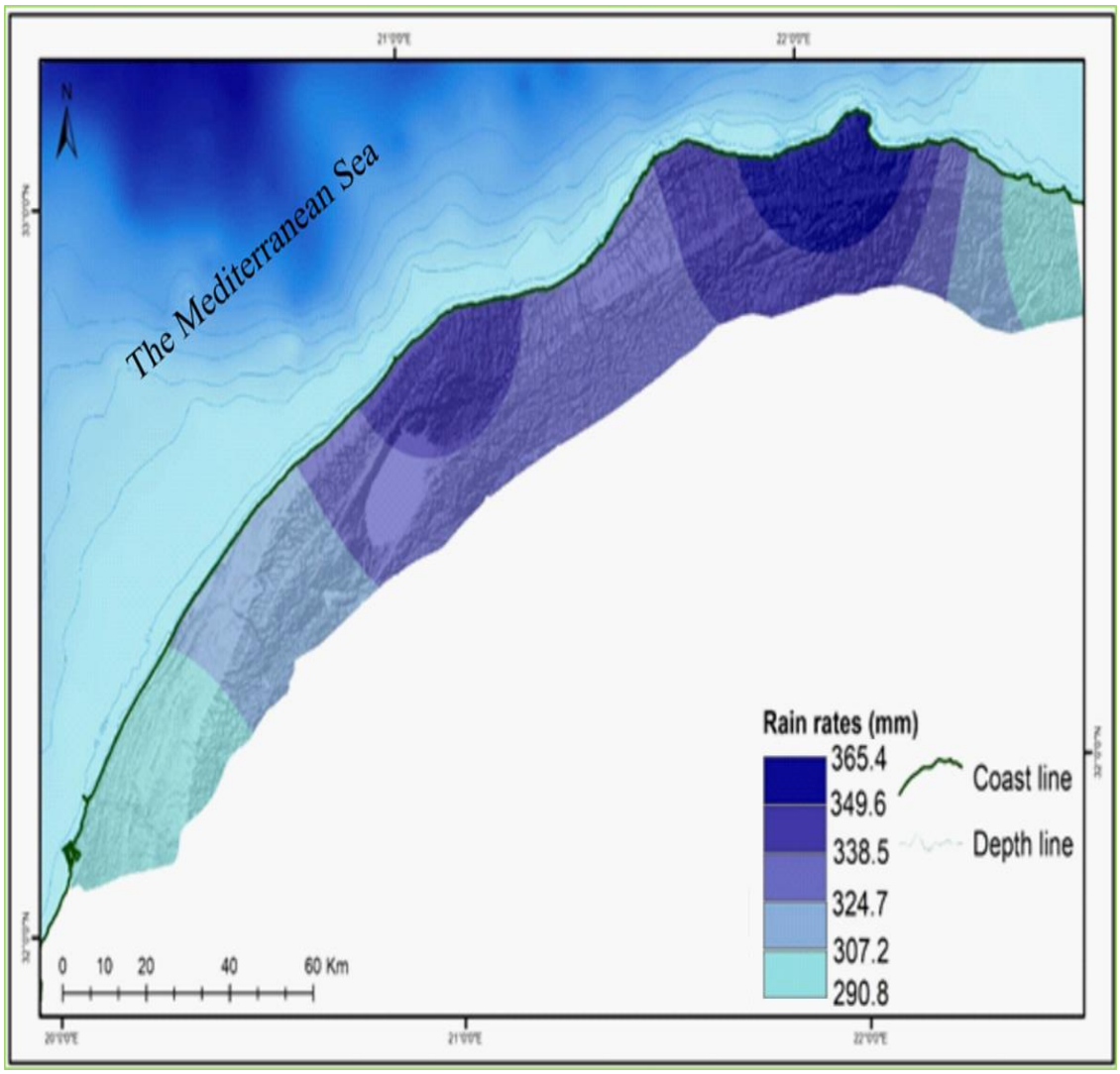


Figure 10. The seasonal average of rainfall between (1960 – 2000)

The average annual rainfall is high at Ras Al Hilal station because it is more advanced towards the north, and the proximity of the edge of the mountain to it allows more condensation, while at Derna station, the edge is farther south and the altitude decreases, and thus the average annual rainfall decreases.



Map 2. Rain rates north between El-Jabal El-El-Akhdar and the Benghazi Plain

El-Jabal El-Akhdar region has winter cyclonic rains linked to the formation of the Mediterranean and Atlantic depressions, which begins to affect the region in late autumn. Precipitation varies significantly from place to place; from Map 2, the distribution of rain in the coastal region is evident. In terms of months, December and January represent the peak precipitation. Seasonally, winter rains are the highest, followed by autumn rains in all stations.

The highest amount of rain falls in the eastern part, especially in the Ras Al-Hilal area, and it decreases as we head towards the west at the Benina station or towards the east at the Derna station.

Many factors affect this distribution, the most important of which is the edge of El-Jabal El-Akhdar, its location from the coast, and the continental influences of the dry southern and southwestern regions.

From the previous presentation, it is evident that the cyclonic winter weather is the predominant one, that the rainy season is from October to March, and that January and December are the wettest months, with a natural drought between mid-May and early September. Snow is a form of precipitation that is rare and hard to find, and (40 cm) in early 1934 is the highest value recorded at the second edge of the mountain (Goudarzi, 1970).

1.1.3. Wind Conditions

Air movement affects vegetation directly through its natural effect or indirectly by raising the amount of moisture loss due to the velocity of evaporation associated with the wind speed. The wind speed is equivalent to 0.5 m/s or 1.15 miles per hour, and the direction of the wind is the direction from which it blows (Ackerman and Knox, 2012).

Wind speed and strength contribute to the formation of coastal dunes of all kinds; wind speed means that dunes require sufficient energy from the wind to capture sand grains and transport them to different distances depending on the nature of the beach that receives these quantities of sand. Wind also affects the moisture content along sandy beaches and the size of sand grains in terms of softness and roughness.

Table 8, Figures 11 and 12 illustrate no significant differences in the average seasonal winds. At Derna Station, the northwest and southwest winds prevail in the winter, and in the summer, only the northwest winds prevail.

Table 8. Monthly seasonal and annual average wind speed km / h (1987 - 2010)

Station		Derna	Benina
Seasons	12	22.2	18.6
	1	20.5	15.7
	2	22.7	16.8
	winter	21.8	17
	3	20.1	18.1
	4	20.5	22
	5	19.7	20.5
	spring	20.1	20.2
	6	19.9	20.7
	7	23.8	22.2
	8	22.2	22.7
	summer	21.9	21.8
	9	17.7	16.8
	10	17.3	17.2
	11	19.7	19.4
	autumn	18.2	17.8
Annual average		20.55	19.1

Source: (LNMC, 2010).

The wind speed at Benina Station decreases in the winter compared to Derna Station and is the lowest in January (15.7 km/h), while the prevailing winds in the winter are northwest and southwest, with frequent occurrences of southerly winds in the summer, El-Qebli winds, they are hot, dry winds that carry dust from the south towards the north and frequently occur in the summer and spring.

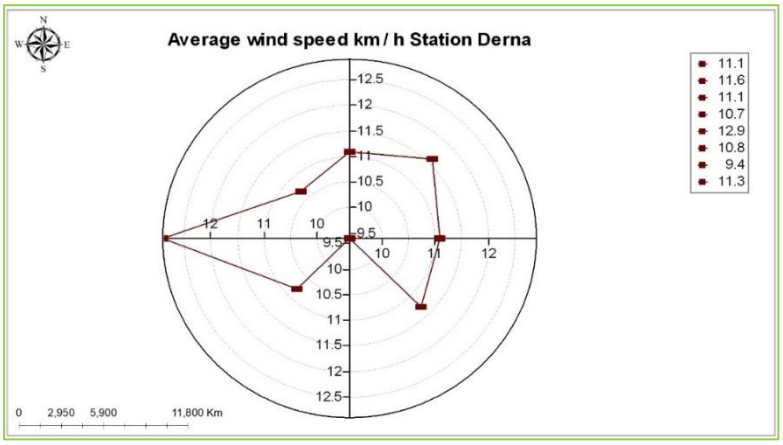


Figure 11. Average wind speed at Derna station (1987 – 2010)

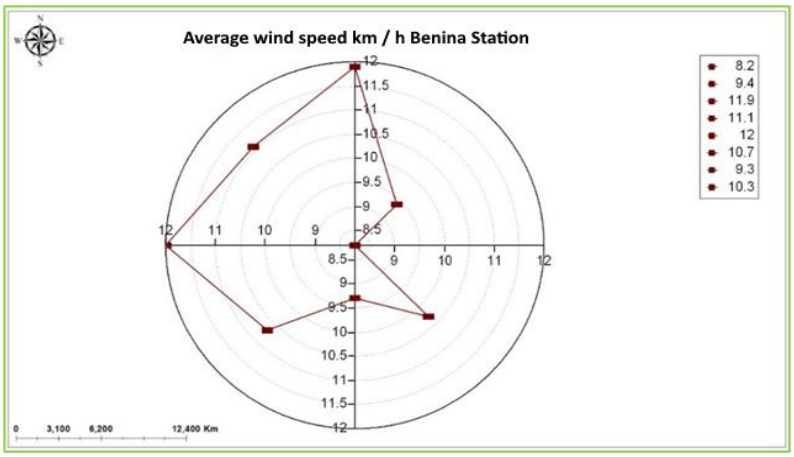
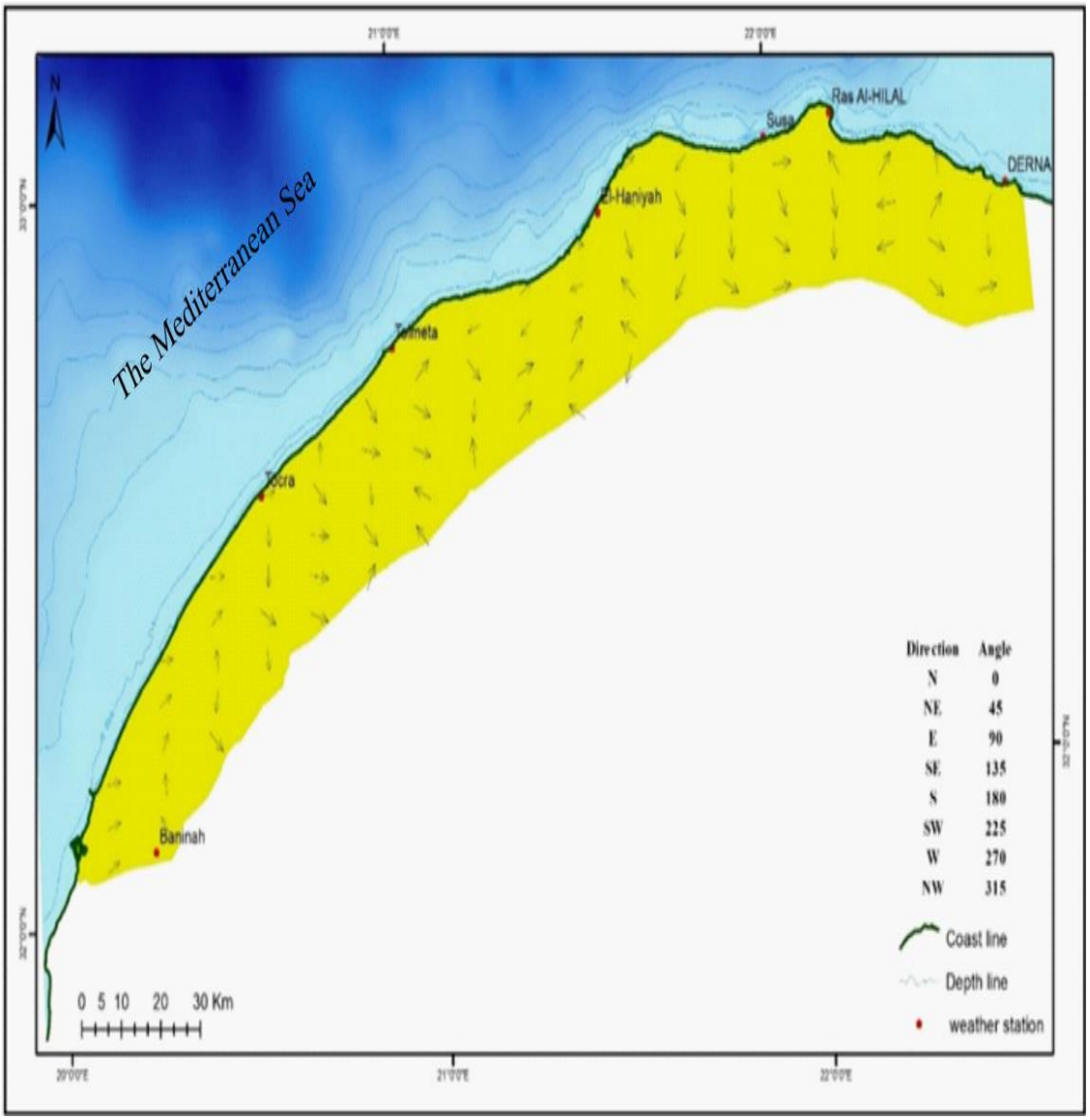


Figure 12. Average wind speed at Benina station (1987 – 2010)

Certainly, winds of all kinds have an apparent effect on coastal dunes and their various habitats; they determine the direction, amount of sedimentation and movement of grains, as well as drying the sand surface and other effects.

Sandy habitats depend on the amounts of sand carried by the wind in different ways, whether creeping, jumping, or hanging, as sand grains accumulate before the obstacles they encounter and create suitable opportunities for plant growth. The wind played an essential role in the distribution of plant species, especially in the Benghazi plain due to the widening of the coast, while the wind speed and strength affected the degraded habitats on the El-Jabal El-Akhdar coast and increased the intensity of erosion. Map 3 shows the directions of the winds in the northern area of El-Jabal El-El-Akhdar and the Benghazi plain, and the prevalence of the northern and northeastern winds coming from the sea in the eastern and central parts, while the northern and northwestern winds coming from the sea prevail in the western part, with a small percentage of the southern winds.



Map 3. Wind directions in the north of El-Jabal El-El-Akhdar and the Benghazi Plain

In the coastal region, and looking at Map 3, the prevailing wind directions are the north and northeast winds coming from the sea in the eastern part, while the north and northwest are in the middle of El-Jabal El-Akhdar, and the winds coming from the sea prevail in the western part. Dry south winds affect the region leading to high temperatures and dust movement towards the north.

Winds, with their types and directions, impact other climate elements and, thus, the distribution and composition of plant communities. The most significant influence of winds on the coastal dunes' environment and the distribution of their plant communities appear.

1.1.4. Data on climate classifications of the research area

In response to many stimuli, vegetation develops, including climatic, morphological, and cultural conditions. Interpretation of the distribution of vegetation based on climatic conditions depends in part on the selection of active climatic factors; the humidity indicator is more valuable, while the temperature and precipitation are poor climatic features(Mather & Yoshioka, 1968).

For various reasons, obtaining climatic data from the Meteorological Department is difficult. Because El-Jabal El-Akhdar and the Benghazi Plain do not have sufficient climatic stations, climatic data is not generally available, particularly in the coastal strip.

According to Thornthwaite, the main factor in the distribution of plants on the Earth's surface is the amount of water needed for the area not to dry out. Latent evaporation is a water requirement. Accordingly, he created the moisture index "M", calculated by the equation:

(Im = 100 x water surplus-water deficit/latent transpiration evaporation)

The result gives positive values for the humid climate (0 to 100), and such climates do not appear in El-Jabal El-Akhdar and the Benghazi Plain. As for dry climates, their values are negative (0 to -60) as follows:

CLIMATIC REGION	IM
Sub humid (C1)	33.3-/0
Semiarid (D)	67.7-/33.3-
Dry	100-/67.7-

The region represents the northern limit of the coastal range and thus is classified within the semi-arid region, where the water needs are less than 1000 mm. According to studies (Al Hanafi & Nooh, 2012), the water budget elements are latent evapotranspiration of 981 mm, a water deficit of 589 mm, and a water surplus of 183 mm. Its value is 0 mm. Botanically speaking, the Maquis and Batha formations appear in this region, bordered to the north by the formations of dunes and swamps. Furthermore, the Thornthwaite classification places the study area within a climatic zone (D), and the area appears to be more extreme than that, at least in some parts.

1.2. Geomorphological Features of the Research Area

The region's land surface consists of low plains, various sandy beaches, swamps and rocky shores. The coastal line follows a general direction from the north-east to the south-west, which is the direction of El-Jabal El-Akhdar and the Benghazi Plain, and it slopes sharply towards the north and east and is moderate to very steep towards the west. This slope has produced a network of deep and wide valleys that transport rainwater and various sediments to the coastal environment; Map 4 shows an aspect of the coastal region's geomorphology, with steep slopes in the east, making the beaches less extensive.

1.2.1. Some Geomorphological Phenomena

Through the field study, it was possible to identify some of the geomorphological phenomena that characterize the environment of coastal dunes and contribute to drawing the botanical picture of this environment.

1.2.1.1. Estuaries of valleys (estuaries of valleys in the sea and swamps)

The wadis provide fresh water, nutrients and various sediments in the coastal dune environment, increasing plant diversity. Not all estuaries end directly in the sea, and some form extensive seasonal marshes that remain for long periods.

1.2.1.2. Swamps of all Kinds

They refer to the depressions in which water accumulates seasonally or permanently. They constitute an ecosystem located in the high intertidal zone, between muddy plains and tides or on the edges of saltwater in the absence of mudflats.

1.2.1.3. Lakes of all kinds

It is a low-lying area in which water collects permanently, some of which are saline, some of which are of medium salinity, and is closed or connected to the sea.

1.2.1.4. Karst Lakes

Deep cylindrical, vertical or almost perpendicular to the Earth's surface and linked to limestone, occupying a small area. It is considered a product of chemically melting rocks, the most famous of which is the Notta Swamp, west of Susa.

1.2.1.5. Cave Weathering

Sedimentary formations are widespread in the region, so cavernous weathering is typical.

1.2.1.6. Sand fans

Sedimentary formations are widespread in the region, so cavernous weathering is widespread.

1.2.1.7. Coastline

It is an area of at least 100 m horizontally in the direction of land, starting from the coastal edge line of the sea and natural lakes. The natural line changes according to the weather events and consists of the points where the water comes into contact with the land, excluding floods. Shoreline can as the intercept of the mean water level along the beach, but it is often used loosely as the swash limit or the landward edge of the backshore (Davidson-Arnott, 2010).

1.2.1.8. Coast

The area between the coast and the coastal rim line The nearshore zone portion of the profile extends from the limit of significant sediment transport by waves to the low tide line.

Front Shore

In general, it consists of fine-grained dunes, the breadth of which depends on the geomorphological profile of the coast and may reach more than 50 m long wide beaches.

Back coast

At the beginning of this area, which represents the outer border of the front shore, dunes appear and form; we find moving and semi-moving dunes and mixtures of materials of marine and land origin. Some factors control the extension of this area inland, the most important of which is the geomorphology of the coast and land uses.

Coastal Edge Line

The natural boundary of the area in the land direction separates the area under the influence of marine conditions and the area under the influence of terrestrial conditions. It is the coast from a geomorphological point of view (Turoğlu, 2009).

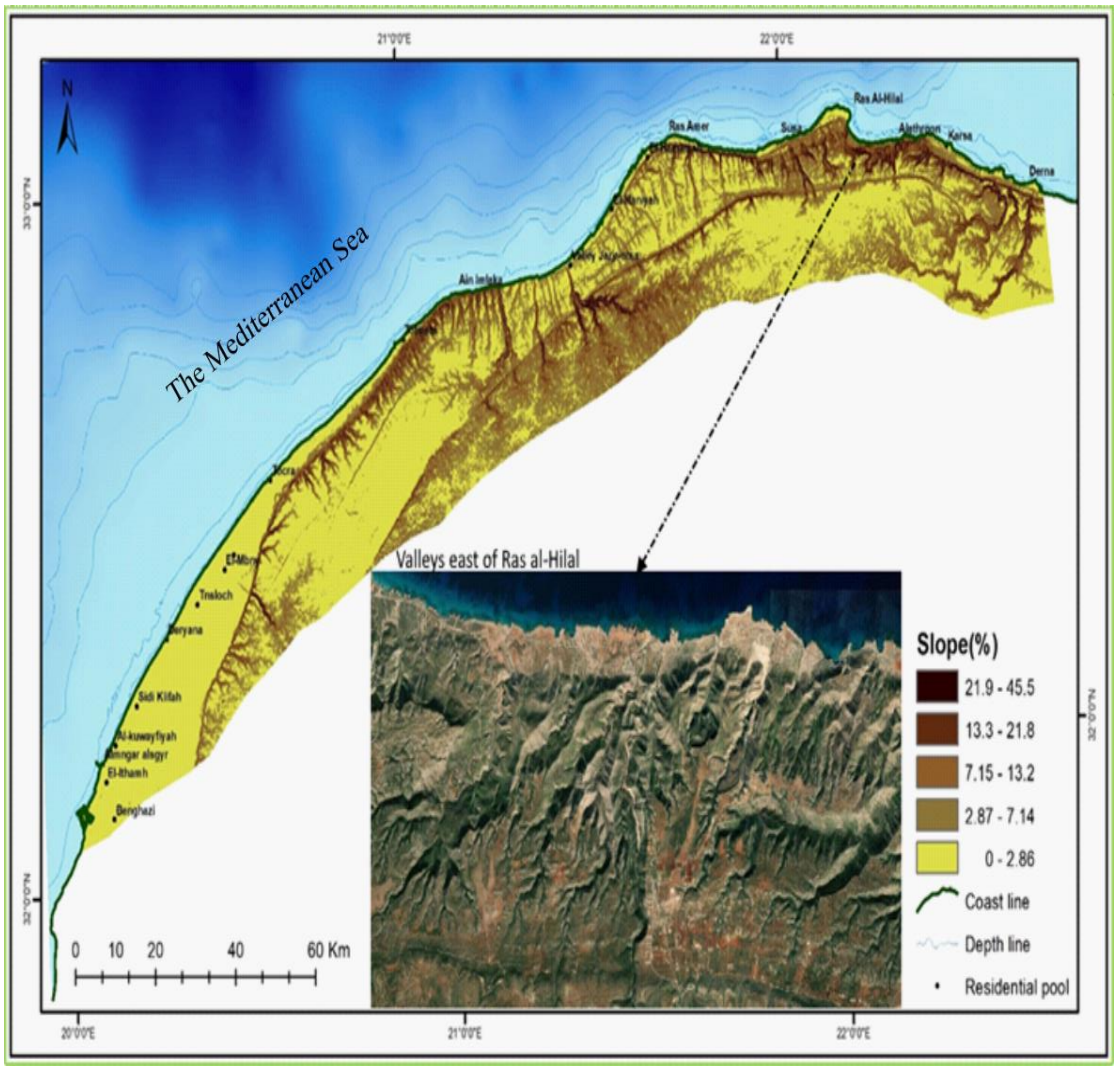
Shoreline Change

Coasts have different geographical features according to their location; formed under the influence of geomorphology, hydrographic, biogeographical, climatic and human factors, coasts are dynamic, and their characteristics are constantly changing.

The coastal zone includes the nearshore area between the low tide line and the maritime limit of wave traffic on the shore (Davidson-Arnott, 2010).

From a geomorphic perspective, shear waves have a direct role in sediment suspension and transport, accounting for up to 16% of total cross-shore transport and up to 37% of oscillatory cross-shore transport (Stephenson & Brander, 2003).

Coastal systems vary significantly in their dynamic range and response to changing controls. The beach foreshore morphology can respond at a temporal scale of seconds to minutes to changes in incident wave conditions and tidal elevation (Davidson-Arnott, 2010).



Map 4. Slopes and valleys in the coastal region north of El-Jabal El-Akhdar and the Benghazi Plain

On the shores of resistant rocks such as granite, the change in shape takes a long time, perhaps hundreds of years.

The limit on land may be a few hundred metres inland from a clifftop or several kilometres where there are extensive dunes or along tidal estuaries.

Changes occur in the shoreline or the coastal area. These changes are rapid and robust due to various human activities; we will discuss this in Chapter Four, shown in Figure 8. which is an approximate division of the beach areas from the sea inward.

1.2.2. Beachfronts

1.2.2.1. Strandline (the simple beach)

A range in which the waves descend and break; sediment is transported along the shore, devoid of vegetation.

1.2.2.2. Foreshore portion (Foreshore area)

This area is between the highest and lowest water levels, the area of movement and transport of various sediments. Hence the formation of primary dunes (embryonic dunes)

1.2.2.3. Backshore portion

This area's vegetation line depends on the shore's width and the coastline's direction; coastal vegetation generally appears as belts parallel to the coastline when the coastal zone is wide (DE Molenaar, 1974). Figure 9 shows the coastal dunes.

Caves and sea arches commonly occur at the base of limestone heads and islands along the coast (Choowong, 2002). Picture 1 depicts some geomorphological phenomena in a wide sandy beach area in the western part where dunes can develop. Figure 13 presents the definitions of the coastal zone, and Figure 14 View of the coastal area.

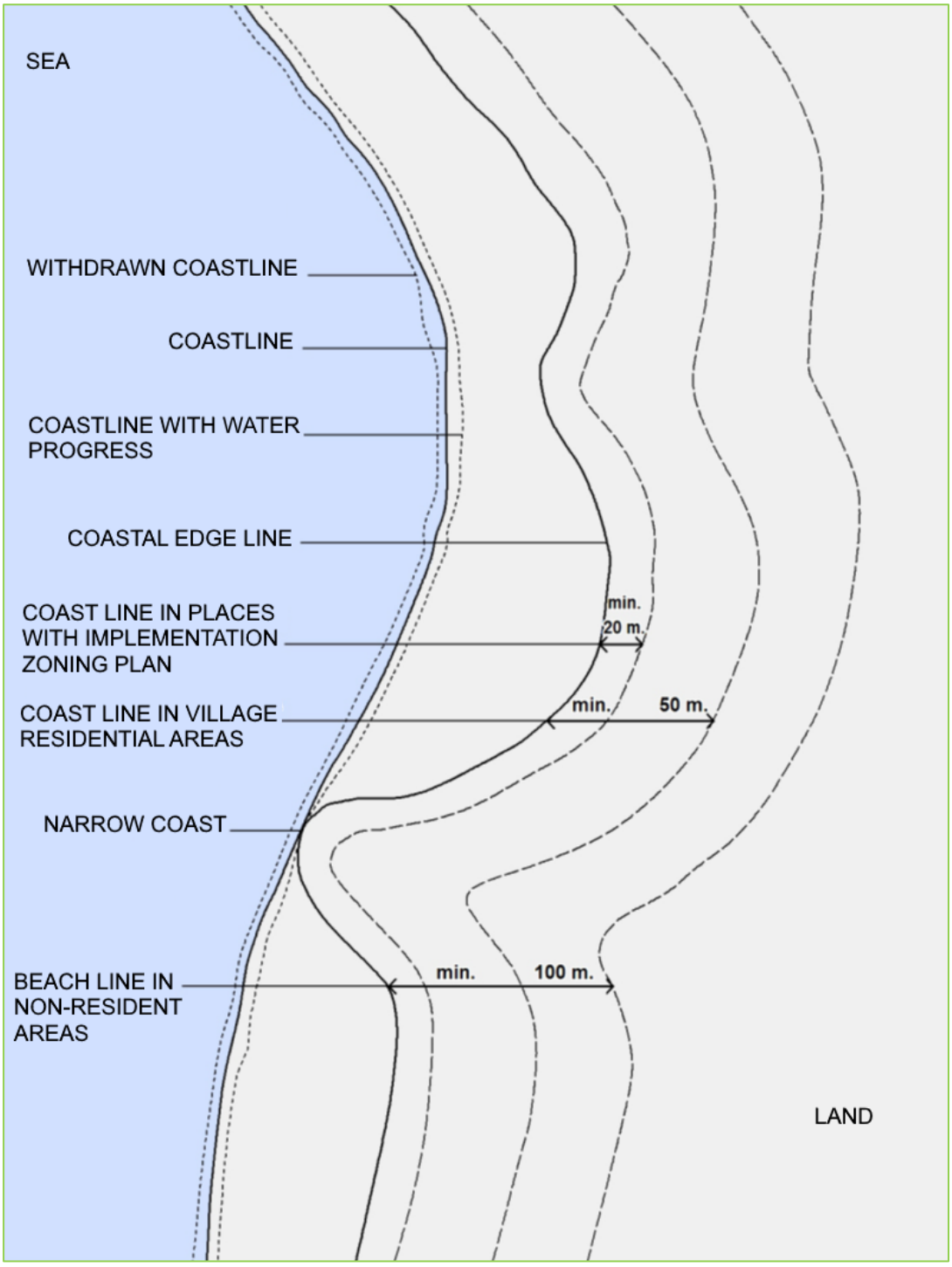


Figure 13. Definitions of the coastal zone. Source: after (Turoğlu & Yiğitbaşioğlu, 2017)

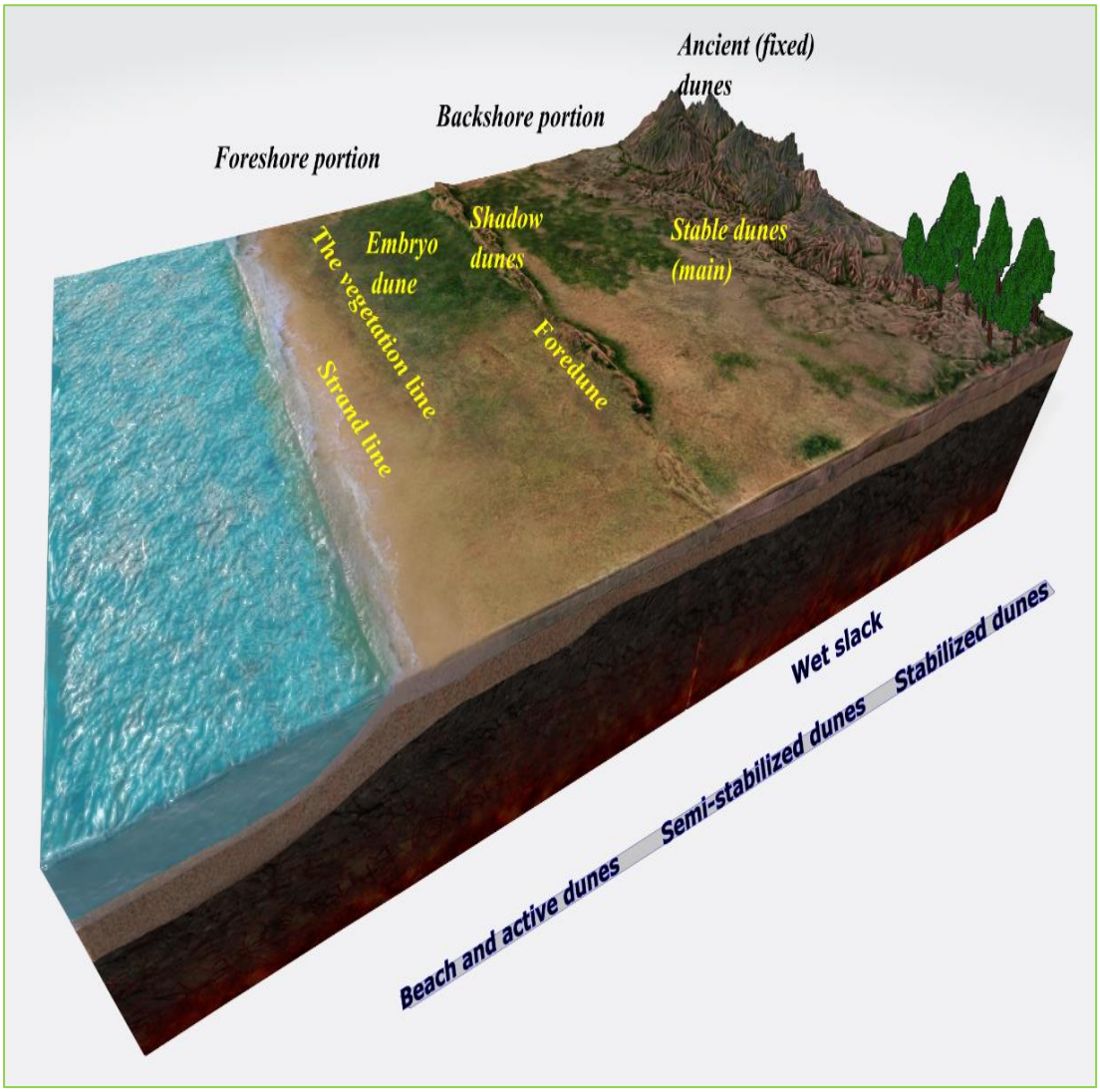
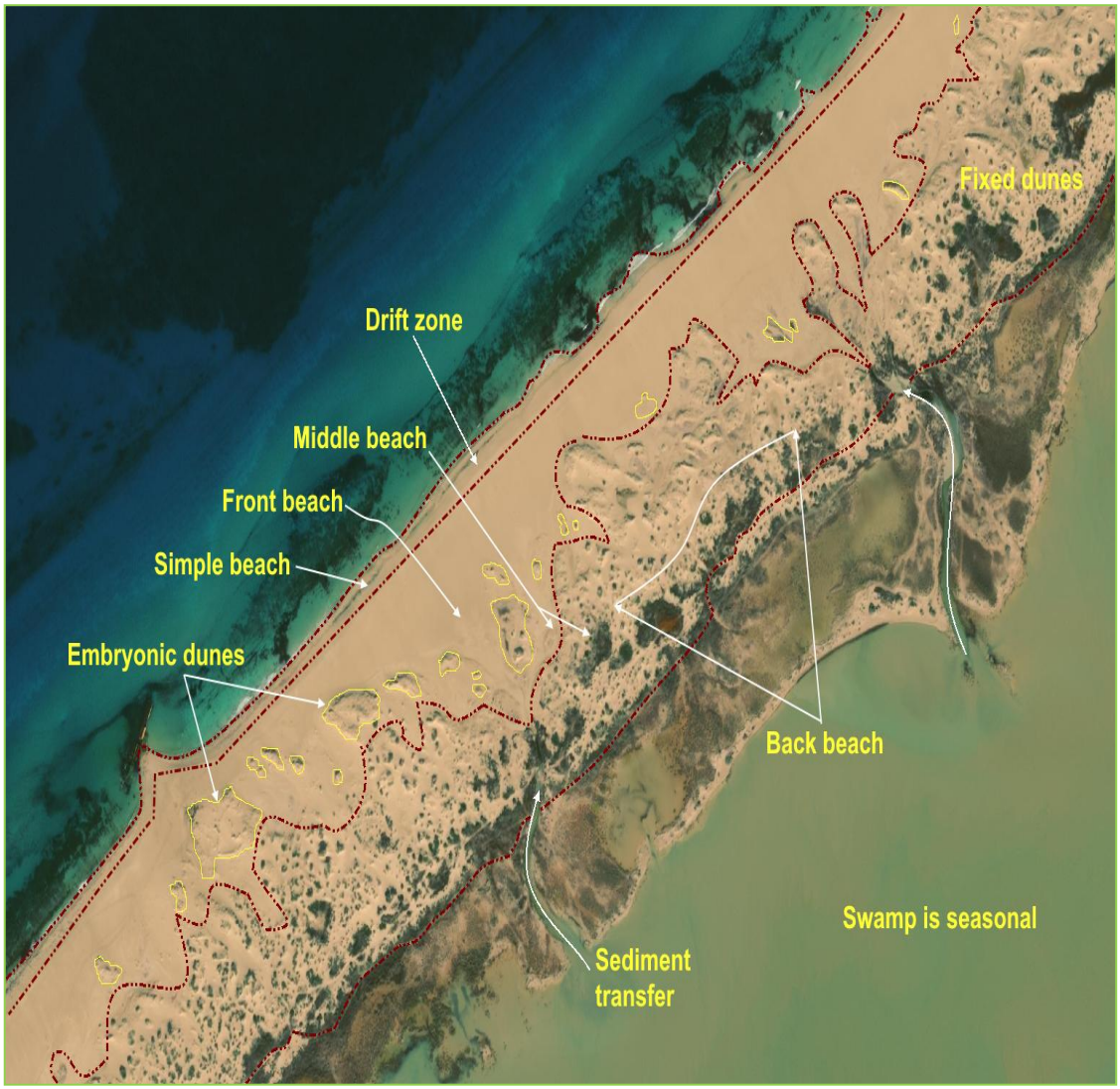


Figure 14. The coastal region, depending on location, is from the shore inland. Source: Prepared by the researcher based on data (Muñoz-Vallés & Cambrollé, 2016)



Picture 1. Geomorphological phenomena in a large coastal area

Picture 1 shows the beach sections, coastal dune types, and the distribution of vegetation between these sections. The beach here is a little steep, bordered by a seasonal swamp, which contributes to the diversity of plants and provides opportunities for forming dunes of all kinds, increasing biodiversity.

In general, divided the area into 3 pa ,which is the eastern part, dominated by high beaches, and the mountain edge, which is close to the sea in a way that does not allow the formation of a sandy beach, except in the estuaries of some valleys, and the middle part, where a narrow coastal plain appears, allows the formation of unconnected sandy beaches. The western part begins with sandy beaches of little breadth, and towards the west, the coastal plain expands and allows the formation of broad and connected sandy beaches and various lakes and marshes. These sections are shown in Table 8.

1.2.3. Description and Data of the Parts of the Area

1.2.3.1. Eastern Part (E)

It represents the coastline from Derna to El-Hamamah and takes a general direction towards the northwest/southeast, in which the heights are close to the sea, the chances of forming a coastal plain and a sandy beach are few, the eastern part is characterized by severe meandering and height, where the average height reaches 21 m, and the slope reaches 65%, and some rocky heads and tongues stand out.

1.2.3.2. Middle Part (M)

It represents the coastline from El-Hamamah to Tolmeta and takes a generally east-west direction. Here, sandy beaches appear at the estuaries of some large valleys and bays, especially at the beginning and middle of this part.

In these areas, there are more excellent opportunities to form a vast sandy coast in line with the width of the mouth of the valley, as is the case in the Shatt of the Jarjr-oma region, and the coastline from Alakla to Tolmeta is very steep and winding. It is penetrated by a large group of small wadis, allowing the formation of a very short and narrow sandy beach; some sandy beaches here do not exceed 50 m in length and 10 m in width.

1.2.3.3. Western Part (W)

It represents the coastline of the Benghazi Plain and extends from Tolmeta Castle to the El-lthamh area, east of Benghazi, and is characterized by a lack of meandering and a gentle slope towards the west, taking a general direction of northeast or southwest. It is an area that is considered typical in terms of dunes of all kinds and abounds in marine tongues, small bays, rocky terraces, pebble beaches, caves, sand barriers, irregular sand surfaces, and some longitudinal dunes parallel to the sea, marshes, and swamps, karst lakes, such as Ain Ziyanah Lake. The vast sandy coasts with the most

developed dunes have an astonishing richness of coastal plant species (Mucina et al., 2014).

The breadth of this coastal plain reaches 27.5 km south of Benghazi, while it narrows to 0.8 km in the north-eastern Tolmeta area and 3.7 km in the Tocra area to the west. As visible in Map 5, contour lines are shown in the northern parts of El-Jabal El-El-Akhdar, the Benghazi Plain.

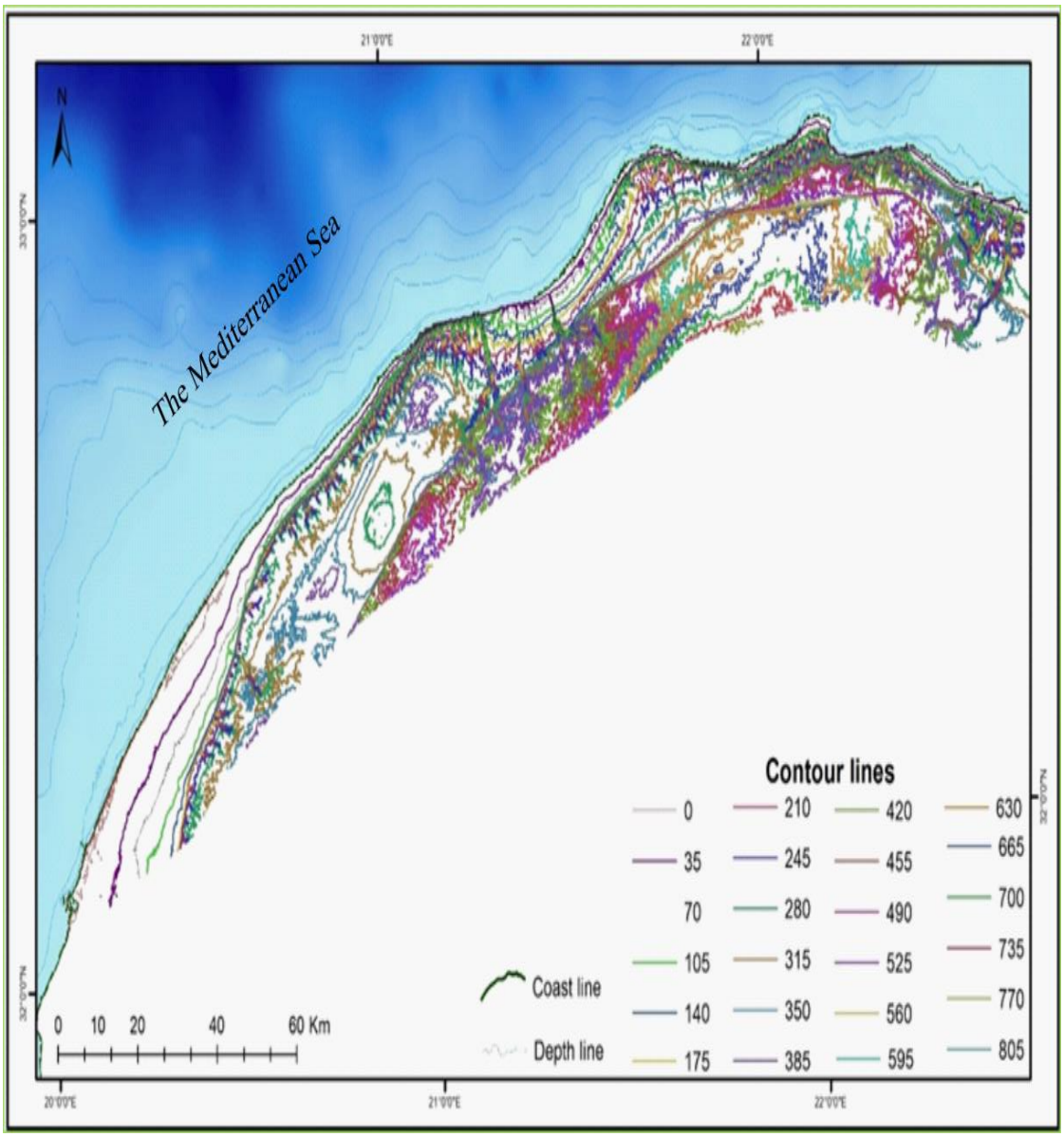
Table 9 illustrates a geomorphological description and comparison of the parts of the region from east to west; on Map 6, the geomorphological appearance and general topography of the northern coastal areas in El-Jabal El-El-Akhdar and the Benghazi plain are visible.

Table 9. Description and data for the parts of the area

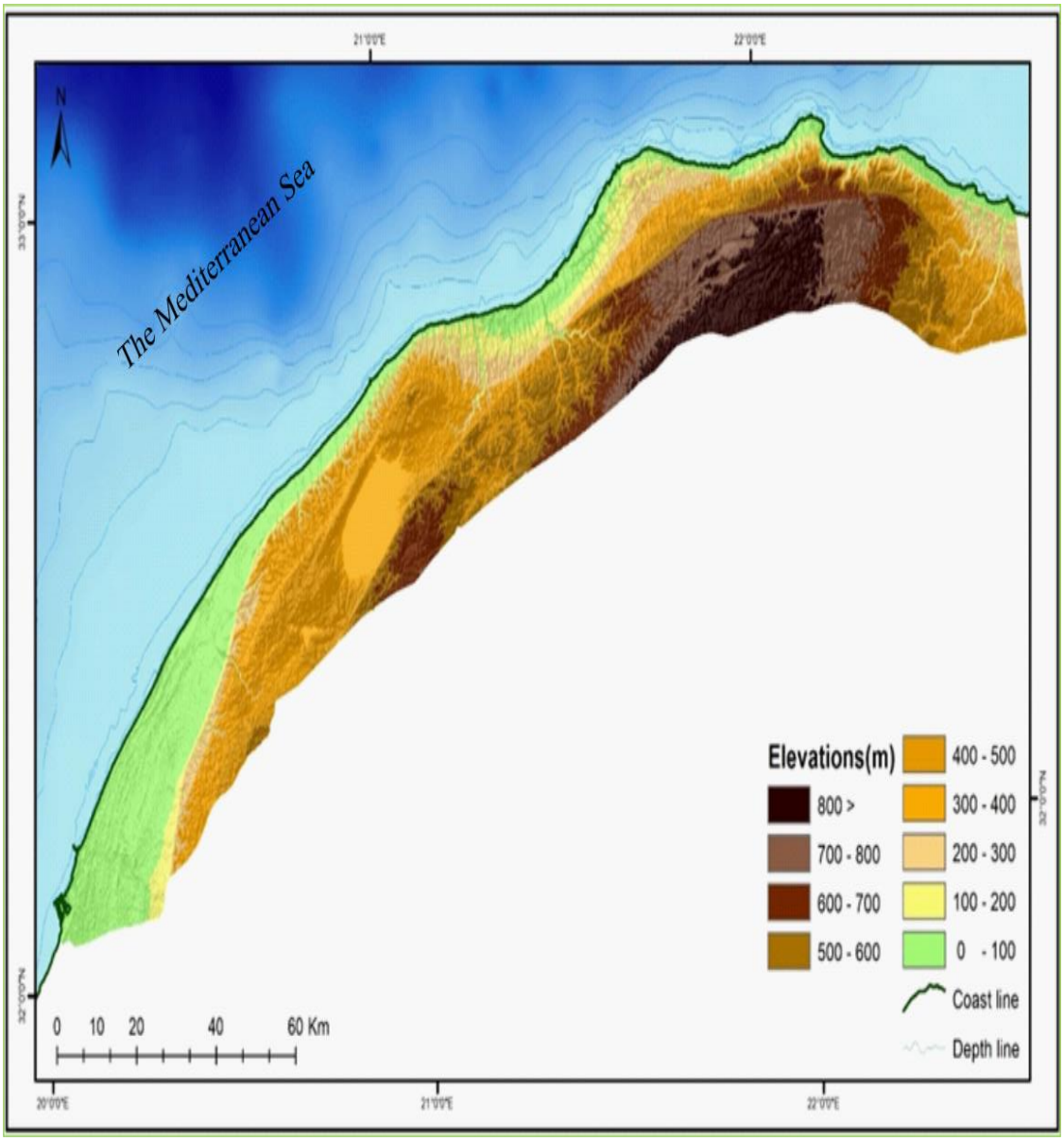
Part name	**East**	**The middle**	**western**
Symbol	E	M	**W**
Extension	West Derna to the east of El-Hamama	West of El-Hamama to the east of Tolmeta	**West of Tolmeta to Eastern Benghazi**
Length (km)	87.37	77	**135.63**
Describe	Sandy beaches are very limited and small	It starts with narrow sandy beaches and expands towards the west	**Wide sandy beaches and high dunes**
Notes	High energy sculpting the large number of bays and sea heads	The abundance of rocky islands, caves terraces and marshes	**Wide sandy beaches and high dunes**
View			

Source: Field Study 2018/2019.

Map 5 shows that the Benghazi Plain area represents a coastal plain that begins to widen towards the west until its maximum width reaches 27.5 km south of Benghazi. This widening has contributed to coastal habitats' growth and development and ecological diversity. While we notice that the coast narrows in the eastward direction, reaching tens of metres in width. It has contributed to the creation of winding sandy beaches of little breadth.



Map 5. Contour lines in the coastal area



Map 6. Physical map of the north between El-Jabal El-El-Akhdar and the Benghazi plain

The region is a coastal plain, bordered by a high plateau edge in some parts, overlooking the Mediterranean Sea with a coastline in the form of a convex crescent towards the north. The edge of El-Jabal El-Akhdar approaches the eastern region and leaves narrow plains and coasts cut by a dense network of narrow valleys.

While this edge turns south to leave a broad coastal plain, in the western part is the Benghazi plain, where the slope is moderate, and the valleys are vast, as shown in Pictures 1, Map 5, and 6.

In the eastern part, we notice a decrease in the chances of forming sandy beaches due to the proximity of the first edge of the mountain to the sea. Despite a large number of valleys, the narrow and lack of a broad coastal plain make the chances of sedimentation and the formation of sandy beaches minimal.

In the central part, the coastal plain expands slightly and provides suitable opportunities for forming sandy beaches of different lengths, breadths, and swamps.

In the western part, the first edge of the mountain follows the direction of the second edge towards the southwest, and here appears a connected coastal plain that is wider towards the west, the Benghazi plain. This makes the opportunities very suitable for the formation of sandy beaches typical of the shape and location, as well as the emergence of various swamps covering large areas and spreading throughout the lands of the coastal plain.

The field study revealed changes in beach morphology due to the different seasons, as the sandy beaches expand in the summer and increase their area, and in contrast, the strength of hydraulic sculpture increases on the beaches and rocky bays in the winter season. The rocky bays and high beaches with their slopes do not provide opportunities for the accumulation of sand sediments to form sandy beaches.

1.3. Coastal Dunes as plant habitats

1.3.1. Coastal dunes

Coastal dunes represent attractive environments in terms of environmental aspects and landscapes. They occupy transition areas between terrestrial and marine ecosystems, creating diverse biological systems between land and water. Botanists and ecologists, in particular, have given greater importance to sensitive ecosystem species. Dune ecosystems are one of them.

Coastal dunes are natural structures that protect the coastal environment by absorbing energy from wind, tide, and wave action (Barman & Pramanik, 2019). They are not just transitional regions; they have their characteristics, although physical factors such as salinity and temperature are variable near the beach (Odum & Barrett, 2005).

Coastal ecosystems are under severe threat worldwide, especially in the Mediterranean region. The vegetation cover in coastal dunes differs entirely from other species, and this difference stems from the characteristics and locations of dunes as habitats. Coastal dune systems provide ecosystem goods and services, such as protection from extreme events, recreation, and habitats for endemic species (Odum & Barrett, 2005). Dunes are very extreme habitats for plant species, and vegetation is a better indicator of environmental conditions (Stesevic, 2017).

Coastal dunes are sand systems near beaches that often receive more than 250 mm of rainfall per year and are considered separate ecosystems in their own right (McLachlan, 1991). Coastal dunes occur at all latitudes and may be tropical, temperate, humid, or dry. Botanically speaking, dunes vary according to general climatic patterns. Thus, the vegetation of coastal dunes in temperate climates is quite different from that of the tropics (Castillo, 1998).

Beach sand consists of weathering products, rock erosion, minerals, organic and inorganic residues, various mixed particles, such as quartz, gravel, rocks, clay particles, shells, snails and parts of manufactured materials such as plastics .It consists of small, round grains somewhat mixed with soil and swamp sediments, giving it a red colour (Hajjaji, 1969). These particles can be carried from the foreshore to the interior by the wind, and over time, dunes form and may reach a height of 9 meters.

Large woody debris (LWD) and Invasive plants are changing sediment budgets and stabilizing coastal dune systems(Page et al., 2011); precipitation determines the types of plants that live where the dunes form. If the country is humid coastal with variable precipitation, it will have an essential variety of plants; if it is dry, there will be a shortage of plants, so the plants will appear less diverse.

Sand creeps like an avalanche; the whole surface moves at once. Wet grains of sand are hard to move. Because they are contiguous, after heating from the sun's rays, a slight movement begins on the outer surface due to drying and disintegration, and the wind helps with that.

Dunes require sufficient wind energy to capture and transport sand grains. Dunes need an ideal location for gathering and building, i.e., a wide back beach area for piling; dunes are difficult to accumulate in narrow bays and rocky cliffs. Near the coast, the

topographical complexity of dune systems is an important ecological factor. It is possible to distinguish three main types of environments:

1. A moving substrate for high salinity sand in an active environment of coastal dunes.

2. Various depressions with high humidity levels.

3. A stable environment where physical factors are no longer severe and biological interactions become increasingly essential (Castillo, 1998).

There is a strong relationship between sediment transport, dune formation, vegetation, and the ability of currents and waves to move sediments. Shear waves contribute up to 16% of total inshore transport and up to 37% of oscillatory shore transport (Stephenson & Brander, 2003); at a certain distance from the coast, the balance between wind speed and the force of gravity or sand grain friction with each other is suitable for these accumulations to occur.

Looking at the satellite image, this appears as follows: the dunes still parallel to the shore are the primary dunes, and redirected dunes are secondary dunes arranged vertically. This way, the development and construction process continues in the coastal dunes. Coastal dune development will occur if there is an adequate supply of beach sand and the wind can move sand from the beach (Barman & Pramanik, 2019). Coastal dunes are often turbulent, suffering from nutrient depletion, frequent droughts, high temperatures, and storms.

The main features of coastal dunes are the spatial and ecological heterogeneity of plant communities and the alteration of substrate properties along the dune concerning relative humidity, such as micro-environmental factors like temperature, light, grain size, organic matter content, pH, and conductivity.

Another major factor affecting dune plant communities is wind movement, which controls the sizeable spatial discrepancy between sand transport, salt spray and evaporation. Burial in the sand can be a disturbing factor, although exposure to wind erosion can be an essential factor in the identification and distribution of cover.

The shore width and wind angle determine the fetch length. Rapid deposition of sediment on the foreshore, formation of embryonic dunes, and establishment of vegetation (Dalyander et al., 2020) topographic features (mounds, dunes, etc.) change in

the extent of local winds and sediment accumulation affect the distribution of vegetation species.

1.3.2. Coastal dunes classification

There is a range of classifications of coastal dunes, the most important of which are classification by sedimentation site, type of vegetation, colour and salinity rates, and others. We will explain two types of these classifications.

Strandline A zone devoid of plant life is of fundamental importance in achieving a balance between marine and terrestrial environments.

Primary dunes represent the growth of the first true plant community, consisting of a few species, such as *Cakile maritima - Salsola kali - Agropyron junceum - Eryngium bourgatii*.

Plants increase the growth of coastal dunes, which can reach a height of about 25 cm in less than a year.

White dunes are often higher and more stable, although their movement is continuous.

The main species, *Ammophila arenaria*, colonizes this area and is an effective barrier to wind-borne sand.

Many other species contribute to dune unification, such as the *Medicago marina*, representing a model for the more mature and developed stage of dunes.

Grey dunes are more mature and stable due to the roots of coastal grasses and plants. This helps in the emergence of woody species, shrubs, and trees such as *Rhamnus - Juniperus*, which are perennial. Hence, the dunes are stable, and the organic matter accumulates more.

A type of beach area classification, showing 4 types of dunes and 5 plant habitats, is presented in Figure 15.

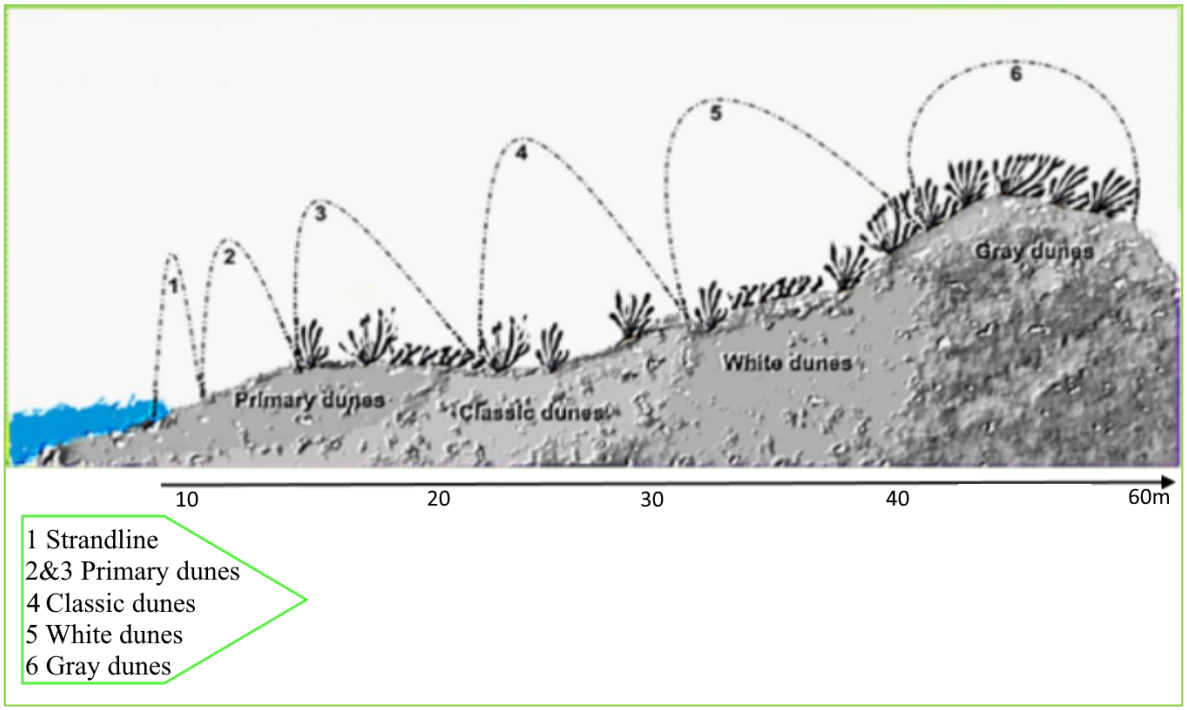


Figure 15. Logical model of coastal dune classification. Source: Based on data from the 2018/2019 field study

Visible in Figure 15 are the classification of dunes, the distribution of plants and materials, and the percentage of salinity.

The plant species in this environment are amazing creatures that require significant effort to overcome the natural forces of tidal waves, wind, salt, and drought in the summer months. These conditions complicate the life of this habitat; the plants of these coastal extensions live thanks to the fragile balance.

Sand movement and water inundation act as disturbance factors in dune systems, affecting the structure and composition of dune vegetation in different ways (Martinez et al., 1997).

The habitat here is chains of sand arranged parallel to the beach line formations. After their accumulation outside the tidal zone, the wind speed coming from the sea slows down in this area, so it is difficult to transport or withdraw sand grains, so they settle in the dunes. Plants intercept this sand, and without it, dunes will not be able to grow normally.

Beach plants consist of species adapted to extreme characteristics and conditions such as drought, insolation, high salt, and wind.

At the beginning of the backshore, the substrate stabilizes, salinity decreases, and plant species spread away from the direct influence of the sea on an ecological gradation in the form of chains of plant communities.

1.3.3. General Characteristics of coastal dunes as Habitat

The coastal environment, which is a transitional environment, represents a diverse habitat; there is a range of small habitats in that environment.

They are complex systems, representing a narrow strip of land and a rapid transition between two large ecosystems.

With the consequent environmental solid gradients and relatively short distances, the plant species that grow on dunes appear in different vegetation forms in a way that is consistent with dunes and growing conditions and forms the arrangement and organization of each community in a distinct habitat along the environmental gradients. With specific adaptations related to local environmental characteristics, such as wind speed, salt concentration, salt spray, geomorphology, and human activities.

There are advantages for coastal dune plants; in this habitat, plants vary in shape, adaptation methods, and colours. Some of them are delicate plants with a pale colour to adapt to insolation, and a thick waxy layer wrapped (like skin) appears on the leaves, representing protection from the friction of granules of Sand with wind speed and reducing the number of stomata so as not to lose moisture, such as *Salsola kali-Medicago marina*.

The leaves provide maximum moisture and store water reserves such as *Cakile marittima -Tetraena fontanesii* branches and leaves, covered with thorns or cilia or a wax layer to protect the plant (lack of complete insulation), providing adequate ventilation and reducing transpiration, as is the case in the *Medicago marina - Centaurea pumilio*.

1.3.4. The endemicity of plants in the coastal dune environment

De Candol was the first to coin the term "endemic species" (endemic taxa) and used endemicity in biogeography to refer to small taxa in the 1820s (Fouad et al., 2019).

Endemism is the natural occurrence of an exclusively biological (animal or plant) group in a geographical area; the endemism of a place or region means that it only exists in that part of the world and not anywhere else is a standard process in plants. Geographical, physical, climatic, and biological factors can contribute to endemism. The term "endemism" is defined only by the aspect of spatial constraint (Hobohm and Bruchmann, 2009).

An endemic type is limited to a particular area for historical, environmental or physiological reasons. Endemic species can be old or new, and endemic classification can be of any rank, often at the family level or below (Major, 1988); in the Al-El-Jabal El-Akhdar region, there are 44 endemic species belonging to 28 families and 41 genera (El-Darier & El-Mogaspi, 2009).

In biologically isolated areas, endemic species or species that are likely to develop on islands can occur. Endemic plants can quickly become extinct or threatened with extinction due to their specific habitat and exposure to human pressures, such as introducing new organisms.

The term "endemism" is defined only by the aspect of spatial constraint (Hobohm and Bruchmann, 2009). Endemic organisms are not the same as native organisms; a native organism in one place can also be local in other locations. An alien, an introduced or naturalized species, is an organism not native to a specific region or place.

Authentic organisms: In botany and ecology, the term "native vegetation" is applied to plant species native to that area. An endemic plant may be endemic to a particular area and become invasive and alien if it moves to other areas. Harper, in 1907, was the first to describe centres of endemism within the coastal plain (Harper, 1909).

He identified six significant centres of distribution (Weakley, 2015). Coastal and saline habitats This group includes 4.2% of endemic vascular plants confined to mainland Europe. The Mediterranean Sea is more flowering, with plants endemic to salt marshes, coastal dunes or rocks (Hobohm et al., 2014).

In Libya, there are four particular areas for endemicity, such as El-Jabal El-Akhdar and the coastal strip. There are 26 endemic species in the coastal strip, of which 9 are frequent in El-Jabal El-Akhdar.

There are two sub-categories of endemism. Paleoendemism and neo-endemism refer to previously widespread species but are now limited to a small area, e.g., *Juniperus oxycedrus* trees in northeastern Libya.

Endemic species can quickly become threatened or extinct if their already restricted habitats change, especially (but not only) due to human actions, such as introducing new species.

The factors threatening the endemic plants are many, viz., industrialization, urbanization, expansion of agricultural areas, excessive grazing, tourism, collecting wild plants for export, agricultural enterprises, pollution, afforestation, and fire (Uysal, 2010) present zonation of coastal sandy habitat zones include illustrated in Figure 16.

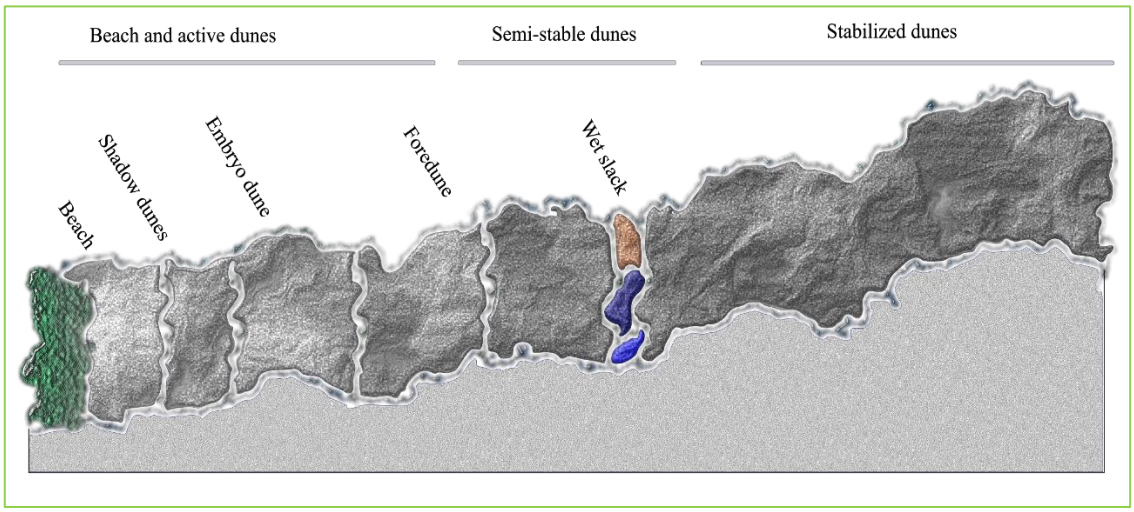


Figure 16. Presents the zonation of coastal sandy habitat zones

Source: Prepared based on data from(Muñoz-Vallés & Cambrollé, 2016) and the 2019 field study.

There is a large volume of published studies that classify sandy habitats based on community structure and plant species distribution.

Typical zonation of coastal sandy habitat zones includes the embryonic dunes (Marcenò et al., 2018)

1. Foredunes (white dunes)

2. semi-fixed dunes.

3. fixed dunes (grey dunes).

The effects of climate and spatial position on plant community structure differ between shifting and stable dunes.

The foreshore portion of the beach is subject to wave action during non-storm conditions, while the backshore portion is subject to wave action only during storms.

Embryonic mobile dunes represent the early stages of dune construction. This habitat consists of shifting dunes (Fagaras, 2015). Pioneer plants partially stabilize them.

Perennial dune-forming plants, for example, *Elymus fractus* and other perennial herbaceous species such as *Cyperus capitatus, Eryngium maritimum*, and *Medicago marina,* dominate embryonic dunes. It develops on a poor sandy substratum with low organic matter and salinity. Sand movement on a local scale buries vegetation (Vecchio et al., 2015).

Small embryonic dunes on which Elymus arenaria grows contain salts ranging from 0.005-0.009% NaCl, compared to the dunes on which *Ammophila arenaria* grows (Olsson-Seffer, 1909).

Moving dunes represent typical associations of the first vegetation belt starting from the coast, where leading ecologically resistant species predominate (Buffa et al., 2007).

Important types contributing to the construction of dunes include Salsola kali, Cakiletum maritime, Elytrigia juncea, Ammophila arenaria, Agropyretum juncei, and Echinophoro spinose.

In the context of the arid portions of stabilized dunes, moving away from the direct influence of the sea allows the development of a more significant number of plant communities, some of which are structurally more complex, have less specialized flora, and are more varied. In this system, greater diversity occurs regarding flora and phylogenetics (Buffa et al., 2007). Fixed dunes are essentially shrub-covered. The first type of woody coastal vegetation is juniper scrub (*Juniperus phoenicea-oxycedrus*).

2. DISTRIBUTION OF DUNE VEGETATION IN THE RESEARCH FIELD

This section covers the distribution of plant species in coastal dunes and provides data on plant communities and their distribution in sandy habitats.

Although climatic conditions are the most important determinants of plant life, local differences in climate, surface appearance, geological structure, and soil type give different images of plant life in one plant area (Al Banna, 1970). Coastal dunes are complex systems in terms of plant growth conditions.

Where there are differences due to the characteristics and location of the dune as a habitat is that some factors limiting growth are little or no nutrients and organic matter, high permeability, exposure to direct sunlight, high temperatures, and exposure to wind (Avcı, 2017) critical vegetation areas in Libya are located in coastal, mountainous, and desert habitats. El-Jabal El-Akhdar region is a critical and unique vegetation area in northeastern Libya; The first checklist of Libyan species ended in 1819 (Cella, 1819). Coastal dune vegetation has adapted to the harsh conditions in these habitats; species some are perennial, many are seasonal, some are semi-seasonal, and the seeds of some species may migrate long distances with seawater or be buried for years in the sand until the right conditions are in place for growth.

When trying to explain the many phenomena of sandy vegetation distribution, many problems are encountered (Olsson-Seffer, 1909). A group of natural and anthropogenic factors participate in the distribution of vegetation and interrelated form relationships with each other. The climate factor, with its various elements, is the most influential in the distribution of plant species.

Plants in these habitats are subjected to substrate movement and fresh and saltwater inundation, dramatically affecting species' germination and spatial distribution (M. L. Martínez et al., 2002). There is a possibility that height, water content and soil texture will affect species distribution (Earle & Kershaw, 1989). Salinity, extensive thermal range, and temperature change due to the rapid heating of surface sand layers (Olsson-Seffer, 1909).affect the local distribution of some plants in sandy habitats and the purity of the spread of some species on sand fans.

Precipitation, wind, humidity, and substrate temperature are among the most critical factors affecting the distribution of species on coastal dunes. Some species sometimes appear in scattered places far from the direct influence of the sea. This species has adapted to the natural conditions of the rear dune areas with a society in which large shrubs or trees predominate(Franks, 2003).

Generally, natural factors cannot be separated from human activities when studying the distribution and diversity of plants in coastal habitats. The emergence of alien plant species may lead to (aiding or threatening) dune habitats having substrate stabilization, sand particle traps, or increased competition and threat to native species. Coastal dune landscapes are a complex mosaic that develops in transitional zones between terrestrial and marine environments, occupying strips parallel to the seashore (Marzialetti et al., 2019). Plant species in the coastal dune environment appear as lines parallel to the coastline. Coastal plant communities mostly range from pioneer vegetation near the shoreline to Mediterranean shrubs on landward-fixed dunes.

2.1. Dune Area Vegetation Between West Derna and Ras El-Hamamah

Due to geomorphology, sandy beaches of little breadth and depth abound between the region's West Derna and Ras El-Hamamah. They are small and discontinuous bays.

The rim of El-Jabal El-Akhdar approaches the sea and leaves a group of shallow beaches and coves. The most prominent activities are the multiplicity of resorts, fishing, and other facilities such as ports. From east to west, this section includes the areas of Adlis, Ras Al-Hilal, Susa, and Ras El-Hamamah. The total length of the sandy beaches subject to the field survey was 2,943 m. Figure 17 shows field survey points in the coastal dunes between West Derna and Ras El-Hamamah.

The following presentation shows the distribution of plant species and data on the nature of this distribution and the types of plant families in the region.

Table 10 shows the distribution of plant species between West Derna and Ras El-Hamamah, classifies the species and genera, and presents data on the abundance and nature of species.

Figure 17. Field survey points between West Derna and Ras El-Hamamah

Table 10. Distribution of plant species between West Derna and Ras El-Hamamah

Family	Scientific name	L. D	Kinds	Order	Abundance scale
Poaceae	*Ammophila arenaria*	Per	Grass	Poales	4
Cupressaceae	*Juniperus oxycedrus*	Per	Tree	Pinales	4
Brassicaceae	*Cakile maritima*	Ann	Grass	Brassicales	2
Zygophyllaceae	*Tetraena fontanesii*	Per	Shrub	Zygophyllales	2
Cyperaceae	*Cyperus capitatus* Vand	Per	Grass	Poales	2
Plumbaginaceae	*Limoniastrum monopetalum*	Per	Shrub	Caryophyllales	2
Amaranthaceae	*Salsola vermiculata*	Per	Shrub	Caryophyllales	3
Boraginaceae	*Heliotropium curassavicum*	Per	Grass	Boraginales	1
Thymelaeaceae	*Thymelaea hirsuta* Endl	Per	Shrub	Malvales	3
Tamaricaceae	*Reaumuria vermiculata*	Per	Shrub	Caryophyllales	2
Polygonaceae	*Polygonum maritimum*	Per	Grass	Caryophyllales	2
Ephedraceae	*Ephedra alata* Decne	Per	Shrub	Ephedrales	1
Compositae	*Bellis sylvestris var. cyrenaica*	Ann	Grass	Asterales	1
Rubiaceae	*Crucianella aegyptiaca*	Ann	Grass	Gentianales	1
Poaceae	*Trisetaria macrochaeta*	Ann	Grass	Poales	1
Asparagaceae	*Drimia maritima* Stearn	Ann	Forbs	Asparagales	2
Compositae	*Onopordum arenarium*	Per	Forbs	Asterales	1

Table 10. follows

Family	Scientific name	L.D	Kinds	Order	Abundance scale
Leguminosae	*Ononis natrix*	Per	Grass	Fabales	2
Poaceae	*Stipagrostis libyca*	Per	Grass	Poales	2
Poaceae	*Sporobolus pungens*	Per	Grass	Poales	3
Amarnthaceae	*Salsola kali*	Ann	Forbs	Caryophyllales	2
Poaceae	*Avena barbata Pott ex Link*	Ann	Grass	Poales	2
Compositae	*Cichorium spinosum*	Per	Shrub	Asterales	3
Poaceae	*Cynodon dactylon*	Per	Grass	Poales	1
Plumbaginaceae	*Limonium virgatum* (Willd)	Per	Grass	Caryophyllales	3
Leguminosae	*Medicago polymorpha*	Ann	Forbs	Fabales	3
Leguminosae	*Medicago tornata* Mill	Ann	Forbs	Fabales	1
Asteraceae	*Limbarda crithmoides*	Ann	Grass	Asterales	1
Poaceae	*Ammophila arenaria*	Per	Grass	Poales	3
Euphorbiaceae	*Euphorbia paralias*	Per	Shrub	Malpighiales	4
Thymelaeaceae	*Thymelea hirsuta*	Per	Shrub	Malvales	2
Leguminosae	*Retama raetam* (Forssk) Webb	Per	Shrub	Fabales	4
Leguminosae	*Ononis vaginalis* Vahl	Per	Shrub	Fabales	2
Anacardiaceae	*Pistacia lentiscus*	Per	Tree	Sapindales	3
Oleaceae	*Phillyrea latifolia*	Per	Shrub	Lamiales	1
Aizoaceae	*Mesembryanthemum nodiflorum*	Ann	Grass	Caryophyllales	3
Amaranthaceae	*Suaeda mollis* (Desf) Delile	Per	Grass	Caryophyllales	2
Poaceae	*Sporobolus pungens*	Per	Grass	Poales	4
Apiaceae	*Torilis nodosa* Gaertn	Ann	Grass	Apiales	2
Lamiaceae	*Teucrium polium*	Per	Shrub	Lamiales	1
Convolvulaceae	*Cressa cretica*	Per	Grass	Solanales	1
Poaceae	*Hordeum marinum* Huds	Ann	Grass	Poales	3
Rosaceae	*Sarcopoterium spinosum*	Per	Shrub	Rosales	4
Lamiaceae	*Phlomis floccosa*	Per	Shrub	Lamiales	3
Plumbaginaceae	*Limoniastrum monopetalum*	Per	Shrub	Caryophyllales	2
Amarnthaceae	*Salsola kali*	Ann	Forbs	Caryophyllales	4
Brassicaceae	*Cakile maritima*	Ann	Grass	Brassicales	3
Zygophyllaceae	*Tetraena fontanesii*	Per	Shrub	Zygophyllales	2
Boraginaceae	*Heliotropium curassavicum*	Per	Grass	Boraginales	1
Euphorbiaceae	*Euphorbia paralias*	Per	Shrub	Malpighiales	1

The following graphs show species abundance at the most critical study sites. Figures 18 and 19 show the distribution of species in the study points. Principal pioneer species are declining in coastal dunes. *Salsola kali* overlaps with most communities on the first beach and backshore, and *Ammophila arenaria*, which marks the beginning of the embryonic dunes, retreats inward when they fall under human pressure. The emergence of *Sarcopoterium spinosum and Euphorbia paralias* is evidence of a decline in plant communities and the invasion of these species into degraded habitats.

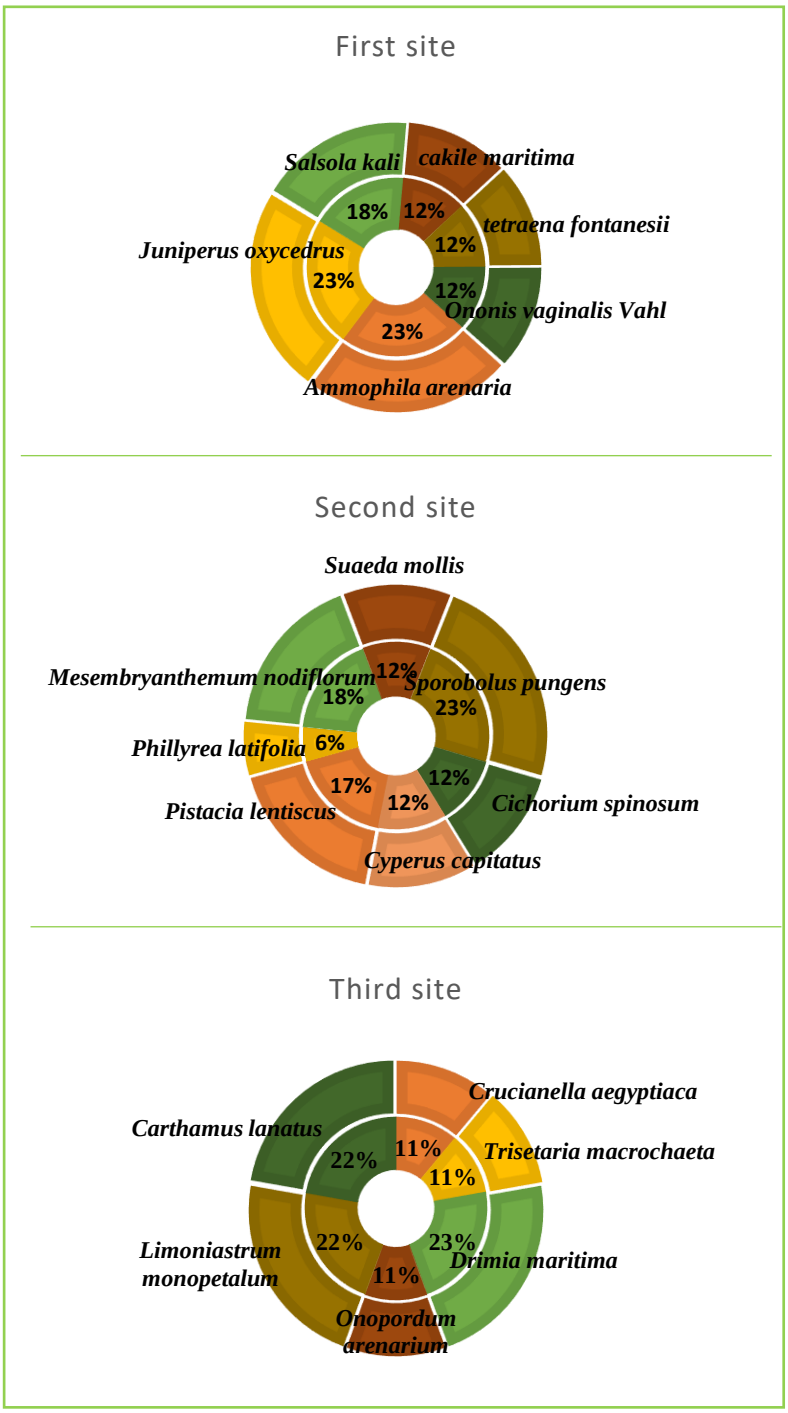


Figure 18. Measuring the abundance of plant species between West Derna and Ras El-Hamamah

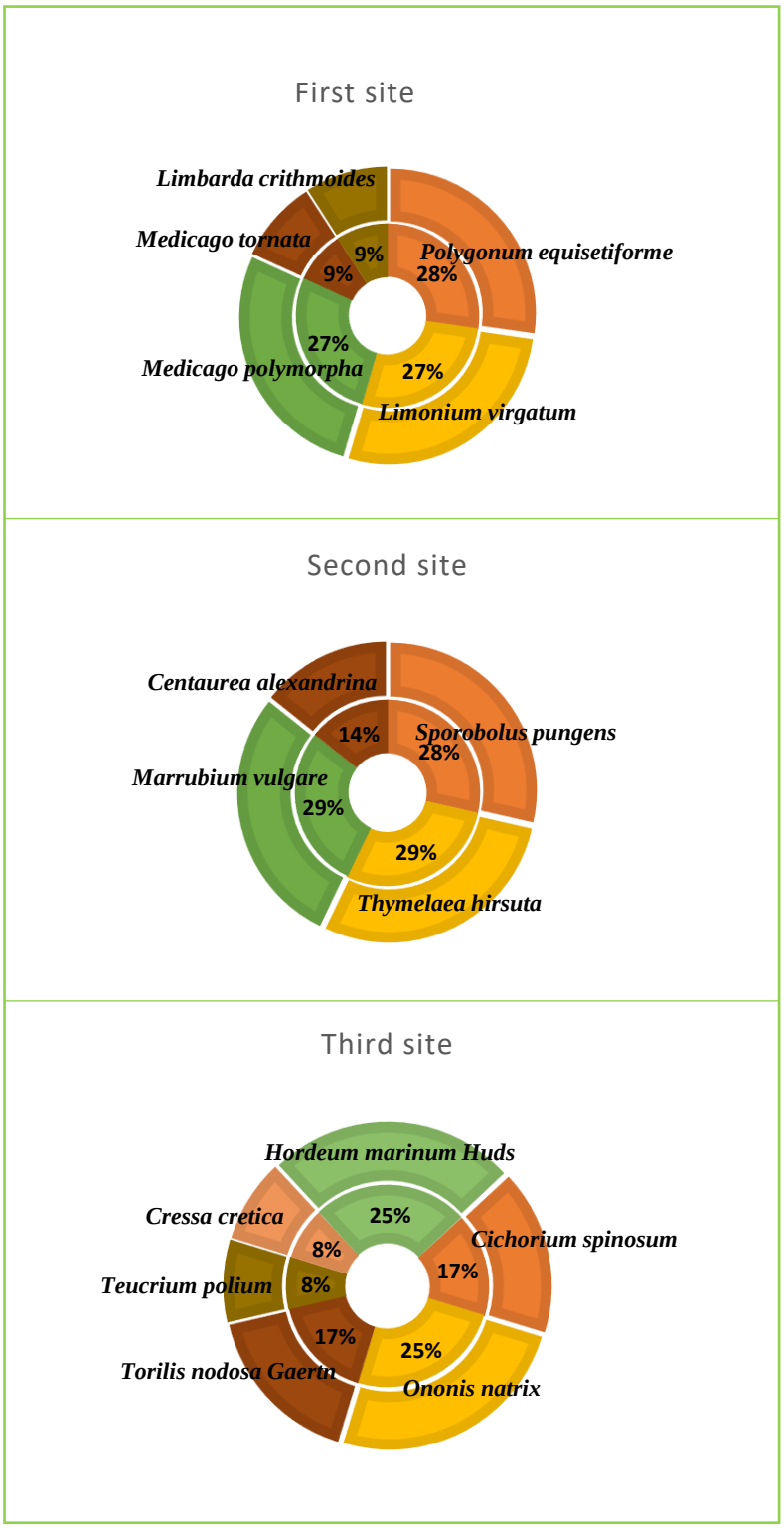


Figure 19. Measuring the abundance of plant species between West Derna and Ras El-Hamamah

Figure 20 presents a model of the distribution of plant species in diverse coastal dune habitats.

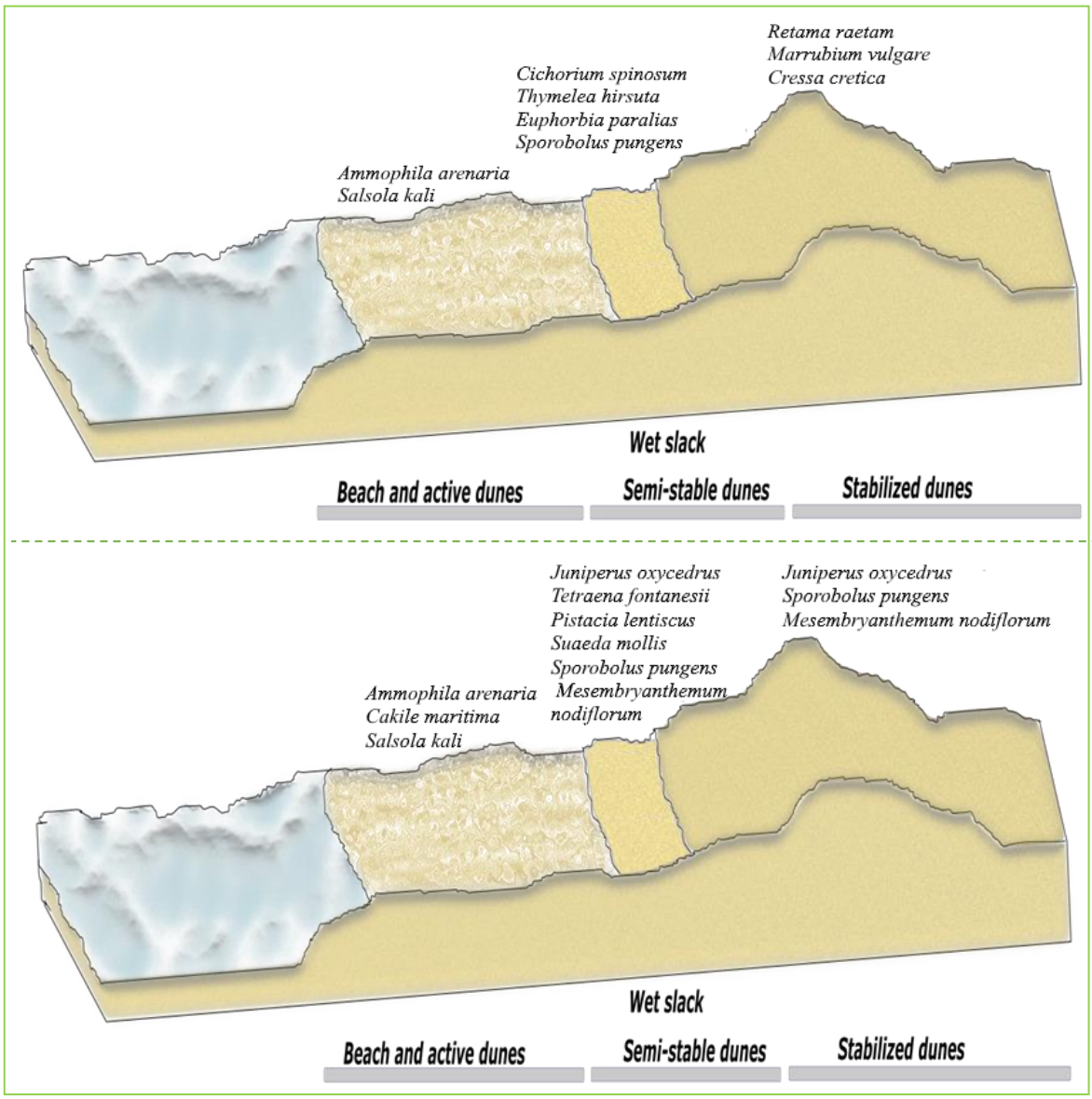


Figure 20. Distribution of plant species in coastal dune habitats between West Derna and Ras El-Hamamah

The most threatening factors for plant diversity are the dredging of sand, from wide beaches, due to its proximity to paved roads and urban centres and the spread of resorts, which is the reason for the decline in species.

Table 11 presents the measurement and description of passive human activities in dune habitats. Table 12 presents the most widespread human activities between West Derna and Ras El-Hamamah, Picture 2 illustrates the plant diversity between West Derna and Ras El-Hamamah, and Picture 3 illustrates the remains of juniper trees on the sandy beach west of Derna.

Table 11. Measuring and describing adverse human activities in coastal dune habitats

Human activities		
Effect	level	Notes on habitat
very strong	<100	Habitat destruction, scarcity, and loss of species (severe desertification)
Intense	75 - 100	Severe species shortage and habitat disintegration
Medium	50 - 75	Lack of diversity, abundance, coverage, and apparent habitat degradation
Few	25 - 50	Variety abundance and little coverage in the habitat,
Low	25	Variety abundance and good coverage in the habitat
very low	5	There is diversity, abundance, and adequate coverage in the habitat

Source: field study data.

Table 12. The most widespread human activities between West Derna and Ras El-Hamamah

	Effect	**very strong**	**Intense**	**Medium**	**Few**	**Low**	**very low**
Human activities	level	<100	75 - 100	50 - 75	25 - 50	25	5
	Type of Activity	Bulldozers scrape sand (from shear area to fixed dune)	Heavy machinery - roads - lanes - cutting - burning	Tourism - waste - cutting - trampling	Heavy trampling (various machines)	walking and jogging	Light stomping

Source: field study data.

The activities affecting plant species distribution in the dune environment between West Derna and Ras El-Hamamah are extensive sand dredging, multiple summer resorts, heavy traffic with different vehicles, multiple pedestrian paths, and various types of waste.

Therefore, we observe a sharp decline in species and the apparent overlap between them and the Maquis community.

The area represents low, winding, rocky shores. In these sites, plant species were spotted, especially in valleys that reach the sea (some of them are endemic), such as *Cupressus sempervirens* L. *var. horizontalis* (Mill) Gord-*Juniperus phoenicea L.*-*Nicotiana glauca -Silybum marianum L. Gaertn. -Rhamnus alaternus subsp. Pendulus* (Pamp) Jafri*: Euphorbia bivonae* Steud-*Ziziphus lotus L. Lam-Periploca laevigata subsp. Angustifolia-Phillyrea angustifolia L-Marrubium vulgare L.*

The following pictures show some types of sandy habitats between West Derna and Ras El-Hamamah and show the geomorphology of the coast and various human activities.

Picture 2. Plant diversity between West Derna and Ras El-Hamamah

Picture 3. Remains of Juniperus oxycedrus trees appear on the sandy beach west of Derna

This tree is one of the endangered species because it is the only natural presence of this species in Libya, and it appears in an area of 524.192 m2.

In Libya, there are two types of *juniper: Juniperus phoenicea*, which covers 75% of the area of El-Jabal El-Akhdar, and *Juniperus oxycedrus*, which is endemic to the west of the tuber in the Shatt Adlis region and highly threatened.

Activities such as roads, resorts, and sand scraping, which are the leading causes of reduced plant diversity, are depicted in Picture 4. Picture 5 presents some sections of the coast between West Derna and Ras El-Hamamah.

Picture 4. Plant diversity decreases with poor habitat management

Plant diversity declines as habitat fragmentation occurs; species mix among coastal dune communities, forest formations, and the Maquis Formation; *Ammophila arenaria -Spoorobolus pungens - Cichorium spinosum - Tetraena fontanesii - Salsola vermiculata -Juniperus oxycedrus - Pistacia lentiscus*.

Pioneering species appear on embryonic dunes in the foreground. Then species are distributed among other habitats. The basis for this distribution depends on a combination of factors, including habitat status, plant characteristics, type of substrate, storms and salt spray, swamps, beach nature, and the history of human activity.

Picture 5. Some sections of the coast between West Derna and Ras El-Hamamah

2.2. Dune area vegetation between El-Hamamah and Tolmeta

The edge of El-Jabal El-Akhdar veers slightly, leaving a choppy coastal plain with a series of deep bays. The most prominent activities are skimming and shovelling sand, the multiplicity of small resorts, and grazing.

The middle range includes, from east to west, Swyrat Ariyf, Sirat Aldwimia, Umm Sayyad, Almalik Idris resort, Ghot Aldis, Bir al-Hussi, West Al-Nakhl, Bir Al-Akla, and Tolmeta. The total length of the sandy beaches subject to the field survey was 16316.5 m. Figure 21 shows field survey points in the coastal dunes between El-Hamamah and Tolmeta.

Table 13 shows the distribution of plant species between El-Hamamah and Tolmeta, classifies the species and genera, and presents data on the abundance and nature of species.

The following graphs show species abundance at the most critical study sites, and Figures 22, 23, and 24 present species distribution at study points.

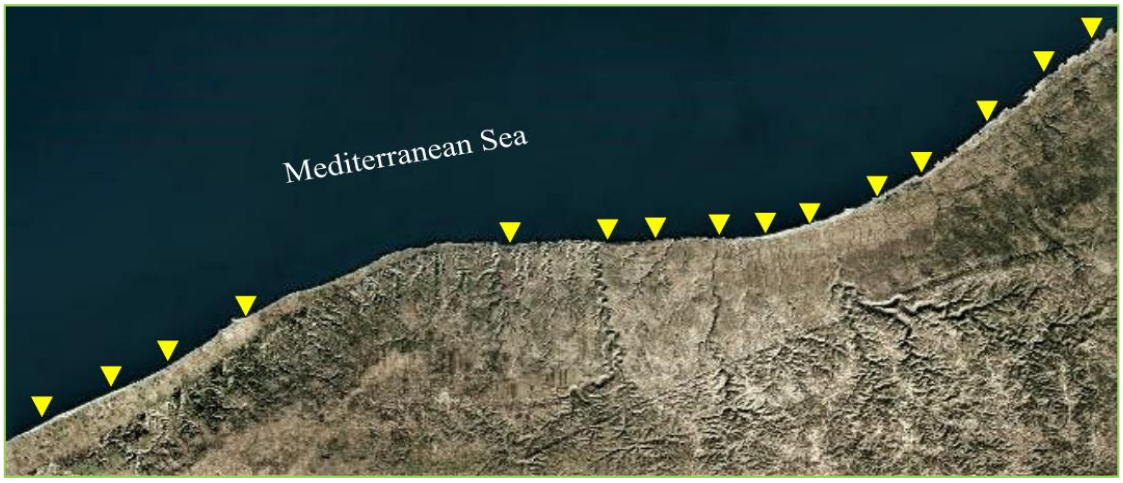


Figure 21. Field survey points between El-Hamamah and Tolmeta

Table 13. Distribution of plant species between El-Hamamah and Tolmeta

Family	Scientific name	L.D	Kinds	Order	Abundance scale
Poaceae	*Sporobolus pungens* (Schreb)	Per	Grass	Poales	3
Leguminosae	*Ononis vaginalis* Vahl	Per	Shrub	Fabales	4
Compositae	*Cichorium spinosum*	Per	Shrub	Asterales	3
Poaceae	*Ammophila arenaria*	Per	Grass	Poales	2
Plumbaginaceae	*Limonium cyrenaicum*	Per	Grass	Caryophyllales	3
Amarnthaceae	*Salsola kali*	Ann	Forbs	Caryophyllales	4
Poaceae	*Cynodon dactylon*	Per	Grass	Poales	3
Zygophyllaceae	*Tetraena fontanesii*	Per	Shrub	Zygophyllales	2
Euphorbiaceae	*Euphorbia paralias*	Per	Shrub	Malpighiales	4
Papaveraceae	*Glaucium flavum* Crantz	Per	Shrub	Ranunculales	4
Polygonaceae	*Polygonum maritimum*	Per	Forbs	Caryophyllales	1
Poaceae	*Sporobolus pungens*	Per	Grass	Poales	5
Solanaceae	*Lycium arabicum* Schweinf	Per	Shrub	Solanales	2
Plumbaginaceae	*Limonium virgatum*	Per	Grass	Caryophyllales	4
Solanaceae	*Lycium arabicum*	Per	Shrub	Solanales	2
Compositae	*Centaurea pumilio*	Per	Grass	Asterales	2
Rosaceae	*Sarcopoterium spinosum*	Per	Shrub	Rosales	1
Tamaricaceae	*Reaumuria vermiculata*	Per	Shrub	Caryophyllales	3
Crassulaceae	*Sedum sediforme*	Per	Grass	Saxifragales	3
Leguminosae	*Retama raetam*	Per	Shrub	Fabales	4
Ephedraceae	*Ephedra altissima* Desf	Per	Shrub	Ephedrales	3
Ephedraceae	*Ephedra alata* Decne	Per	Shrub	Ephedrales	3
Leguminosae	*Calicotome villosa*	Per	Shrub	Fabales	2
Anacardiaceae	*Searsia tripartita*	Per	Shrub	Sapindales	3
Poaceae	*Ammophila arenaria*	Per	Grass	Poales	4
Cyperaceae	*Cyperus capitatus* Vand	Per	Grass	Poales	5
Compositae	*Centaurea pumilio*	Per	Grass	Asterales	5
Boraginaceae	*Echium angustifolum*	Per	Grass	Asterales	2
Rosaceae	*Sarcopoterium spinosum*	Per	Shrub	Rosales	4
Brassicaceae	*Cakile maritima*	Ann	Grass	Brassicales	2
Poaceae	*Sporobolus virginicus*	Per	Grass	Poales	4

Papaveraceae	*Glaucium flavum* Crantz	Per	Shrub	Ranunculales	3
Cucurbitaceae	*Citrullus colocynthis*	Per	Grass	Cucurbitales	3
Compositae	*Silybum marianum*	Per	Forbs	Asterales	2
Compositae	*Reichardia tingitana*	Ann	Grass	Asterales	2
Leguminosae	*Ononis natrix*	Per	Grass	Fabales	2
Apiaceae	*Torilis nodosa*	Ann	Grass	Apiales	3
Tamaricaceae	*Tamarix tetragyna* Ehrenb Delil	Per	Tree	Caryophyllales	4
Thymelaeaceae	*Thymelaea hirsuta*	Per	Shrub	Malvales	4
Juncaceae	*Juncus acutus*	Per	Grass	Poales	1
Leguminosae	*Retama raetam*	Per	Shrub	Fabales	1
Amaryllidaceae	*Pancratium maritimum*	Per	Grass	Asparagales	3

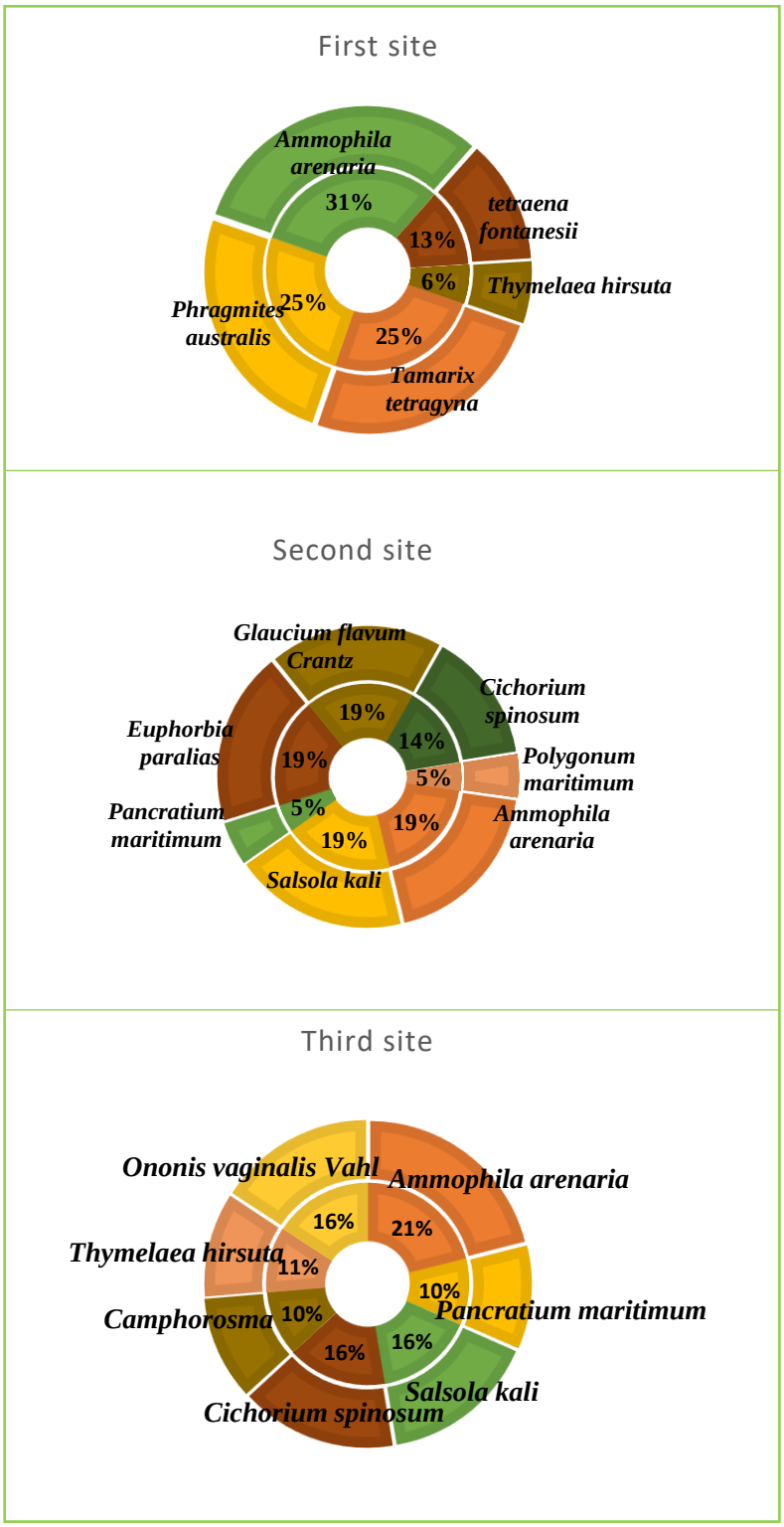


Figure 22. Measuring the abundance of plant species between El-Hamamah and Tolmeta

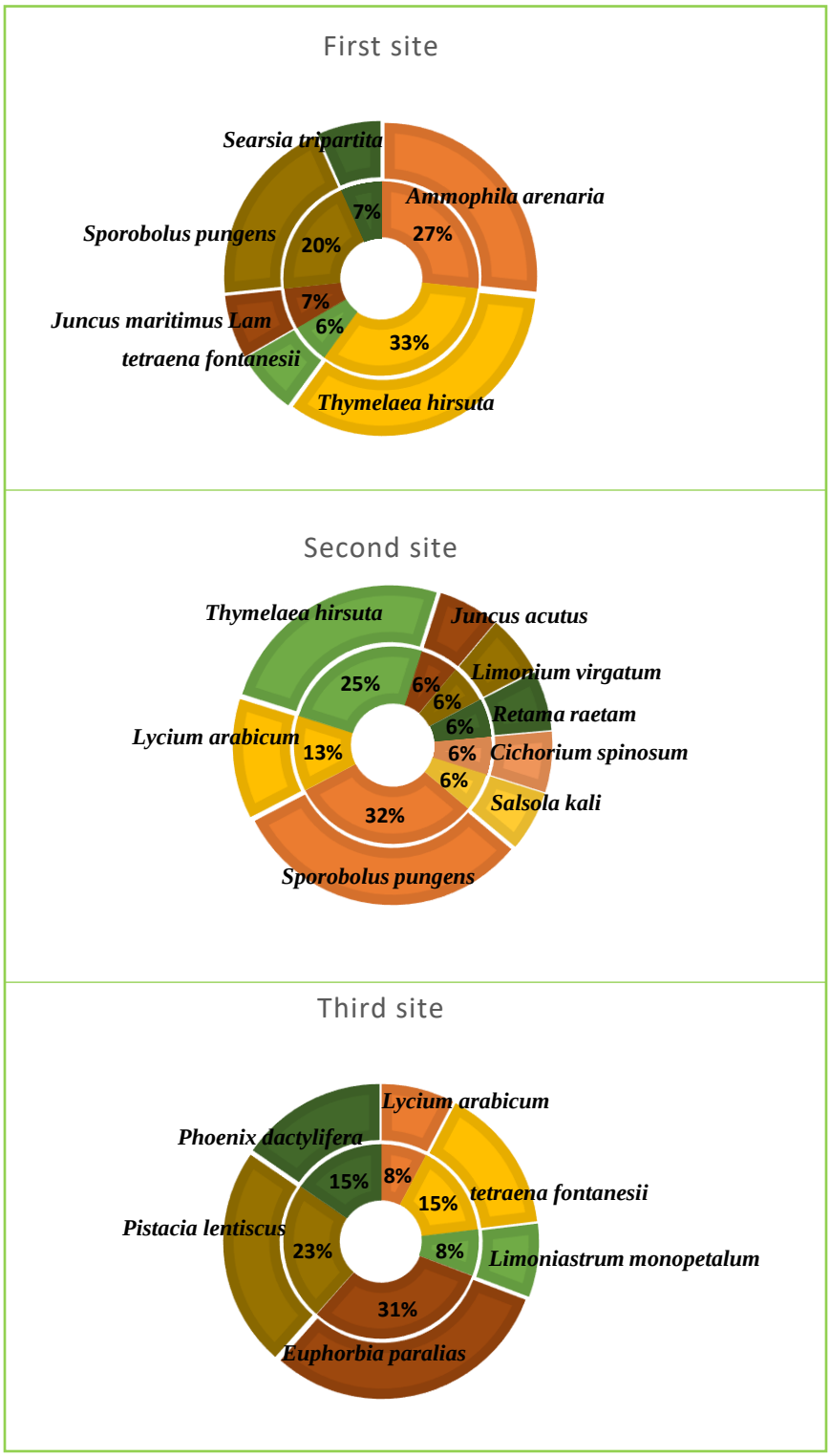


Figure 23. Measuring the abundance of plant species between El-Hamamah and Tolmeta

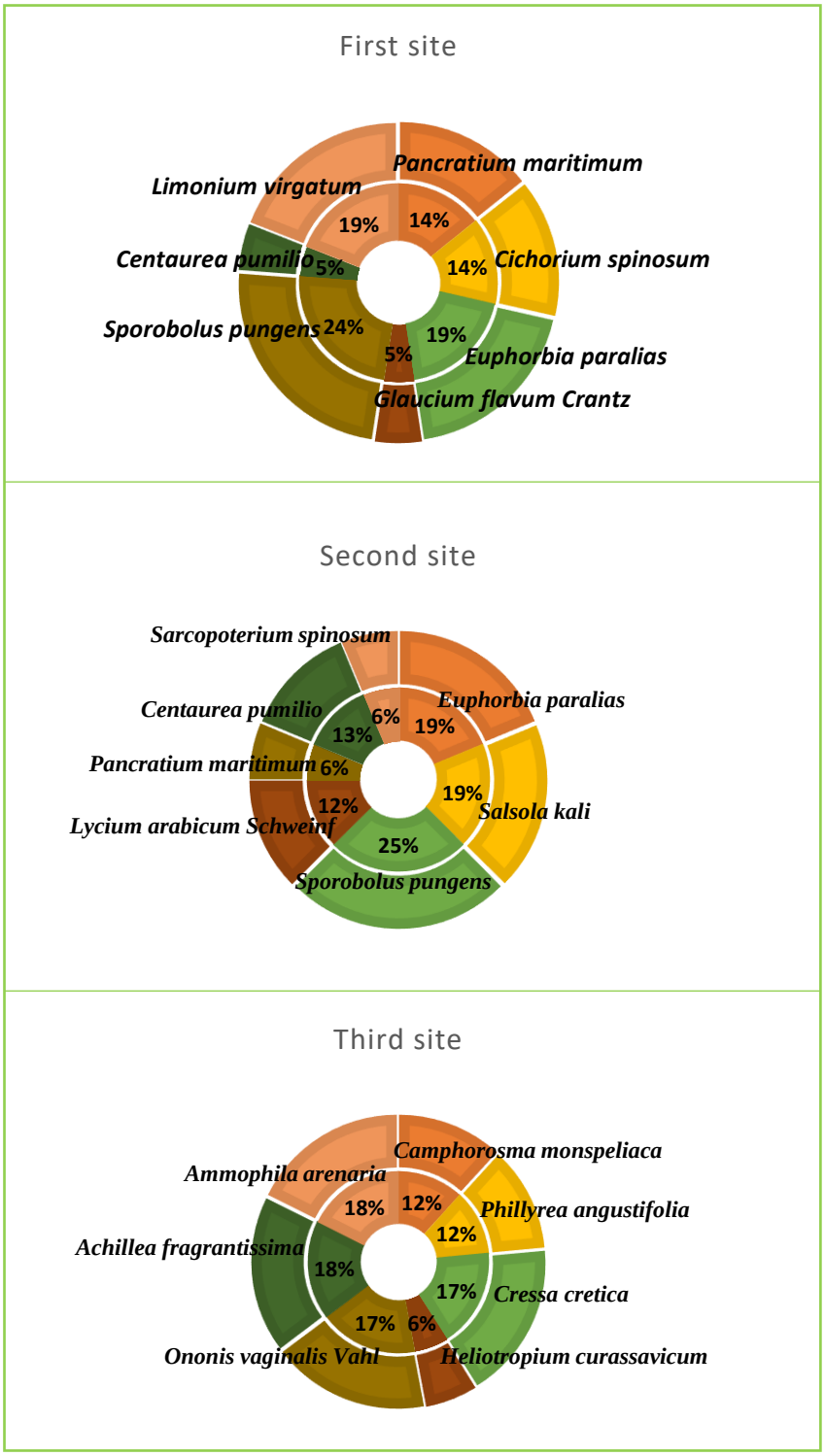


Figure 24. Measuring the abundance of plant species between El-Hamamah and Tolmeta

Figure 25,26 presents a model of the distribution of plant species in diverse coastal dune habitats between El-Hamamah and Tolmeta

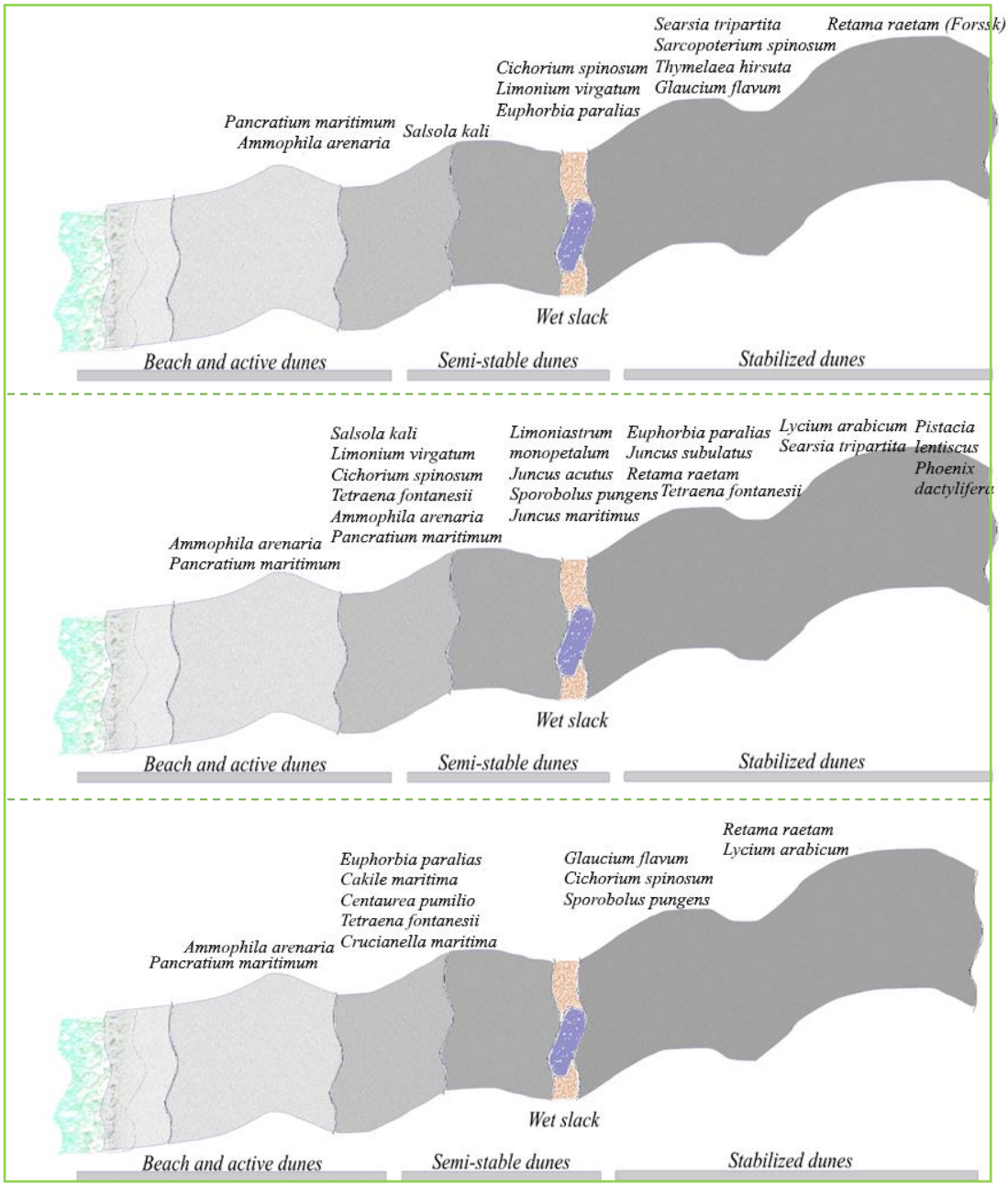


Figure 25. Distribution of plant species in coastal dune habitats between El-Hamamah and Tolmeta

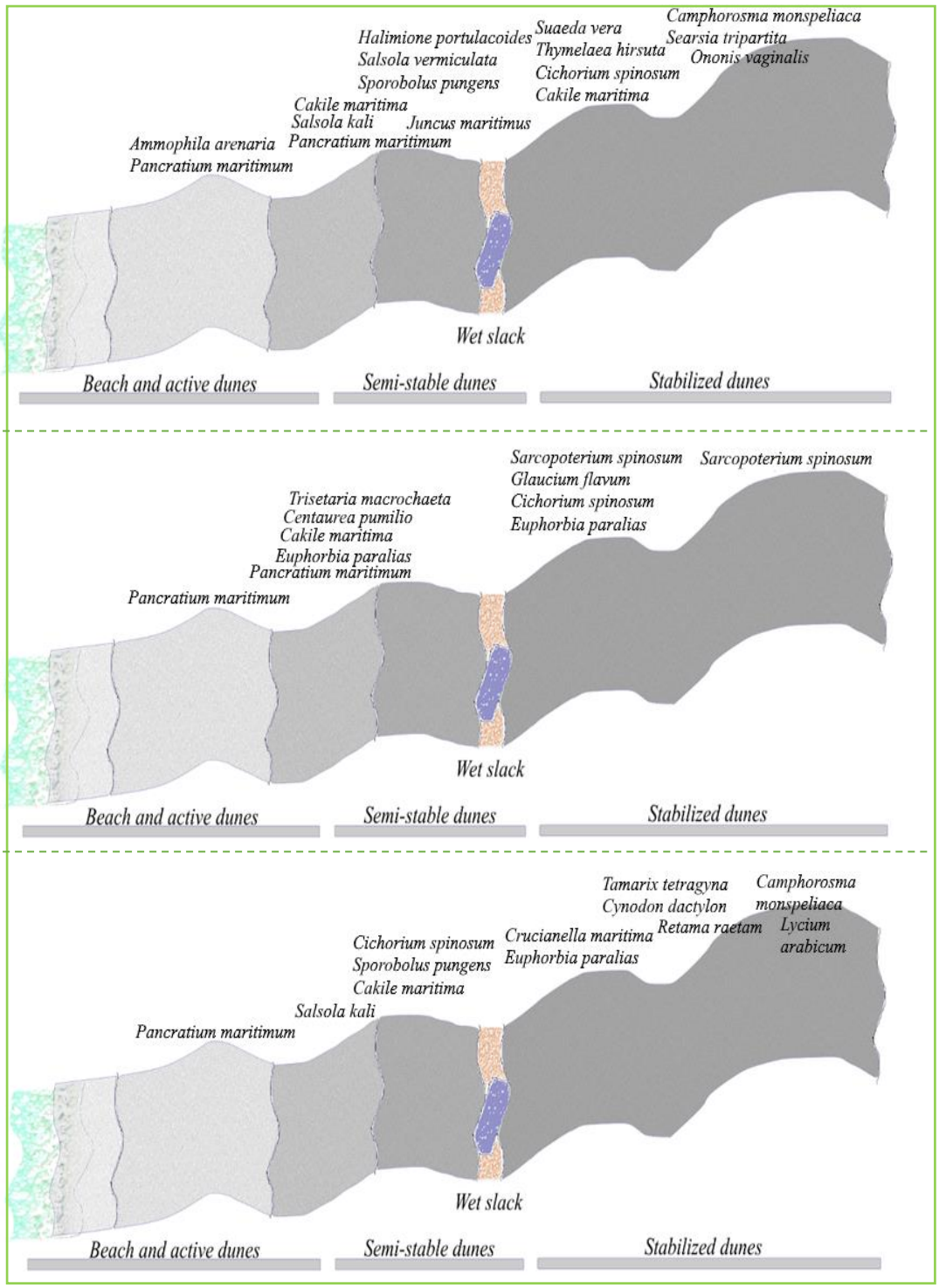


Figure 26. Distribution of plant species in coastal dune habitats between El-Hamamah and Tolmeta

Table 14 estimates the most widespread human activities between El-Hamamah and Tolmeta, and Picture 6 presents the distribution of the main species among dunes, soft sand meadows, and dry swamps.

Table 14. The most widespread human activities between El-Hamamah and Tolmeta

Human activities	**Effect**	**very strong**	**Intense**	**Medium**	**Few**	**Low**	**very low**
	level	<100	75 - 100	50 - 75	25 - 50	25	5
	Type of Activity	Bulldozers scrape sand (from shear area to fixed dune)	Heavy machinery - roads - lanes - cutting - burning	Tourism - waste - cutting - trampling	Heavy trampling (various machines)	walking and jogging	Light stomping

Source: field study data.

Activities that affect the diversity and distribution of plant species in coastal dunes are sand scraping, heavy vehicle traffic, pedestrian paths, waste, and marsh-filling.

Types spread in locations where rocks mix with a small quantity of sand *Thymelaea hirsuta* - *Limonium virgatum* (Willd) Fourr - *Nicotiana glauca* - *Marrubium vulgare* - *Thymelaea hirsuta* invades solid waste sites very quickly.

It may be a mixed species group, forming a wider community, such as Marrubium vulgare - Cichorium spinosum - Sarcopoterium spinosum - Crucianola maritima - Lycium arabicum, *Schweinf* - *Ononis* vaginalis Vahl - *Camphorosma monspeliaca* - *Alkanna* - *Onopordum* arenarium.

In the old dunes and on the edges of the swamps, plant types appear in a distinctive density and abundance, the most important of which are: in the swampy territory: *Limoniastrum monopetalum L.* Boiss - *Juncus maritimus* Lam - *Tamarix* tetragyna Ehrenb Delile - *Atriplex halimus.*

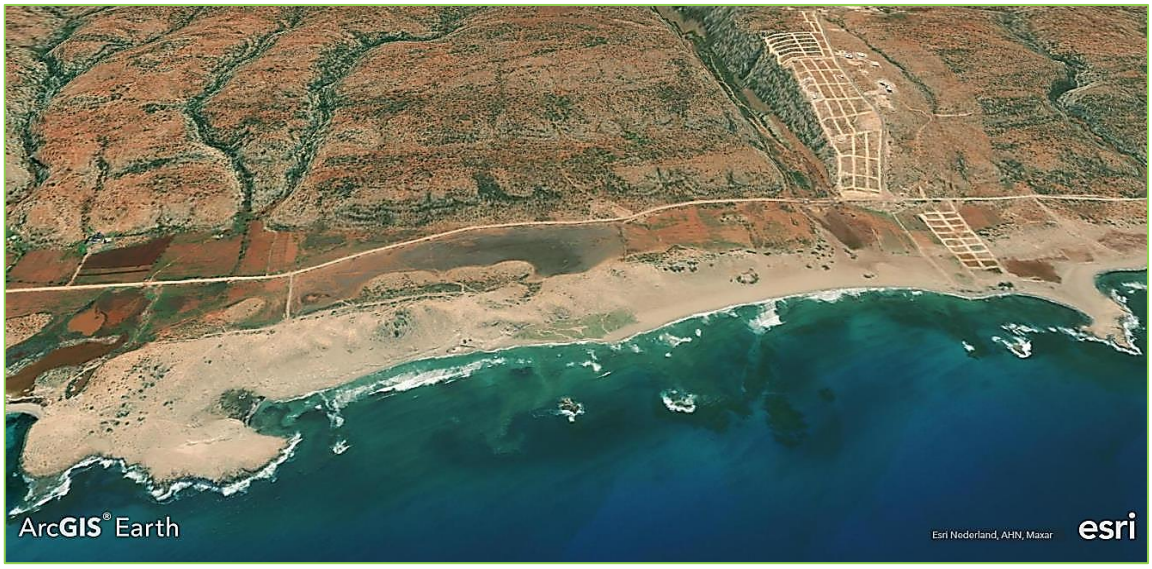
Source: Photograph by the researcher, field study, 2018 - 2019.

Picture 6. Distribution of significant species among sedentary dunes, soft sand meadows, and dry swamps

The distribution and gradation of plant species in dunes depend on species characteristics, substrate age, ability to adapt to natural conditions and human activity.

Picture 7 presents swamps, dunes, and extensive beaches that contribute to the diversity of plants. Picture 8 presents dune types in Wadi Jarjr-oma Beach, characterized by a diversity of vegetation, and Picture 9 presents some parts of the coast between El-Hamamah and Tolmeta.

Picture 7. Various swamps and dunes contribute to plant diversity



Picture 8. Human activities threaten plant diversity in Wadi Jarjr-oma

Wet and dry swamps help preserve species and plant diversity, reduce human activities, and retain large amounts of rainwater. Plant diversity does not mean many species spread over large areas; the plant diversity may be several meters wide in the form of a mosaic of plant species.

Picture 9. Some sections of the coast are between El-Hamamah and Tolmeta

2.3. Dune area vegetation between Tolmeta and El-lthamh

The edge of El-Jabal El-Akhdar moves to the south, and the Benghazi plain appears in the form of a triangle with its head in the east, interrupted by large and deep valleys. Among the most prominent activities are the multiplicity of resorts, agriculture, and grazing.

The western range includes the village districts of Bo Trabah, Alqatf, Umm al-Alhajl, Alqalea, West Tocra, Bograr, El-Mbny, Alkuz, Tinslukh, Easila, Deryana, Aleariba t, Ain Zayana, El-lthamh. The total length of sandy beaches covered by the field survey was 39826 m. Figure 27 shows field survey points in the coastal dunes between Tolmeta and El-lthamh.

Table 15 shows the distribution of plant species between Tolmeta and El-lthamh, classifies the species and genera, and presents data on the abundance and nature of species.

The following graphs show species abundance at the most crucial study sites, and Figures 28, 29, and 30 present species distribution at study points.

Figure 27. Field survey points between Tolmeta and El-lthamh

Table 15. Distribution of plant species between Tolmeta and El-lthamh

Family	Scientific name	L.D	Kinds	Order	Abundance scale
Poaceae	*Ammophila arenaria*	Per	Grass	Poales	3
Amaryllidaceae	*Pancratium maritimum*	Per	Grass	Asparagales	3
Brassicaceae	*Cakile maritima*	Ann	Grass	Brassicales	3
Compositae	*Cichorium spinosum*	Per	Shrub	Asterales	2
Leguminosae	*Ononis vaginalis* Vahl	Per	Shrub	Fabales	2
Poaceae	*Sporobolus pungens*	Per	Grass	Poales	4
Rosaceae	*Sarcopoterium spinosum*	Per	Shrub	Rosales	3
Anacardiaceae	*Pistacia lentiscus*	Per	Tree	Sapindales	4
Papaveraceae	*Glaucium flavum* Crantz	Per	Shrub	Ranunculales	3
Compositae	*Artemisia campestris*	Per	Grass	Asterales	4
Amaranthaceae	*Hammada scoparia*	Per	Shrub	Caryophyllales	4
Apocynaceae	*Periploca laevigata*	Per	Shrub	Gentianales	1
Aizoaceae	*Mesembryanthemum nodiflorum*	Ann	Grass	Caryophyllales	4
Papaveraceae	*Glaucium flavum* Crantz	Per	Shrub	Ranunculales	5
Amaranthaceae	*Halimione portulacoides*	Per	Shrub	Caryophyllales	3
Amaranthaceae	*Hammada scoparia*	Per	Shrub	Caryophyllales	4
Amaranthaceae	*Salicornia europaea*	Ann	Grass	Caryophyllales	3
Compositae	*Artemisia campestris*	Per	Grass	Asterales	4
Aizoaceae	*Mesembryanthemum nodiflorum*	Ann	Grass	Caryophyllales	3
Boraginaceae	*Heliotropium curassavicum*	Per	Grass	Boraginales	3
Solanaceae	*Solanum elaeagnifolium* Cav	Per	Shrub	Solanales	4
Poaceae	*Avena barbata* Pott ex Link	Ann	Grass	Poales	2
Solanaceae	*Lycium arabicum* Schweinf	Per	Shrub	Solanales	4
Amaranthaceae	*Salsola kali*	Ann	Grass	Caryophyllales	5
Cucurbitaceae	*Ecballium elaterium*	Per	Forbs	Cucurbitales	2
Poaceae	*Elytrigia juncea*	Per	Grass	Poales	3
Amaranthaceae	*Atriplex halimus*	Per	Shrub	Caryophyllales	1
Rubiaceae	*Crucianella aegyptiaca*	Ann	Grass	Gentianales	3
Rubiaceae	*Crucianella maritima*	Per	Shrub	Gentianales	3
Crassulaceae	*Sedum rubens*	Per	Grass	Saxifragales	3

Table 15. Follows

Family	Scientific name	L.D	Kinds	Order	Abundance scale
Poaceae	*Lygeum spartum*	Per	Grass	Poales	4
Amaranthaceae	*Halocnemum strobilaceum* (Pall)	Per	Shrub	Caryophyllales	3
Arecaceae	*Phoenix dactylifera*	Per	Tree	Arecales	4
Euphorbiaceae	*Euphorbia peplis*	Ann	Grass	Malpighiales	5
Euphorbiaceae	*Euphorbia paralias*	Per	Shrub	Malpighiales	5
Leguminosae	*Retama raetam* (Forssk) Webb	Per	Shrub	Fabales	2
Juncaceae	*Juncus acutus*	Per	Grass	Poales	3
Amaranthaceae	*Salsola kali*	Ann	Grass	Caryophyllales	5
Euphorbiaceae	*Euphorbia peplis*	Ann	Grass	Malpighiales	3
Poaceae	*Avena barbata* Pott ex Link	Ann	Grass	Poales	5
Poaceae	*Stipa tenacissima*	Per	Grass	Poales	5
Poaceae	*Ammophila arenaria*	Per	Grass	Poales	5
Euphorbiaceae	*Euphorbia paralias*	Per	Shrub	Malpighiales	3
Zygophyllaceae	*Tetraena fontanesii*	Per	Shrub	Zygophyllales	3
Amaranthaceae	*Suaeda mollis* (Desf) Delile	Per	Grass	Caryophyllales	3
Solanaceae	*Lycium arabicum Schweinf*	Per	Shrub	Solanales	5
Poaceae	*Stipa tenacissima*	Per	Grass	Poales	5
Amaranthaceae	*Suaeda aegyptiaca*	Per	Grass	Caryophyllales	5
Juncaceae	*Juncus acutus*	Per	Grass	Poales	2
Tamaricaceae	*Tamarix tetragyna* Ehrenb Delile	Per	Tree	Caryophyllales	1
Compositae	*Echinops spinosissimus*	Per	Shrub	Asterales	4
Tamaricaceae	*Tamarix tetragyna* Ehrenb Delile	Per	Tree	Caryophyllales	2
Poaceae	*Sporobolus pungens*	Per	Grass	Poales	5
Poaceae	*Stipagrostis libyca*	Per	Grass	Poales	2
Arecaceae	*Phoenix dactylifera*	Per	Tree	Arecales	5
Zygophyllaceae	*Tetraena fontanesii*	Per	Shrub	Zygophyllales	2
Juncaceae	*Juncus subulatus* Forssk	Per	Grass	Poales	5
Compositae	*Limbarda crithmoides*	Ann	Grass	Asterales	5

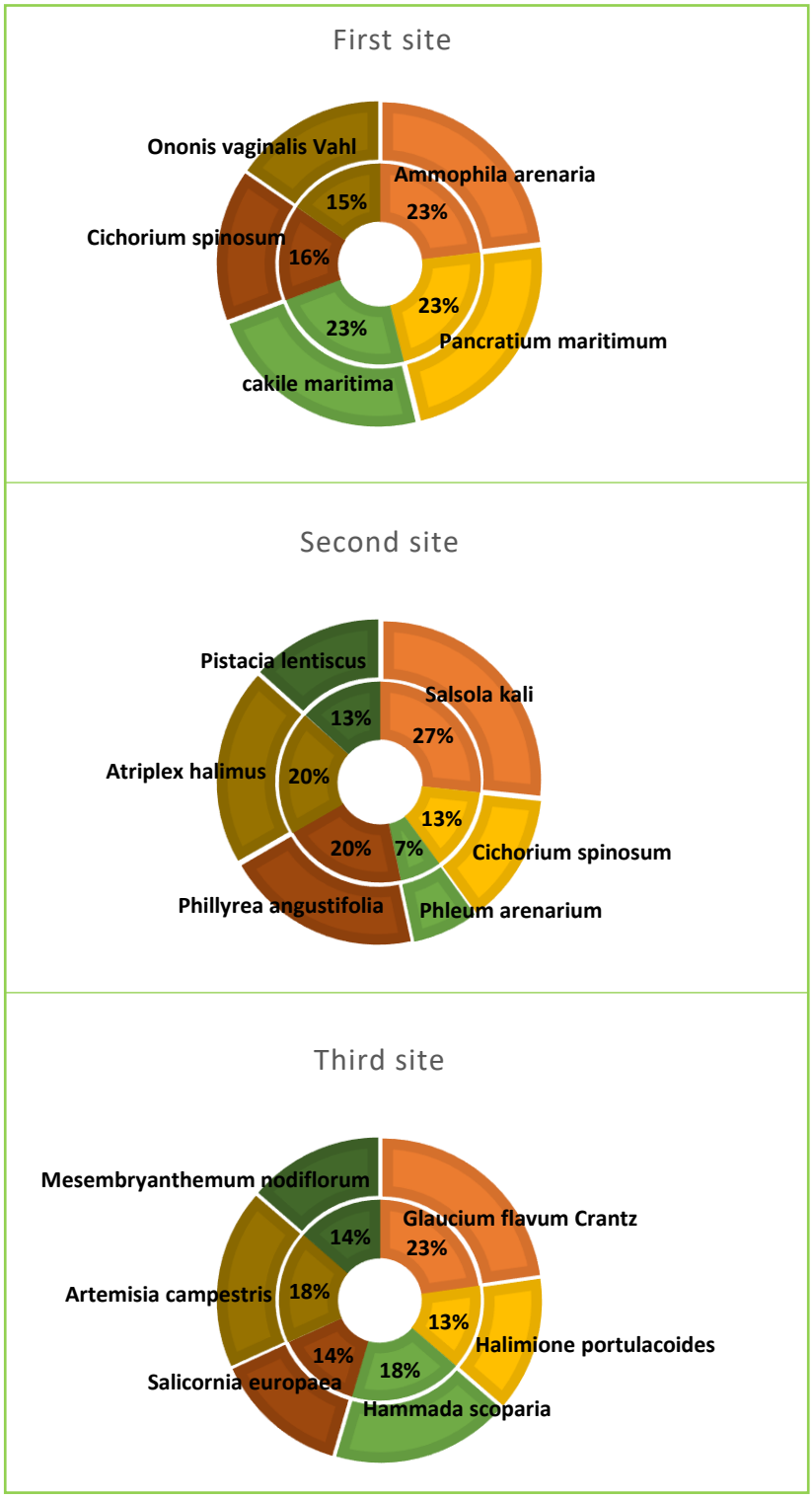


Figure 28. Distribution of plant species in coastal dune habitats between Tolmeta and El-lthamh

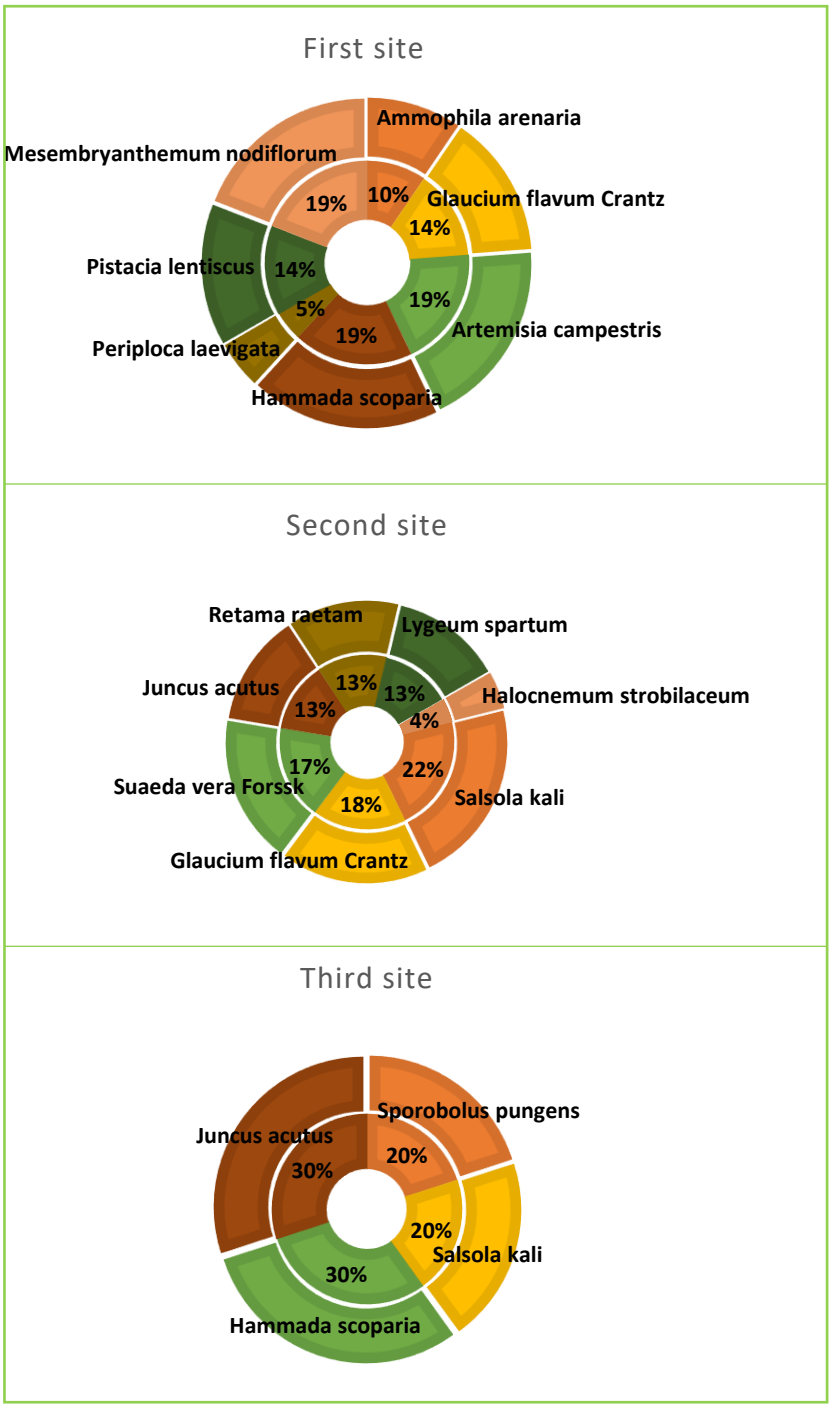


Figure 29. Distribution of plant species in coastal dune habitats between Tolmeta and El-lthamh

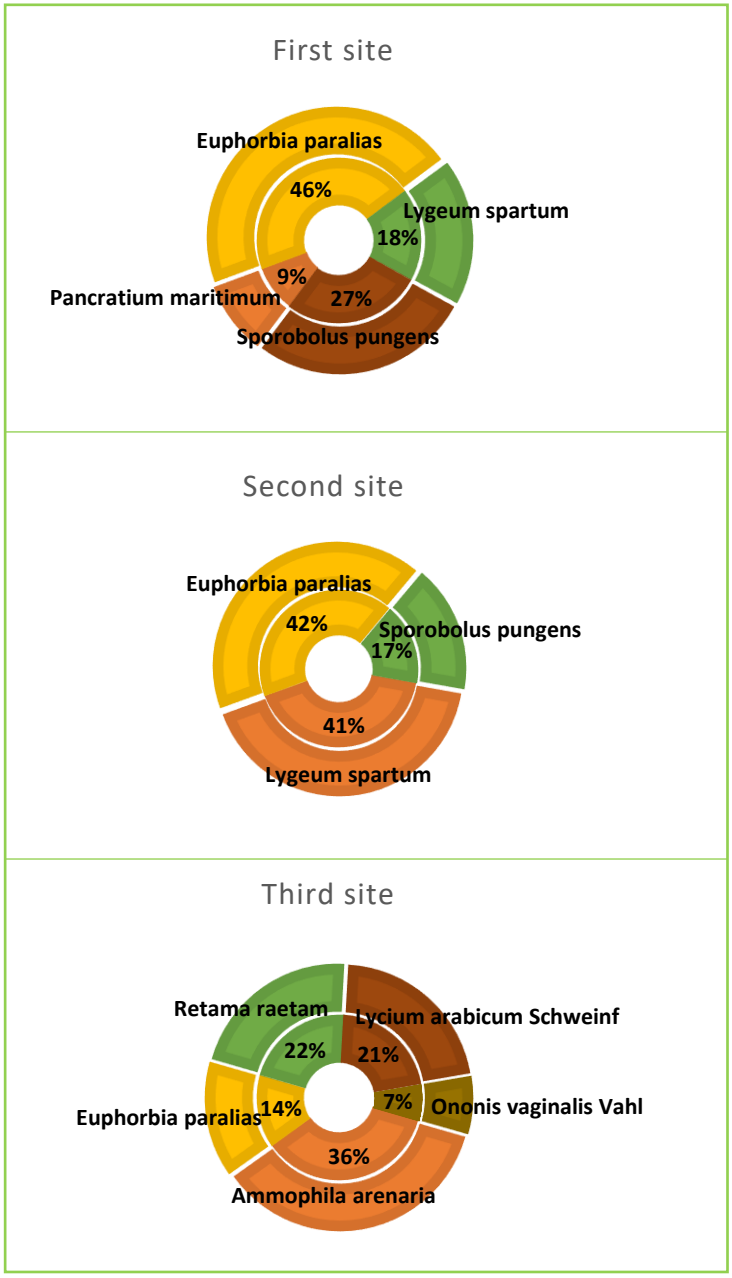


Figure 30. Distribution of plant species in coastal dune habitats between Tolmeta and El-lthamh

Figures 31 and 32 provide a model for the distribution of plant species in diverse coastal dune habitats between Tolmeta and El-lthamh.

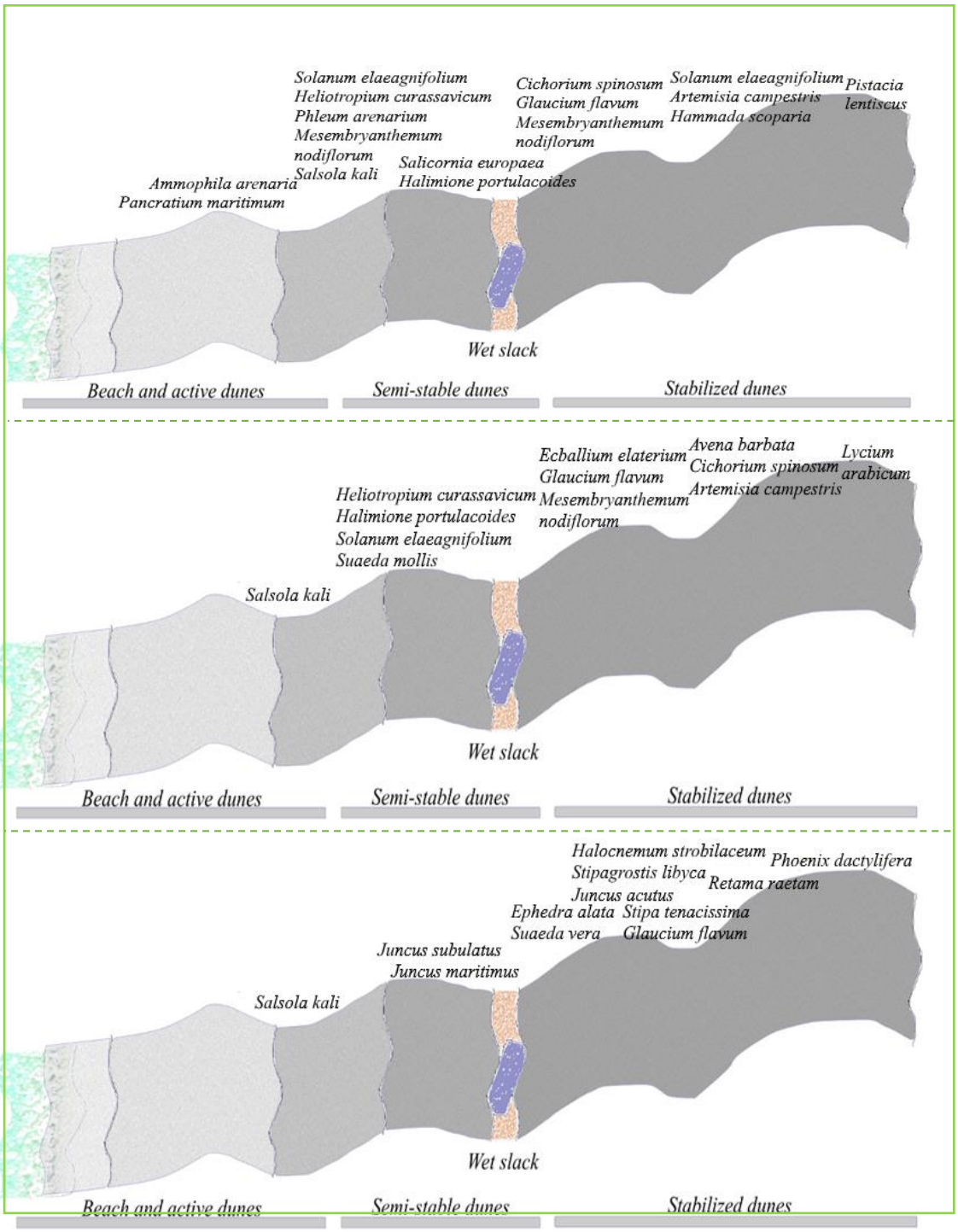


Figure 31. Distribution of plant species in coastal dune habitats between Tolmeta and El-lthamh

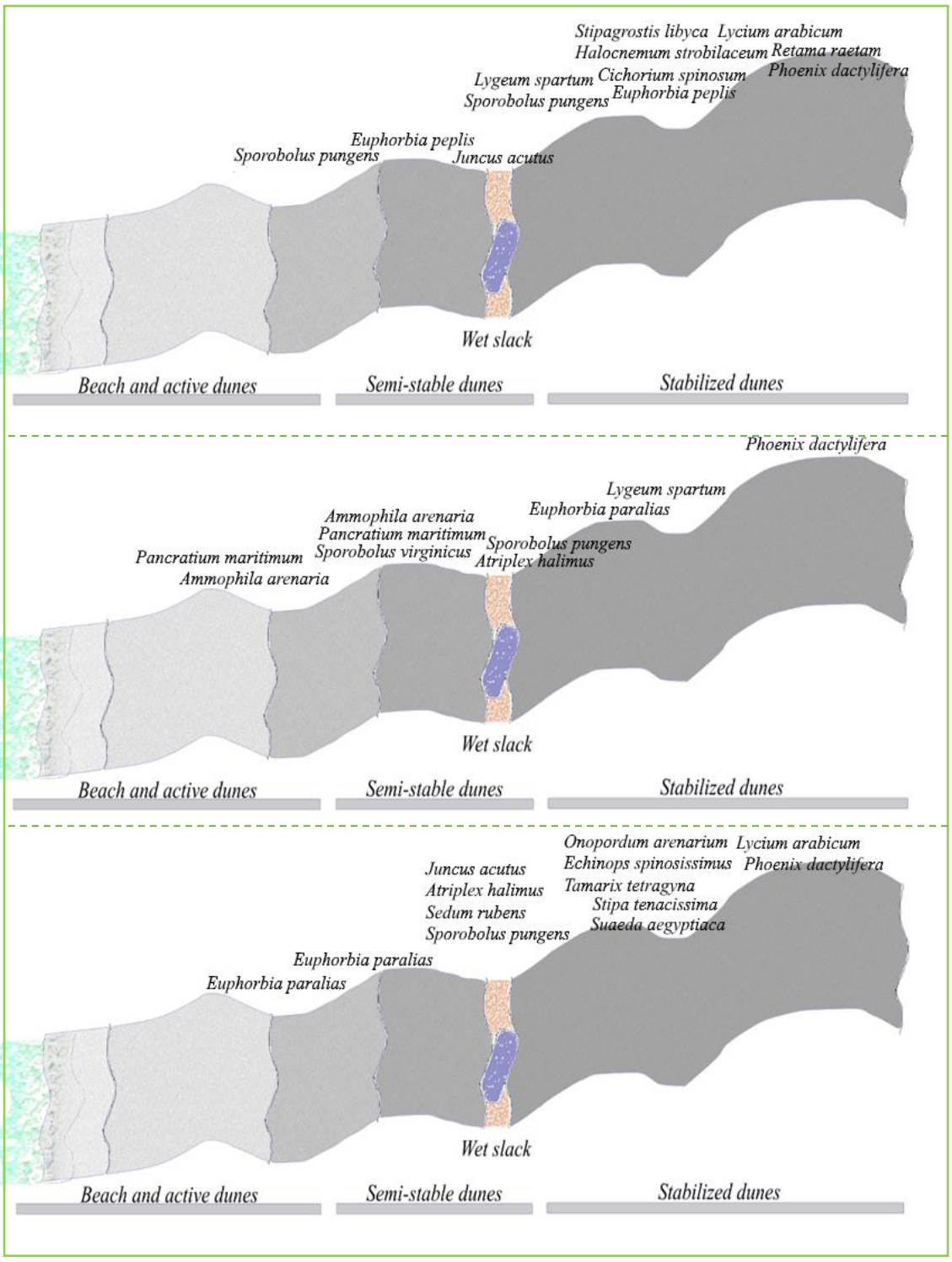


Figure 32. Distribution of plant species in coastal dune habitats between Tolmeta and El-lthamh

Table 16 shows the most widespread human activities between Tolmeta and El-lthamh; picture 10 shows some parts of the coast in this region.

Table 16. The most widespread human activities between Tolmeta and El-lthamh

	Effect	very strong	Intense	Medium	Few	Low	very low
Human activities	level	<100	75 - 100	50 - 75	25 - 50	25	5
	Type of Activity	Bulldozers scrape sand (from shear area to fixed dune)	Heavy machinery - roads - lanes - cutting - burning	Tourism - waste - cutting - trampling	Heavy trampling (various machines)	walking and jogging	Light stomping

Source: field study data.

The most prominent human activities in this range are the various forms of trampling and camping, the density of footpaths, and waste, all of which are factors that increase the degradation of habitats, the decline in plant diversity, and the scarcity of species. Sand fans and swamplands contribute to plant diversity and species conservation.

Picture 10. Some sections coast is between Tolmeta and El-lthamh

The study and analysis of previous data show that the first vegetative belt started from the front, followed by the embryonic dunes colonized by *Cypero capitati - Elytrigetum junceii*. Between these two bands, there is an accumulation of organic

matter. We may find the *Salsola-Cakiletum Mari-timae* community, the slightly higher inland (backshore) dunes, colonized by *Medicagini marinae-Ammophiletum australis*, effectively protect the areas behind the dunes, where more mature plant species can settle. In particular, the more stable surfaces near the *Medicagini marinae - Ammophiletum australis* host the chamavite plants of *Seselio - Crucianelletum maritime.*

Picture 11 presents that protecting sandy habitats from trampling is one factor that contributes to plant diversity.

Picture 12 demonstrates that urban sprawl and the expansion of urban centres are among the factors that increase pressure on plant species.

Picture 13 presents that lakes and swamps represent high plant diversity and protection for endangered or rare plant species.

Picture 11. Reduced trampling of all kinds is one of the factors that contribute to plant diversity

Picture 12. Urban centres are expanding, increasing pressure on plant species.

Picture 13. Lakes and swamps of all kinds represent protection for plant species, and images of plant diversity increase in limited and small areas

The proximity of urban centres to the lack of beach protection is an essential factor in the degradation of the dune environment, leading to sand erosion and varying degrees of trampling, loss of native species, and possibly the introduction of invasive species.

Coastal dune ecosystems are habitats under constant pressure, with few species resulting from natural and human conditions. These habitats exhibit ecological gradients over a relatively small area and high ecological diversity at the level of drift lines, coastal dune types and dry and wet swamps.

2.4. Maps distribution of families and plant species

Heterogeneity appears in the eastern section .Sandy beaches vary in breadth and extension; some are tiny bays, and others are wide beaches with a vegetative image appropriate to the surrounding conditions, as we explained earlier. The following presentation shows the distribution of species and plant families.

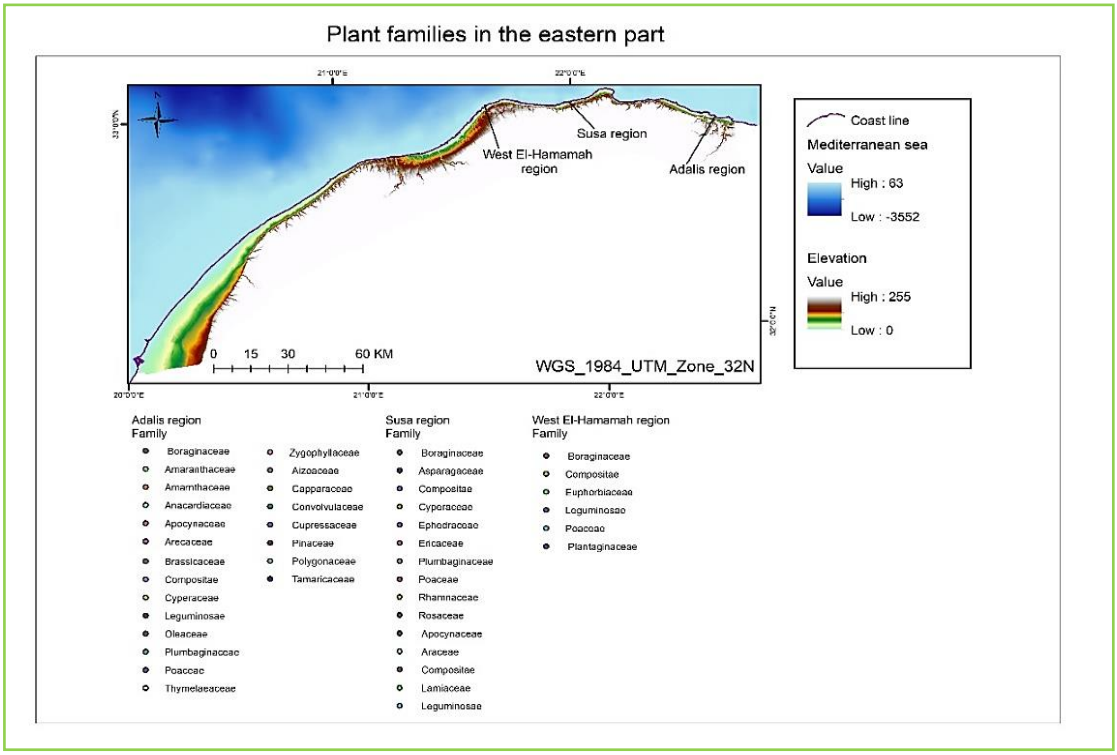
2.4.1. Distribution of families of plant species between West Derna and Ras El-Hamamah

Map 7 depicts the plant families found between West Derna and Ras El-Hamamah. Plant diversity can be observed in the plant families in this region, although the area is small, where the high beaches represent a large part of it, Low beaches are under human pressure, represented by dredging, heavy scraping, spas and cleaning beaches using heavy machinery.

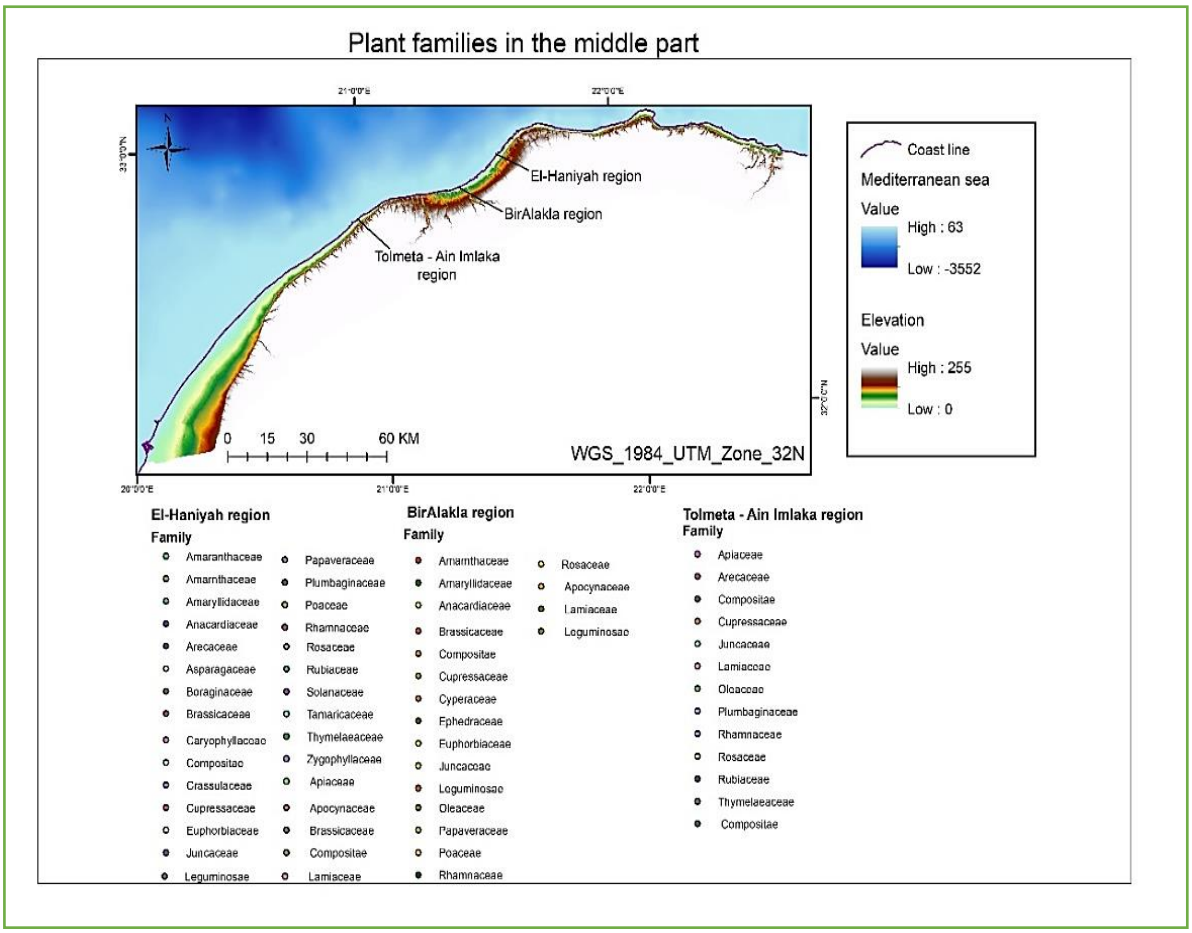
2.4.2. Distribution of families of plant species between El-Hamamah and Tolmeta

Map 8 shows the plant species between El-Hamamah and Tolmeta. Plant diversity often appears due to geomorphological features such as extensive sandy beaches and large swamps contributing to habitat and species protection.

The coastal dune environment is under various pressures that have a rapid and devastating impact. The most important are sand scraping, trampling, grazing, and waste.



Map 7. Plant families between West Derna and Ras El-Hamamah



Map 8. Plant families between El-Hamamah and Tolmeta

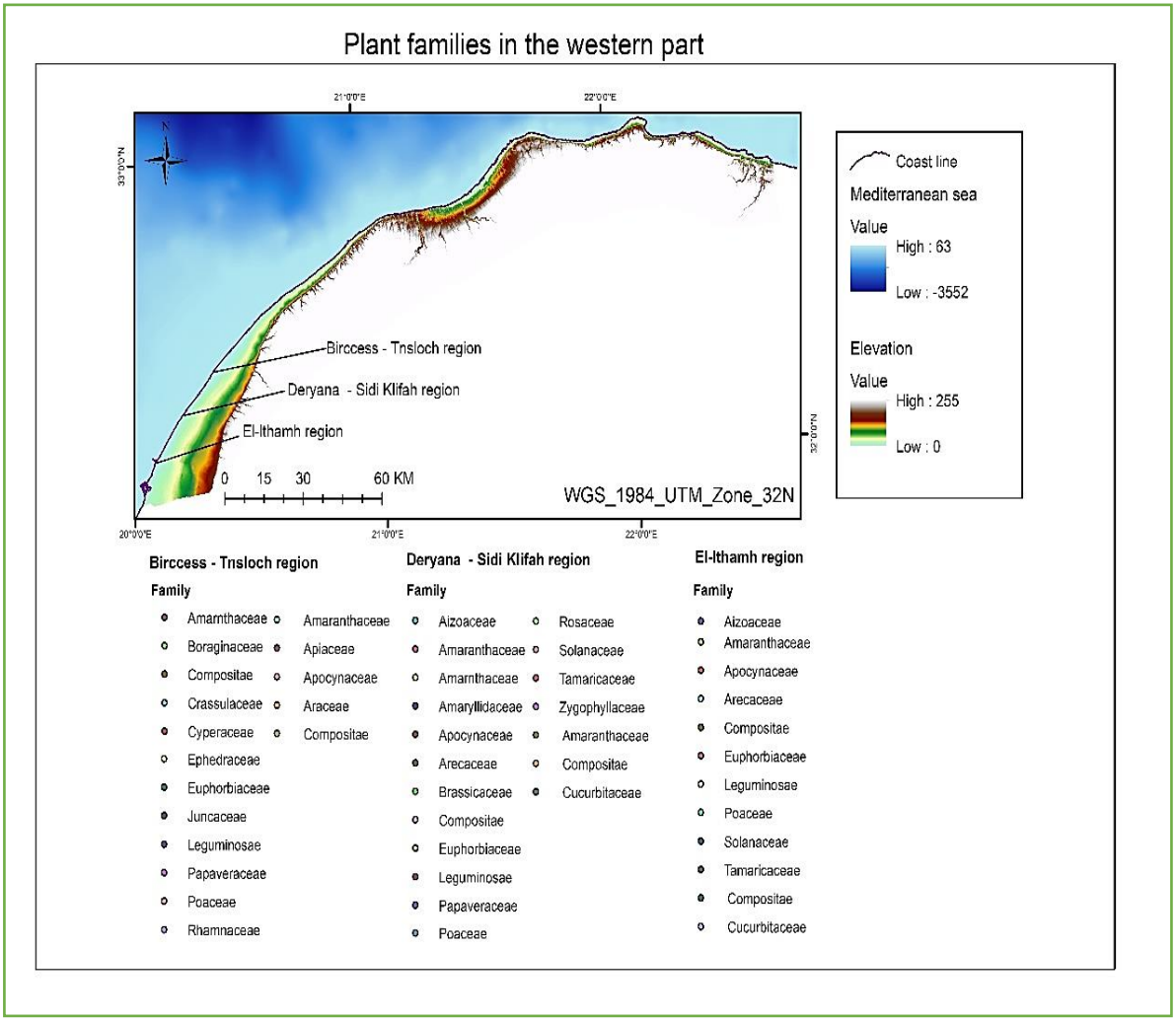
2.4.3. Distribution of families of plant species between Tolmeta and El-lthamh

Map 9 displays the plant species between Tolmeta and El-lthamh. Plant diversity in plant families is high in this region. It is more diverse in plants than others due to the wide sandy beaches and the most extensive seasonal swamps. This made dredging and transporting sand difficult and expensive, helping preserve the diversity of habitats and species. These beaches are under human pressure through resorts, trampling and grazing.

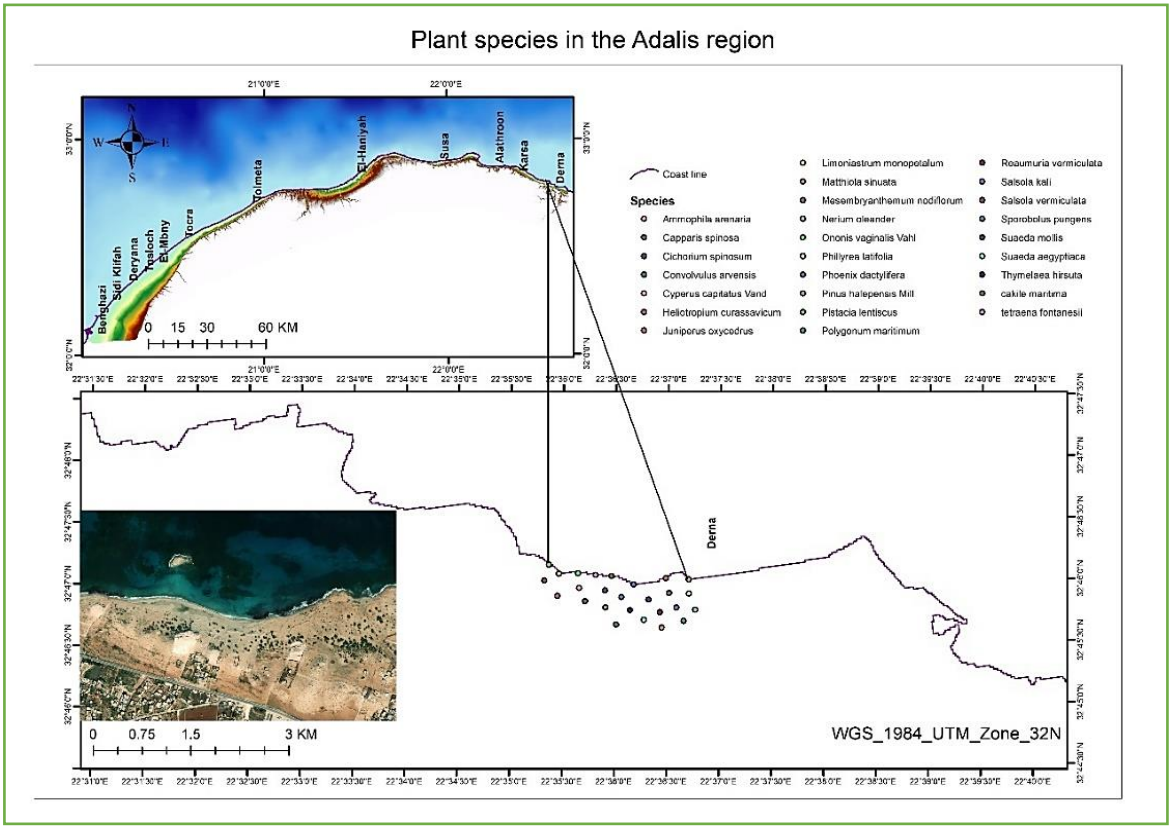
2.4.4. Maps of plant species distribution in selected regions

Map 10 shows the types of plants in Adalis. Plant diversity can be observed in the plant species in this region. However, the area is small and human pressures are high, the most important of which are camping, trampling, and cutting, and the spread of local and global invasive species, while noting the remains of trees from the formation of Mediterranean forests.

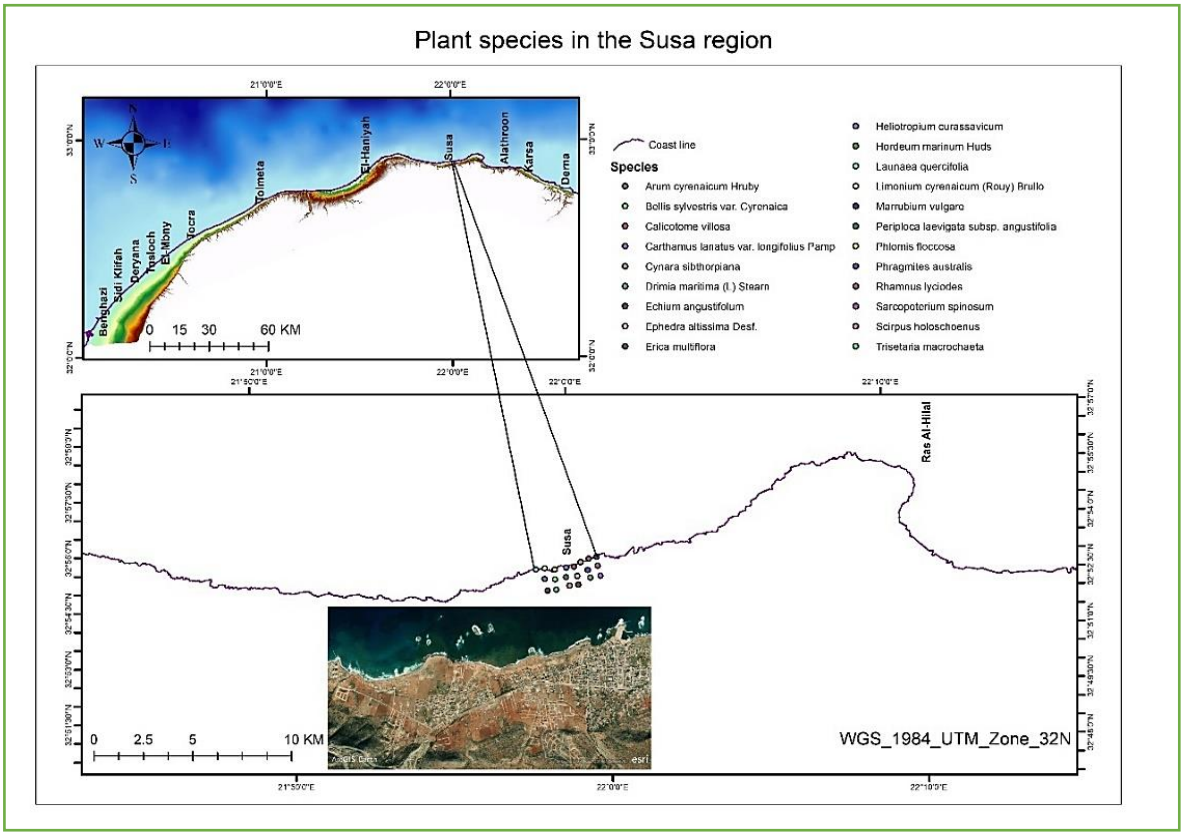
Map 11 illustrates the types of plants in the Susa region. Plant diversity has declined because sandy beaches are sparsely wide, under pressure from human activities, the most important of which are industrial facilities, resorts, fishing, and grazing.



Map 9. Plant families between Tolmeta and El-lthamh



Map 10. Plant species in the Adalis regions

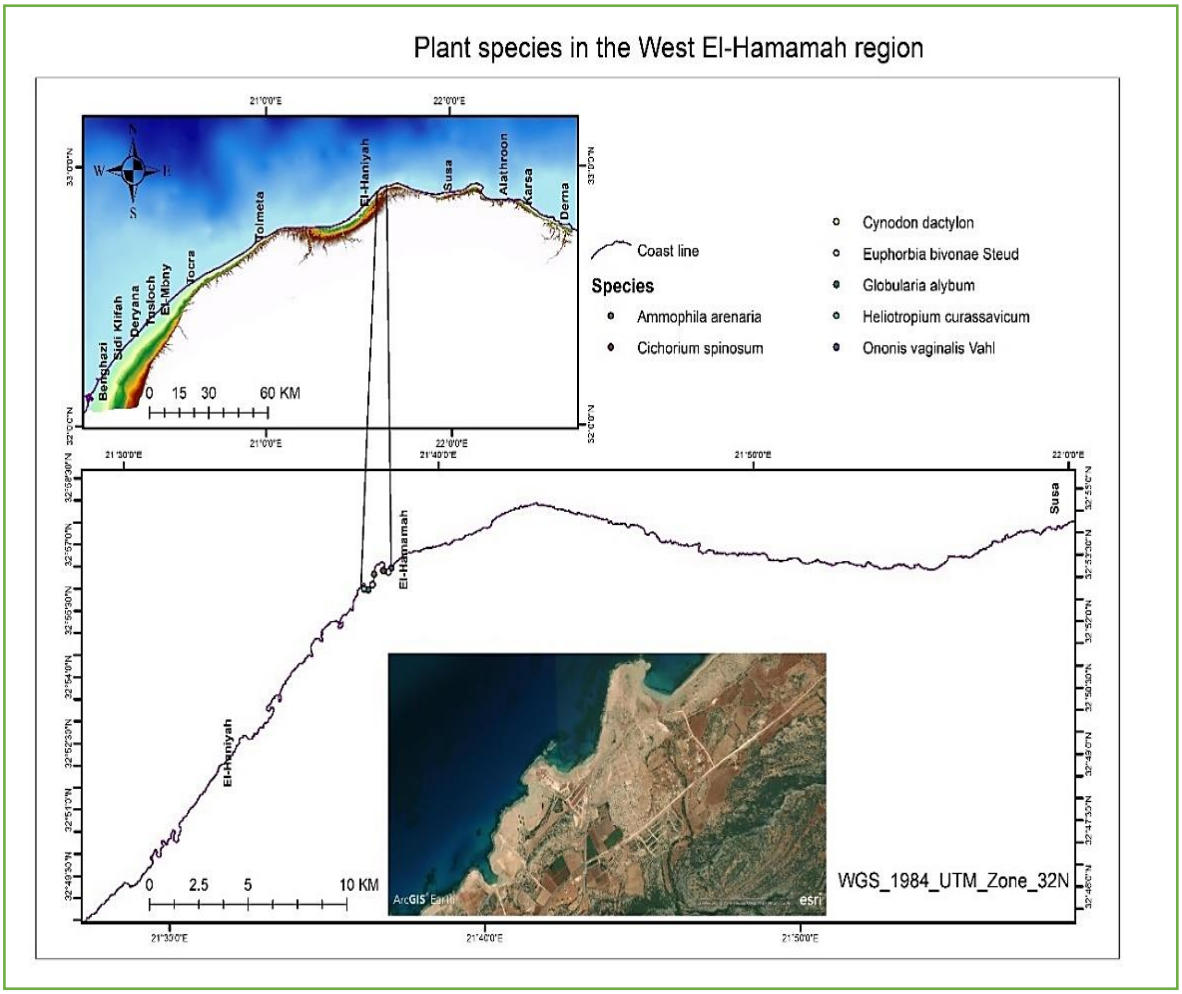


Map 11. Plant species in the Susa region

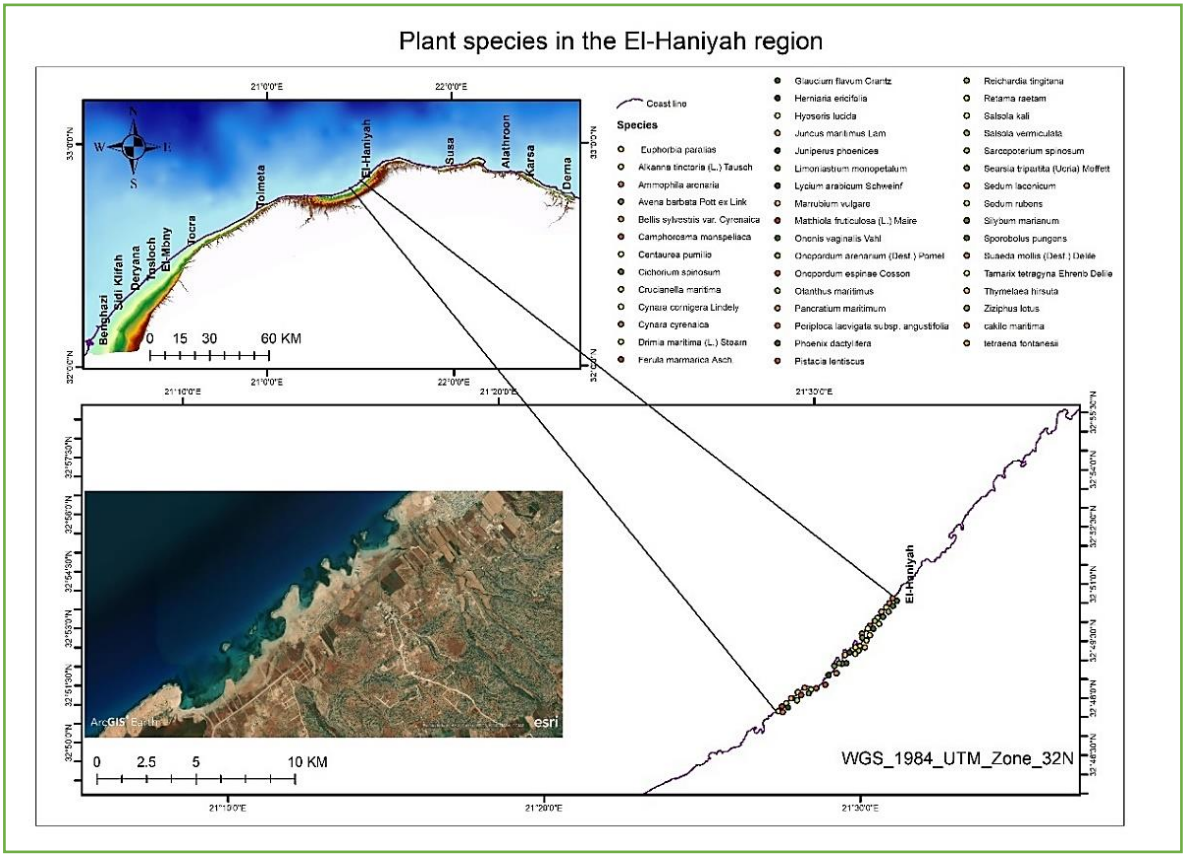
Map 12 shows the types of plants in the West El-Hamamah region. Species populations and diversity are declining, although the beaches are more expansive due to the extensive exploitation of the beaches in resorts and sand scraping.

Map 13 shows the plant species in the El-Haniyah region. We note the plant diversity and the number of plant species in this area, resulting from many beaches, the multiplicity of sandy habitats and the wide short bays. Among the most dangerous human activities are sand dredging, various trampling, and the disintegration of sandy habitats.

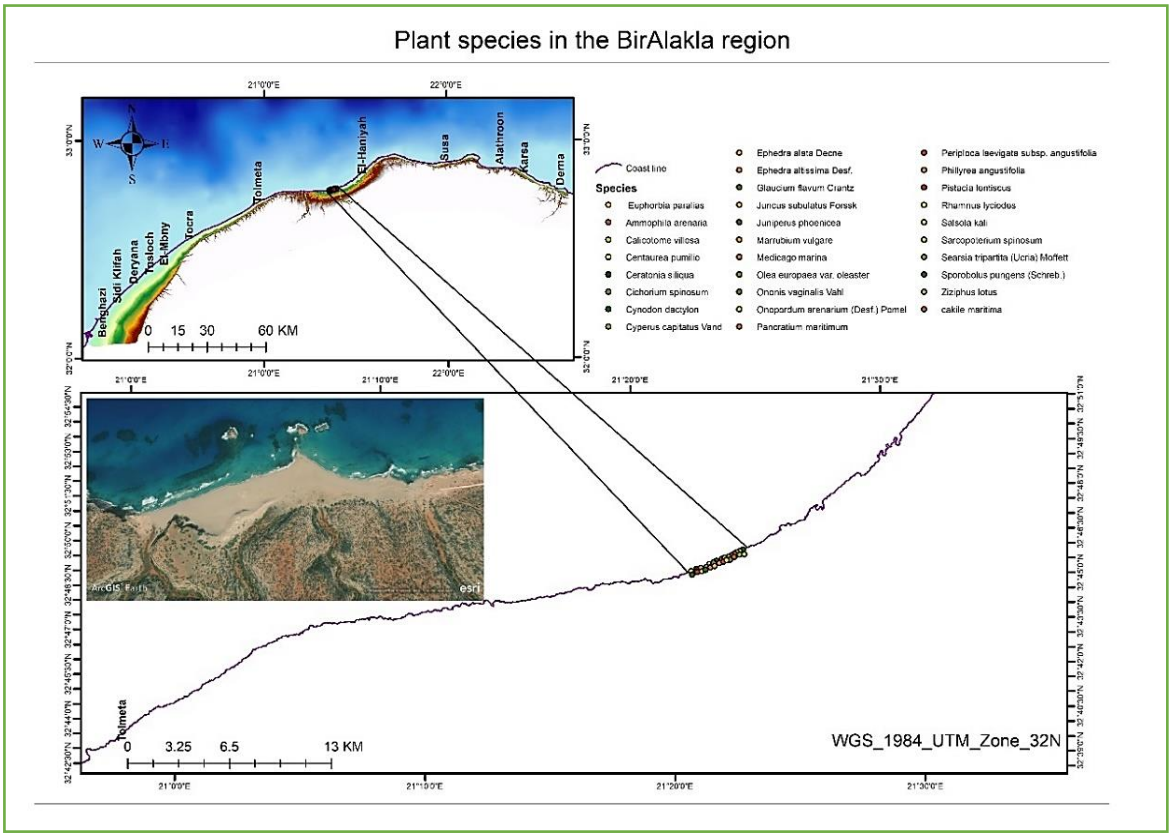
Map 14 shows the types of plants in the Bir Alakla region. We note an increase in the number of species and the diversity of plant families. Here the dunes are more expansive; among the most important human activities are sand dredging, trampling, habitat disintegration, and grazing.



Map 12. Plant species in the West El-Hamamah region



Map 13. Plant species in the El- Haniyah region



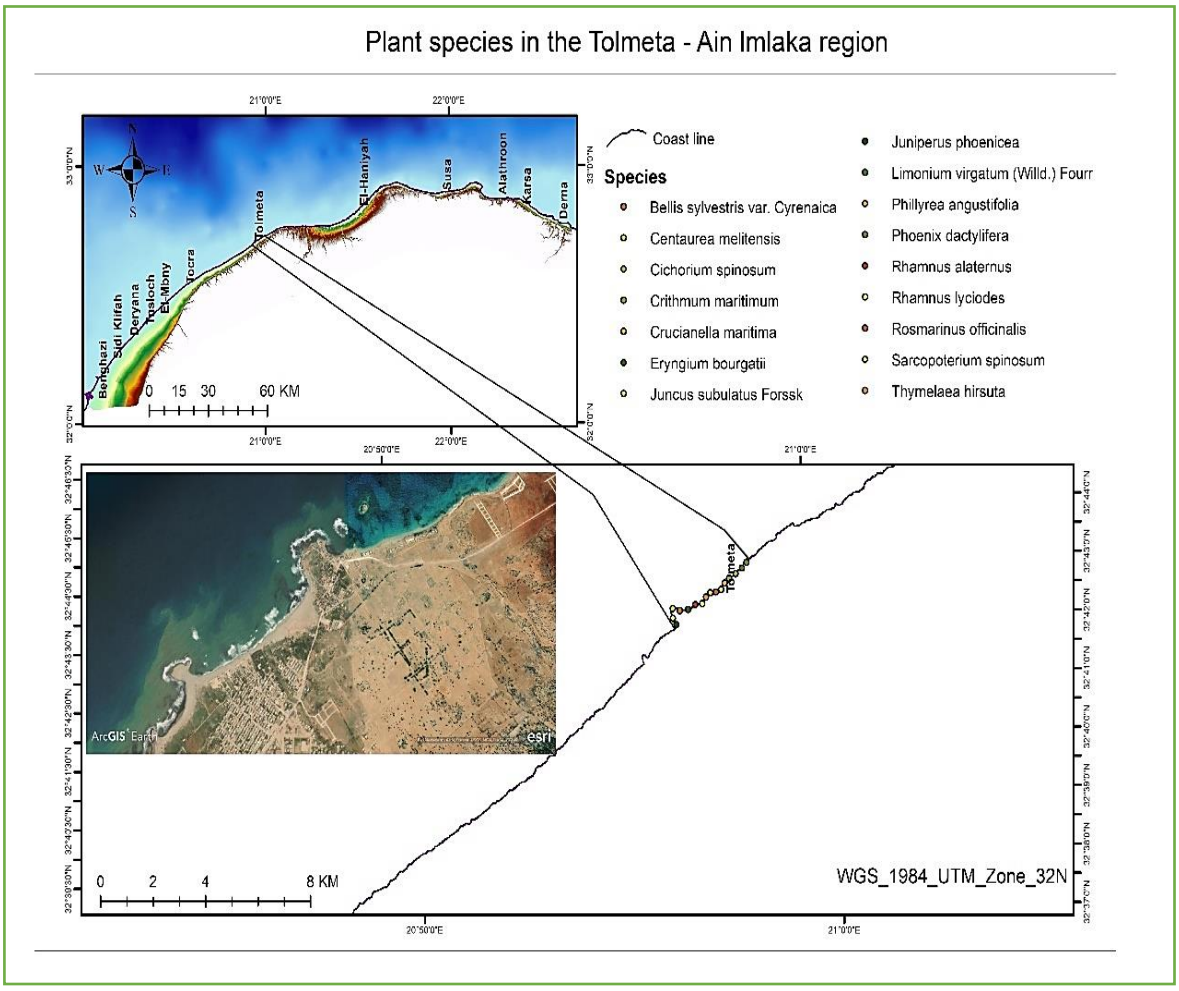
Map 14. Plant species in the Bir Alakla region

Map 15 depicts the plant species found in the Tolmeta-Ain lmlaka region. We notice an increase in the number of species and diversity in families.

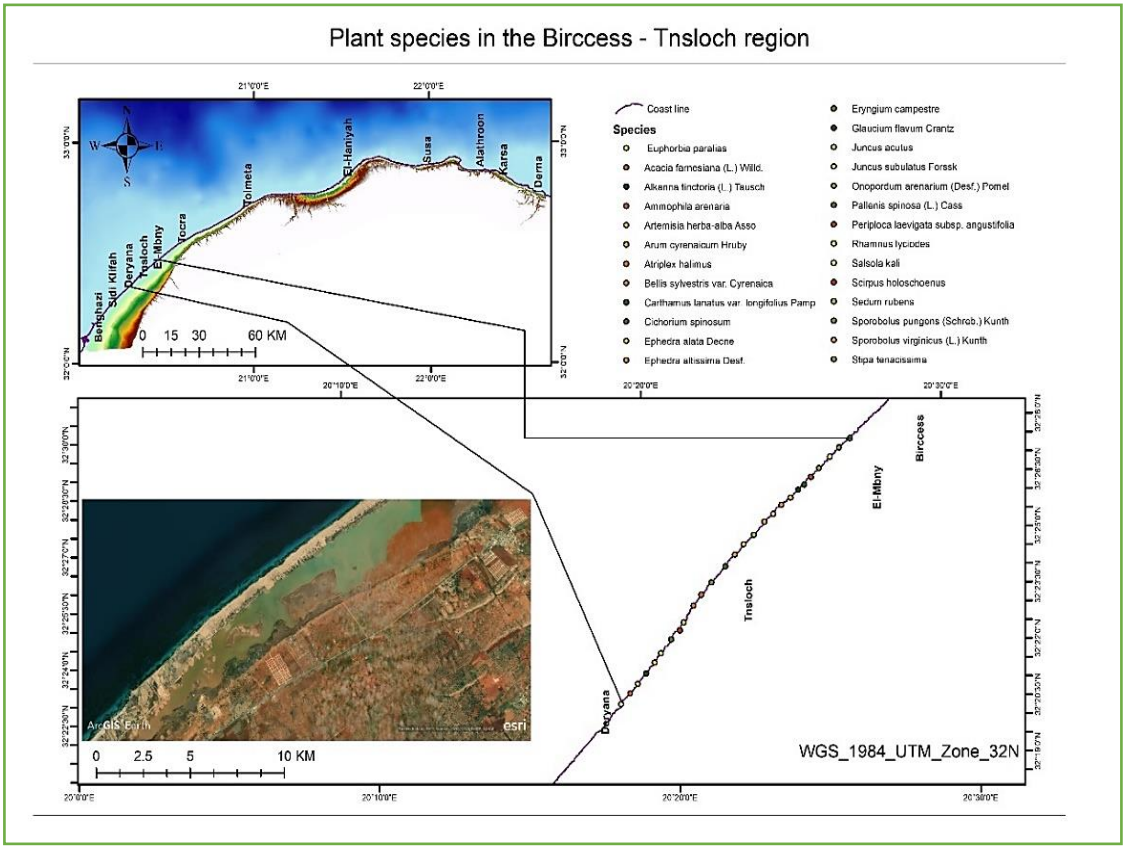
Map 16 shows the types of plants in the Birccess-Tnsloch region, characterized by plant diversity and multiple habitats. The most prominent human activities are trampling and grazing.

Map 17 shows the types of plants in the Deryana - Sidi Klifah region. Plant diversity and habitat diversity in this region result from the spread of seasonal marshes. The most significant human activities are urban expansion, resorts and grazing.

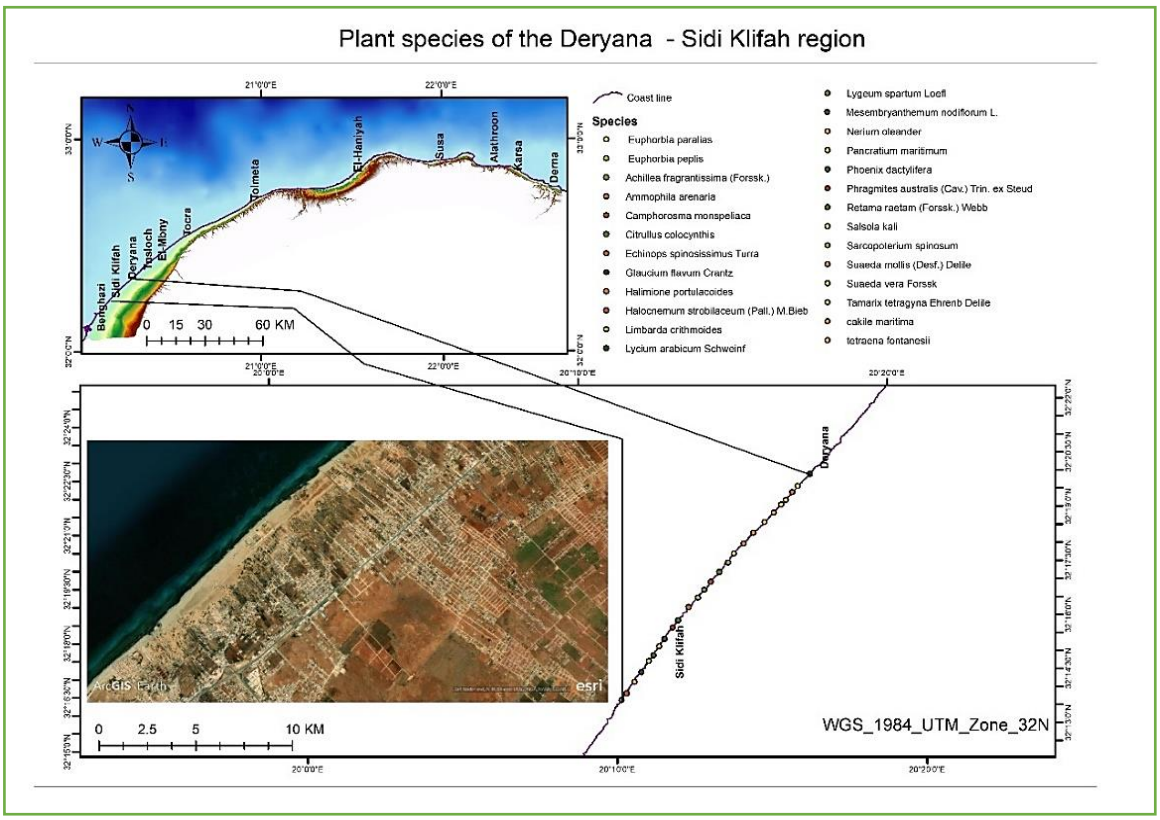
Map 18 shows plant species in the El-lthamh region. Plant diversity is declining due to habitat degradation. There are very narrow beaches and permanent swamps in a few areas. The most prominent human activities are industrial facilities, resorts and roads.



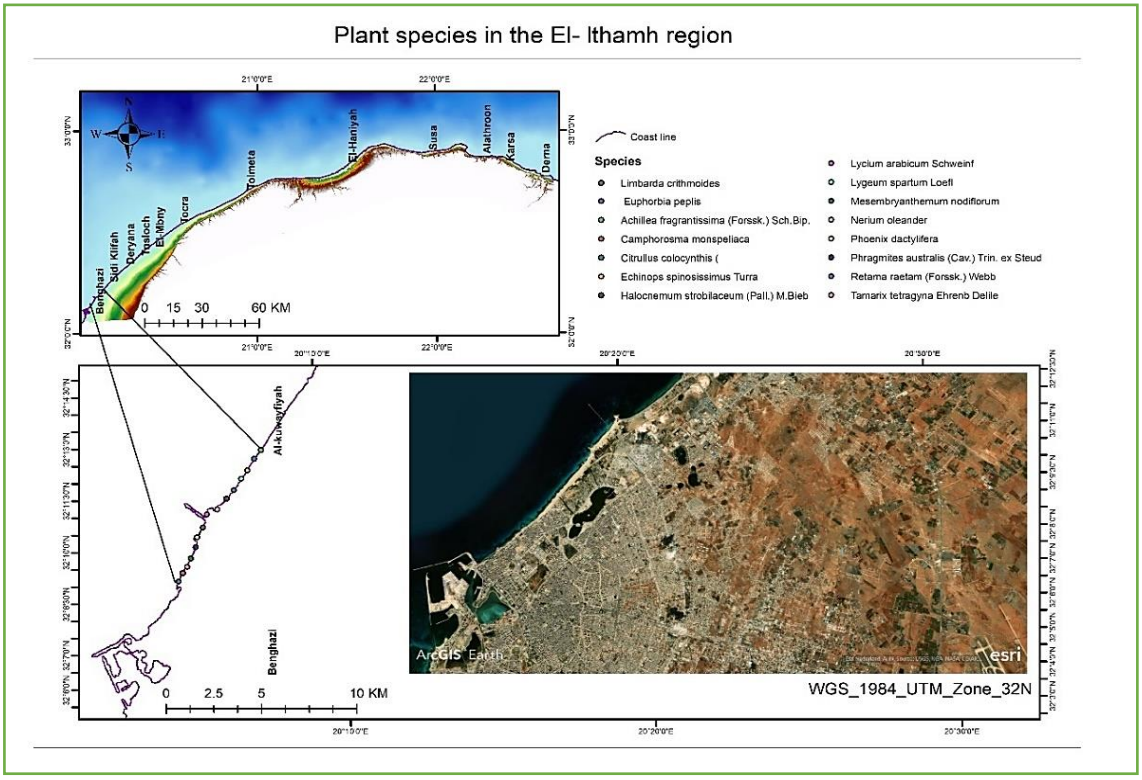
Map 15. Plant species in Tolmeta - Ain lmlaka region



Map 16. Plant species in the Birccess - Tnsloch region



Map 17. Plant species in Deryana - Sidi Klifah region



Map 18. Plant species in El-lthamh region

Plant distribution maps give a clear picture of plant diversity in different environments, predict species trends and habitat status, and are a decision-making tool widely used for a variety of biogeographic applications, such as studying the effects of climate change, studying the effects of climate change, studying coastal change, coastal dune erosion, identifying potential protected areas, identifying vulnerable habitats, and identifying species and migration trends.

We noticed the presence of plant diversity in these habitats despite their small area, a decrease in the number of species and families, and a deterioration in a group of sandy habitats, especially those under human pressures such as various scraping and trampling.

We observed an overlap of plant communities in the coastal dune environment and a change in the locations of some species in degraded habitats. This change includes an increase in invasive species and a decrease in the model and pioneer species.

3. PLANT DIVERSITY OF COASTAL DUNES IN THE RESEARCH FIELD

In this chapter, we explain the diversity of coastal dune plants, the nature of this diversity in sandy habitats, and the distribution of plant communities, with a quantitative and qualitative description of some characteristics of plant species in this environment.

3.1. Character of Plant Diversity

We can say that biodiversity is one of the natural phenomena of global nature, and it has evolved since the advent of life on planet Earth .Plant diversity in all habitats, including coastal dunes, there are many attempts to systematically organise and arrange plant communities, where different species are classified and grouped at certain levels.

Species are the basic unit of biological classification. There may be subspecies within the main species due to some genetic characteristics and characteristics that the subspecies possess. It is found in the main species, for example, the Aleppo pine or the mountain cat.

Biodiversity does not include a considerable number of species distributed in systematic groups. It includes genetic differences between individuals of the same species, and biodiversity also lies in the ecosystems that make up the organisms that interact with each other and the environment, including humans.

In short, biodiversity does not depend on the diversity and multiplicity of species but rather on genetic diversity and the diversity of ecosystems and landscapes. Biodiversity is not only for nature; it refers to what has been altered by man; in this case, man's role is not limited to that of a user and observer, but rather it is a component that affects all ecosystems. Biodiversity does not mean endangered species or protected areas, but all biodiversity contributes to producing biological materials and environmental services.

Vegetation in the coastal sandy habitat on the front shore consists of perennial grasses, shrubs and trees. If dune formations do not develop, forests usually border the upper shore, and dune vegetation rarely advances towards the forest. While some types

of forest formation can move towards the shore, the impact of harsh environmental conditions on vegetation forms is very pronounced, with stunting and dispersion.

Coastal dunes are subject to various constraining environmental conditions, such as salinity, substrate instability, wind, and marine aerosols (Marzialetti et al., 2019); the difference between the vegetation on the inner slope and above the dunes is frequently more affluent and more diverse than the species on the inner slope. Sandy meadows have a relatively flat surface, uniformly sized sand grains that prevent undulation, can retain moisture, and are richer and more diverse in vegetation than any of the other sandy formations.

Ammophila arenaria is the main dune-building plant species, with extensive root systems that help bind sand and a rapid growth rate(Jones et al., 2021). Dunes represent a significant challenge regarding the dynamics of plant communities (Tomaselli et al., 2014).

They are represented from above by the formations *Juniperus, Pistacia* and *Villiers*. The species ends in *Pancratium maritimum, Ammophila arenaria*, and *Caquill maritima*; the narrow bands are continuous and diverse (albeit degraded in plant species).

There are several classifications of coastal dunes concerning plant diversity and sandy habitats, the most prominent of which are the following:

- The strand line (the simple beach), devoid of plant life, is fundamentally important in balancing marine and terrestrial environments.
- The primary dunes, here, founded and grew the first true plant community, consisting of a few species that developed methods more resistant to extreme conditions. Such species as *Cakile maritima - Salsola kali*.
- Plants play an essential role in constructing coastal dunes, which can reach a height of about 25 cm in less than a year.
- White dunes are often higher and more stable, although constantly moving. The main species, *Ammophila arenaria*, colonizes this area and is an effective barrier to wind-borne sand. The species *Traganum* could be used to restore front dunes (García-Romero et al., 2017).

- Grey dunes are more mature and stable due to the time factor. They have gone through stages of settlement due to the roots of coastal weeds and plants, which reduce the immediate evaporation of rainwater and the accumulation of organic matter. The wide presence of *Juniperus* distinguishes it from other shrubs widely spread behind stationary dunes (Gamper et al., 2008).

Figures 33 to 38 illustrate a simulation of the distribution of plant species in sandy, fore-and-aft shore habitats; human activities influence this distribution with an immediate impact on the habitat.

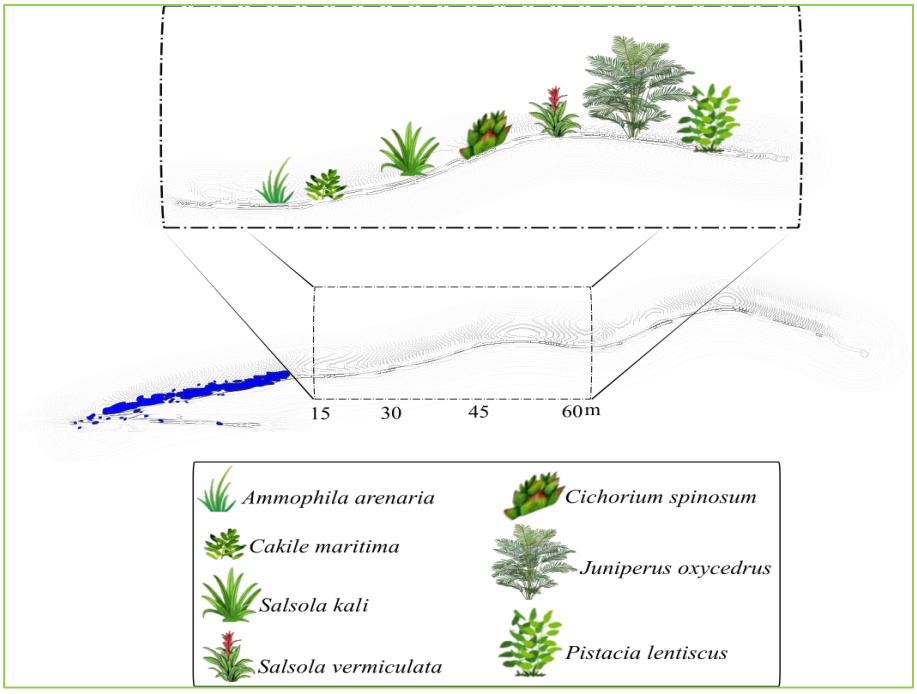


Figure 33. Species distribution on the front beach between western West Derna and Ras El-Hamamah

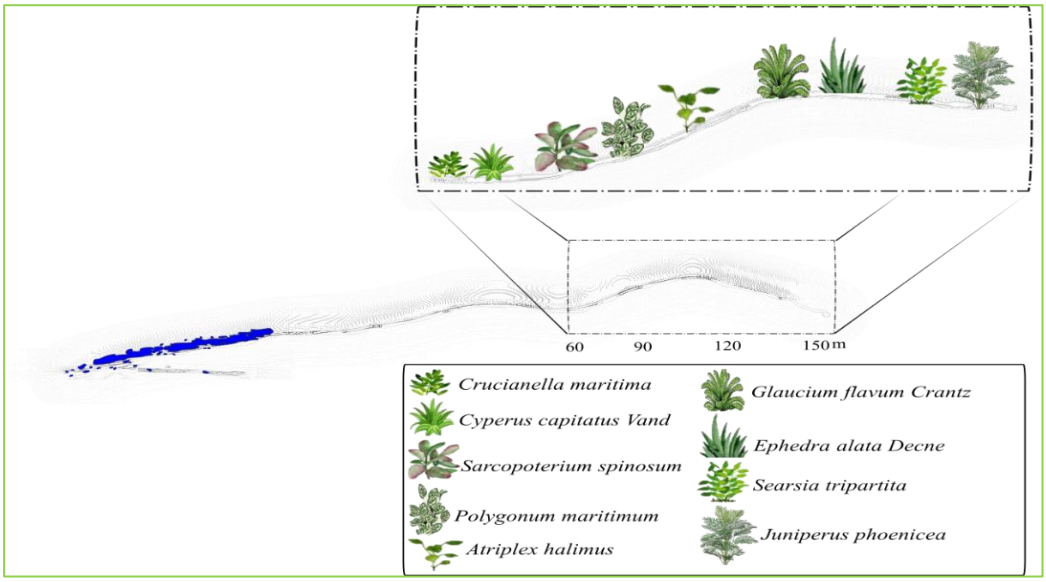


Figure 34. Species distribution on the back beach between western West Derna and Ras El-Hamamah

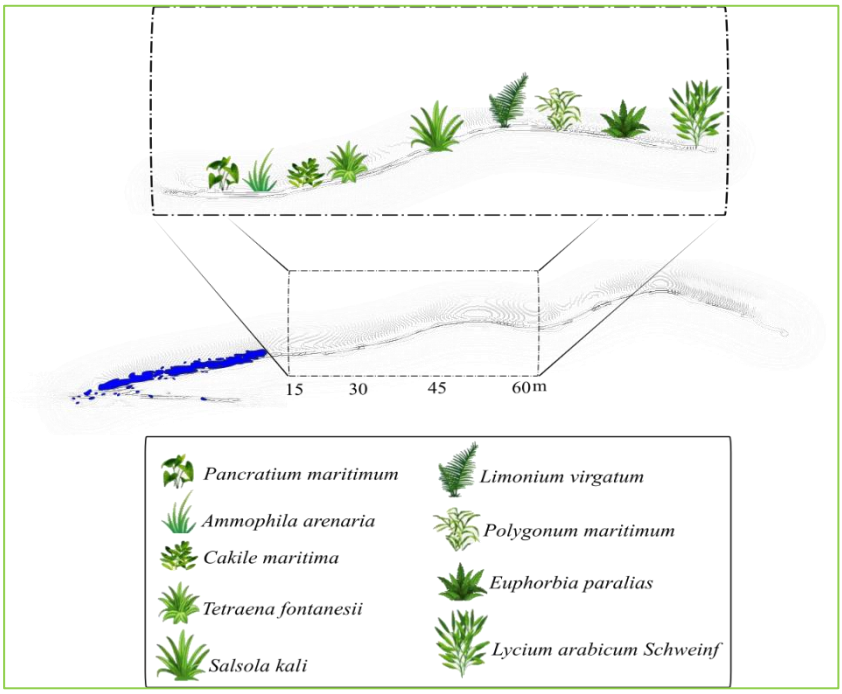


Figure 35. Species distribution on the front beach between El-Hamamah and Tolmeta

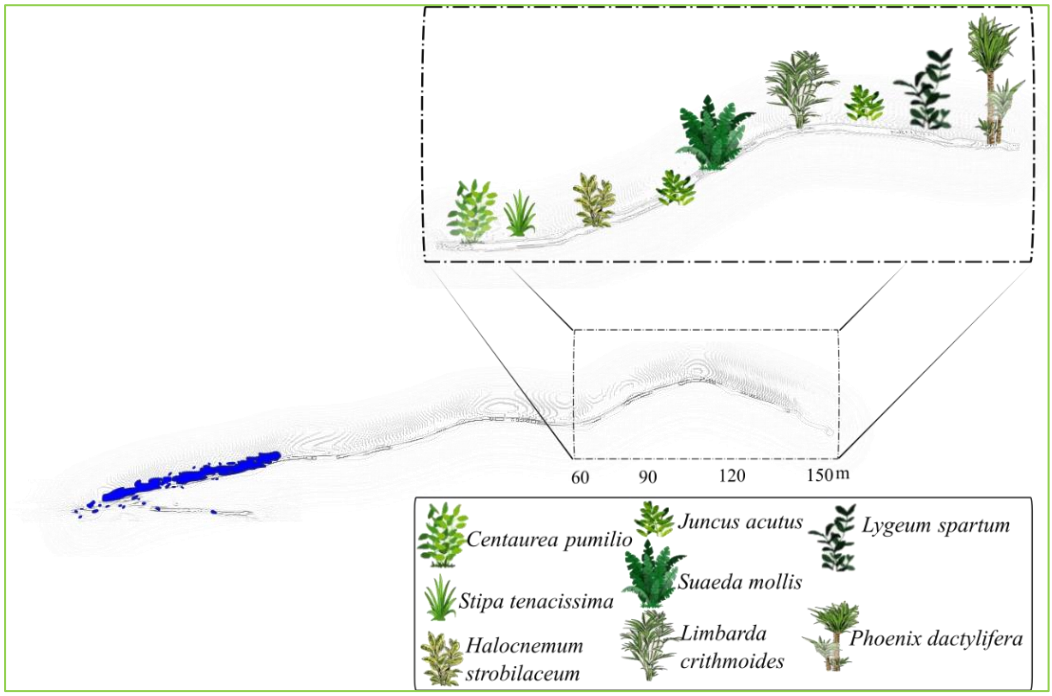


Figure 36. Species distribution on the back beach between El-Hamamah and Tolmeta

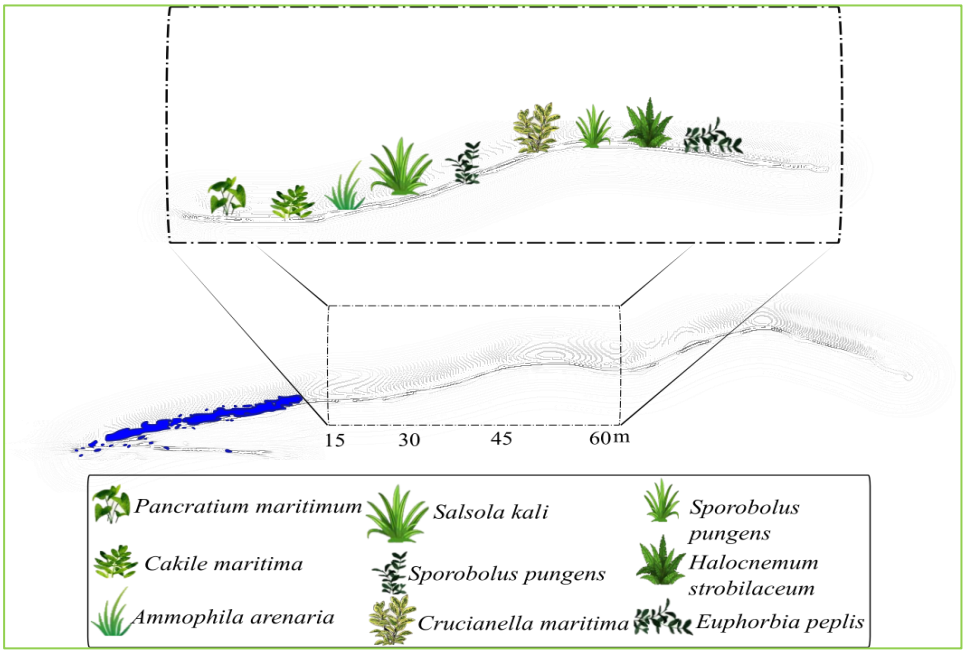


Figure 37. Species distribution on the front beach between Tolmeta and El-lthamh

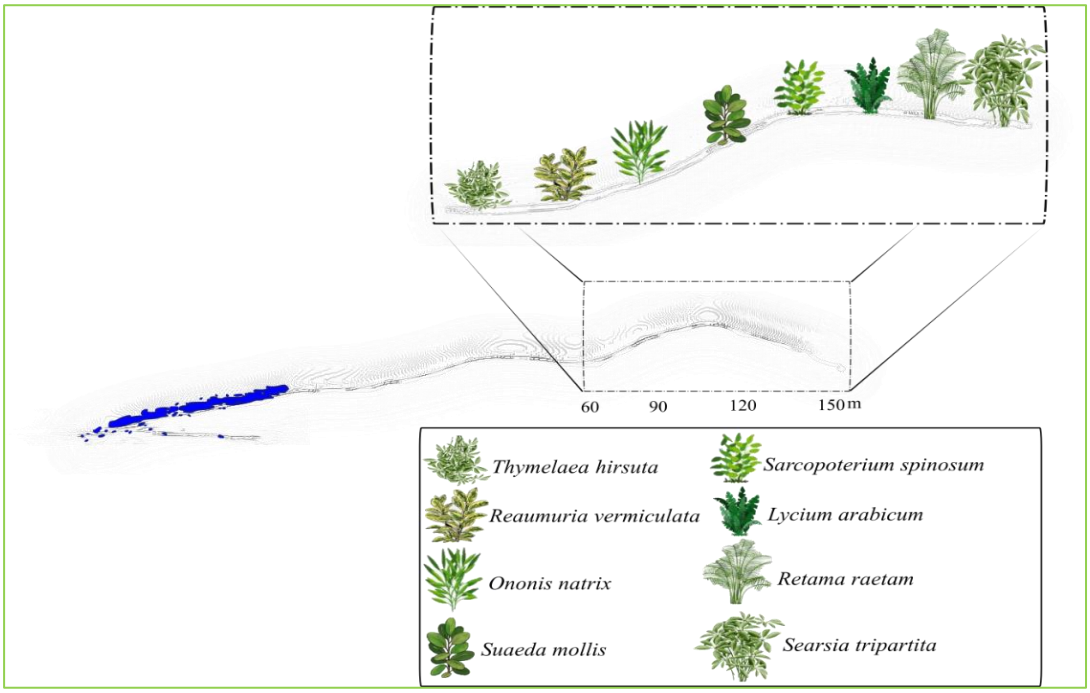


Figure 38. Species distribution on the back beach between Tolmeta and El-lthamh

From the analysis of Figures 33 and 38, we conclude:

- Habitats of embryonic dunes and unconsolidated dunes

Distinguished species: Ammophila arenaria, Otanthus maritimus, Pancratium maritimus.

Accidental types: Echium angustifolum, Tetraena fontanesii, Elytrigia juncea.

These sand accumulations appear more precise and connected because the type of *Ammophila arenaria* grows at a high density, can stabilize the sandy substrate because of its solid and branched roots, and forms small dunes with the direction of the wind. Despite the strength and speed of the wind, salt spray, and immersion, it is a permanent plant type.

The inner slope habitat of unconsolidated and stable dunes is by the species of vegetation: Crucianella maritima, Verbascum sinuatum, Heliotropium curassavicum, Ononis natrix, Echium angustifolum, Matthiola sinuata, Glaucium flavum.

Accidental types: *Ammophila arenaria, Cyperus capitatus, Sporobolus virginicus, Helichrysum stoechas*; this habitat begins to develop in the posterior (dorsal)

zone of unstable dunes, where erosion is less and produces a more stable substrate. This habitat is one of the most diverse in terms of plants.

- Semi-stable dunes

Distinguished species: Lagurus ovatus, Anchusa undulata, Plantago major, Bellis sylvestris var. cyrenaica.

- Accidental types: Tetraena fontanesii, Sedum laconicum, Euphorbia paralias.

A stable substrate of sandy accumulations characterises this habitat, and there are types of herbaceous perennial, annual, and semi-annual communities spread here, as well as permanent woody species that may appear, and many species are widespread in this habitat.

- Extensive sand accumulations (sand meadows)

Distinguished species: Euphorbia peplis, Euphorbia paralias, Centaurea pumilio, Cakile maritima, Cyperus capitatus, Matthiola sinuata, Phleum arenarium.

Accidental types: *Echium angustifolum, Cynara cyrenaica, Crucianella maritima, Pancratium maritimum, Polygonum equisetiforme, Polygonum maritimum, Lycium arabicum* Schweinf, in the wild artichoke family, for example, they are very similar in morphological characteristics but differ in distribution between habitats (Hand & Hadjikyriakou, 2009).

There are two types of sandy meadows, the first is coarse-grained with various rock pieces, and the second is fine-grained. These habitats appear when conditions are met, including a low beach, a wide area with little terrain, or a wide valley estuary.

This habitat is far from the direct influence of waves and winds. Plant diversity is good where annual and perennial herbaceous and broadleaf species mix.

- Grey dunes with herbaceous plants

Phleum arenarium, Polygonum equisetiforme, Teucrium brevifolium Schreb, Sedum sediforme, Cutandia dichotoma.

The stability of the substrate characterises this habitat, a collection of herbaceous plants, and the direct influence of the sea does not reach it. Here, stable, grey dunes and communities of woody plants may develop in this habitat. Figure 39 shows the logical gradient of habitat distribution and plant species in coastal dunes.

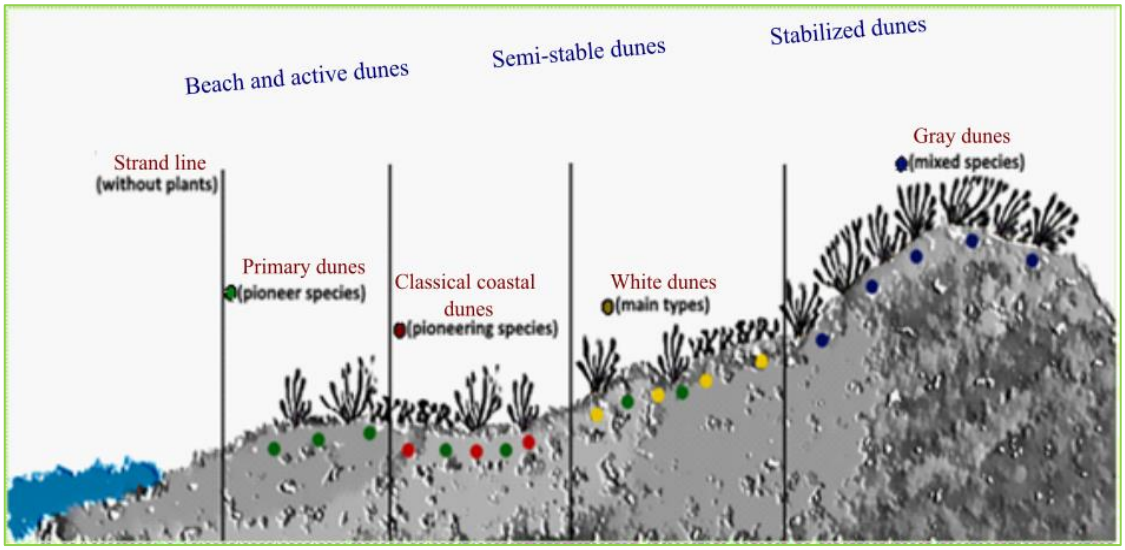


Figure 39. Logical gradation of habitat and plant species distribution in coastal dunes, source data from the field study

The pioneer species are the first to have the ability to adapt to a very harsh environment, followed by the less adapted species, and then the species that grow in the old dune environment. Visible in Figure 40 is the classification of dunes, the distribution of plants and materials, and the percentage of salinity.

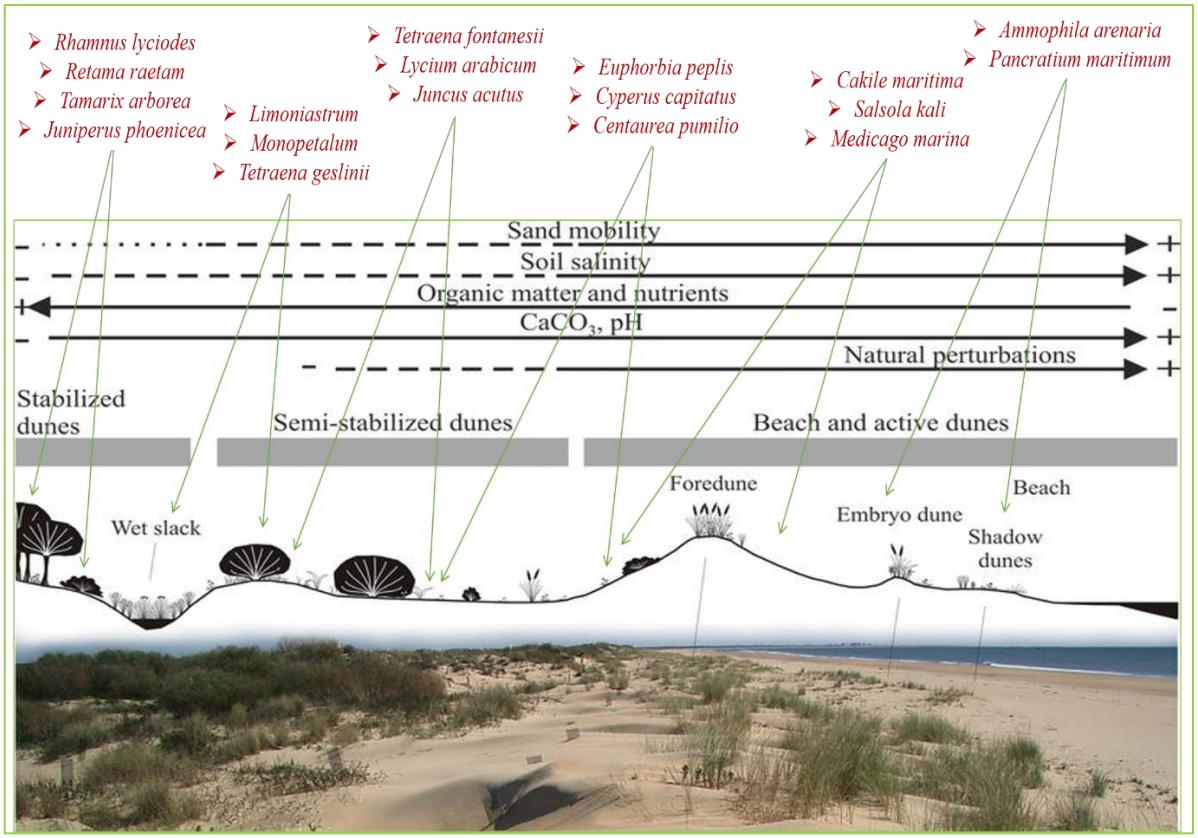


Figure 40. Illustrates the classification of dunes, the distribution of plants and Materials and the percentage of salinity**.** Source:(Muñoz-Vallés & Cambrollé, 2016)

The study of figures 33 to 40 showed the plant diversity of coastal dunes; they are classified according to their vegetation cover into:

- In the barren area, the very harsh conditions do not allow the existence of plants, as the substrate is mobile and variable, and it is directly under the influence of the waves.
- In primary vegetation area, in extreme conditions, the waves arrive unevenly, the substrate is nearly stable, the salt spray is continuous, the wind is strong, some species managed to adapt and specialize in growing in this area without competition from other species, and these species can be called "pioneer, advanced, or superior.
- In specialized plants area, moving away from the impact of waves and direct salt spraying, the substrate is more stable, and the plant community is more diverse and distributed and has unique biological and morphological characteristics in terms of shape and height, such as size, colour, leaves, branches, and roots.
- Mixed plant area is more remote from the direct impact of waves, wind, and salt spray because the substrates are stable, at the top of which are pioneering and specialized sandy species, and then overlap with woody and semi-woody species adapted to sandy soils and salt levels.
- Stable conditions characterised the Maquis area compared to its predecessors, representing a transitional area. The substrate consists of sand, silt, and gravel. Here the leading, specialized, and main species retreat into the environment of dunes, and the Mediterranean species spread, which are shrubs and dwarf trees, forming the Maquis community.
- In petrified dunes, the species are mixed, as areas with modern sediments are characterised by small plants, whereas perennial and annual plant species, grass and shrubs, and trees characterised hardened sites.

We mentioned that coastal dune habitats have a dynamic cycle, and among the decisive factors in this cycle are the type of plants and their annual cycle; some semi-annual, some annual, and some species wait for special germination conditions for several years.

The biological cycle of plants, from root formation, germination, flowering, fruit ripening, and ageing, is usually completed in winter and spring, when there is rain and moderate temperature, and is found away from the sun in summer.

The nature of these plants, from their root systems and growing season, controls the growth of embryonic and other coastal dunes. Tables 17 and 18 show the community, species represented and distribution of plant species in the coastal dune environment.

Table 17. Illustrates communities and species in coastal dune habitats

Community Type	Community Structure and Environment	Representative Species
***Cakile maritima* and *Salsola kali* community**	Annual, nitrophilous community of the strandline zone of the beach, exposed to wind action and occasionally to breaking waves	C. Maritima, Polygonum maritimum, S. kali, Chamaesyce peplis
***Elytrigea juncea* and *Sporobolus virginicus* community**	Pioneer, perennial, and halophilous community of the low embryo dunes, dominated by dune-forming plants such as *E. juncea*	E. juncea, S. virginicus, Echinophora Spinosa, Medicago marina, Otanthus maritimus
***Ammophila Arenaria subsp. australis* and *Calystegia soldanella* community**	Perennial herb community stabilized mobile dunes dominated by a rhizomatous species, *Ammophila arenaria*	A. Arenaria subsp. australis, Echinophora Spinosa, C. soldanella, Eryngium maritimum, Anthemis Maritima
***Crucianella maritima* and *Cyperus capitatus* community**	Perennial community of the inland side of mobile dunes, dominated by chamaephytic and herbaceous species	C. maritima, Pycnocomon rutifolium, Lotus cytisoides, Euphorbia terracina, Silene canescens, C. capitatus
***Juniperus oxycedrus subsp. macrocarpa* and *Juniperus phoenicea* community**	Pioneer juniper scrub of the seaward side of the semi-consolidated dunes and fixed dunes, exposed to wind action	J. oxycedrus subsp. macrocarpa, J. phoenicea, Daucus gingidium, Lonicera implexa, Prasium majus, Dorycnium hirsutum
***Phillyrea angustifolia* and *Pistacia lentiscus* community**	Evergreen Mediterranean Maquis of the fixed dunes, dominated by *P. Angustifolia, P. lentiscus,* and *Q. ilex*, sheltered from winds	Rhamnus alaternus, P. angustifolia, P. lentiscus, Arbutus unedo, Rubia peregrina, Asparagus acutifolius, Smilax aspera, Clematis flammula
***Schoenus nigerians* and *Erianthus ravennae* community**	Herbaceous wet community of the dune slack; in summer, the water table remained near the surface	S. nigricans, E. ravennae, Juncus acutus, Lysimachia nummularia
***Quercus ilex* community**	Evergreen wood of the dune slack transition, dominated by Q. ilex	Q. ilex, Viburnum tinus, Phillyrea latifolia, Myrtus communis, Ruscus aculeatus, Hedera helix, Cyclamen repandum

Source: modified after (Acosta et al., 2007)

The data in Table 17 differ according to the history and type of human activities in the area and a set of natural factors such as geographical location, climate, sediment

availability, and the nature of the coast. They contribute to the distribution of plant communities among the different habitats. Table 18 shows the distribution of plant species in the coastal dune environment.

Name	Vegetation Types
Annual vegetation of drift line (upper beach)	Pioneer annual vegetation characterises the strandline zone of the beach
Embryonic shifting dunes (embryo dunes)	Pioneer, a perennial community of the low embryo dunes dominated by *Elymus farctus*
Shifting dunes along the shoreline with *Ammophila Arenaria* (mobile dune)	Seaward and semi-permanent cordons of dune systems dominated by *Ammophila arenaria* subsp. *australis*
Crucianellion maritimae fixed beach dunes (*)	Chamaephytic community of the inland side of fixed dunes dominated by *Crucianella Maritima*
Malcolmietalia dune grasslands	Annual, species-rich community colonized by small xerophytes in dry, interdunal depressions of the coast
Coastal dunes with *Juniperus spp. (*juniper scrub*)* (*)	Juniper on stationary dunes is the most dominant
Cisto- Lavanduletalia dune sclerophyllous scrubs	Shrub formations dominated by sclerophyllous species
Wooded dunes with *Pinus pinea* or *Pinus pinaster*	Mediterranean and Atlantic thermophilous pines colonized coastal dunes

Table 18. The distribution of plant species in the coastal dune's environment

An asterisk (*) indicates the most degraded, high-priority habitat for conservation

As depicted in Table 17, the plant communities in the coastal dune environment are exposed to many environmental pressures because they exist in a unique and sensitive environment. The restoration of some species takes time; some are endemic and have priority in rehabilitation and conservation. We will explain these types later.

3.2. Characteristics of Plant Species in the Dune Drum

3.2.1. Scientific name: *Ammophila arenaria*

Family: Poaceae.

Biological Form: A height of between 25 and 90 cm; erect succulent type, robust cylindrical, branched from the base, in the form of dense tufts, long shiny linear interchangeable leaves, pressed ribbed spike flowers.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A pioneering model species specialized in embryonic, moving and stable dunes, and among the primary species in the formation and construction of sand accumulations, and assisted by this diffuse horizontal root system and resistance to the direct impact of the sea such as salt spray, where it plays a vital role in the maintenance and restoration of the front dunes. Picture 14 presents *Ammophila arenaria.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 14. *Ammophila arenaria*

3.2.2. Scientific name: *Pancratium maritimum.*

Family: Amaryllidaceae.

Biological Form: height between 15 and 40 cm, non-succulent, bulbous with a long neck, long leaves, softly wrapped, appear in winter, substantial solitary flowers, elliptical in the shape of a funnel, the root is a small tuber ending in a set of short roots. The fruits are spherical and triangular, with several seeds. They become black at maturity and move with water, spreading a wonderful aroma on summer nights.

L.D: Per.

Kinds: grass.

Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flowering												

Ecologia: is a pioneering and exemplary species specialized in embryonic dunes and a variety of mobile and stable dunes, observed as agglomerations or as individuals on rocky sidewalks with few sand accumulations very close to the sea, sandstone wrecks, rough sandy meadows, and prefer sunny and dry locations, do not prefer swamps, do not tolerate trampling, and resist sea wind and salt spray. Picture 15 illustrates *Pancratium maritimum.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 15. *Pancratium maritimum*

3.2.3. Scientific name: *Otanthus maritimus.*

Family: Compositae.

Biological Form: Height: 10–30 cm, non-succulent, pale grey, woody-branched at the base, cottony-covered with very thin cilia, erect stems, radial and close together, alternate leaves appearing as white cushions. Soft woolly, bright yellow flowers gathered in heads at the end of the branches.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A pioneering and typical species in embryonic and moving dunes, it emerges as a homogeneous community, growing and developing beyond the range of waves and withstanding high rates of sand supply, trampling and partial burial, and direct exposure to the sea. Picture 16 illustrates *Otanthus maritimus.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 16. *Otanthus maritimus*

3.2.4. Scientific name: *Salsola kali.*

Family: Amarnthaceae.

Biological form: height between 10-40 cm, succulent type, bright green with red edges, branched from the base, erect or seated, linear leaves ending with a terminal thorn, pink to copper flowers individually on the axis of the branch, ending with small spines, small fruits, when browned, detached from the stem and moving with the wind.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A pioneering species specializing in embryonic dunes and meadows, widespread in neglected fields and rocky sites with coarse sand accumulations, appearing as individuals spaced and mixed with other species, prefers sunny places and resists trampling, immersion and direct exposure to the sea. Picture 17 illustrates *Salsola kali.*

Source: Photograph by the researcher, field study, 3/2018.

Picture 17. *Salsola kali*

3.2.5. Scientific name: *Tetraena fontanesii \ Zygophyllum album L.*

Family: Zygophyllaceae.

Biological: Height between 15 and 40 cm (up to 1 m) dense green and orange, branched from the base, or with a short stem standing and woody branches, opposite leaves of green colour, orange fruits close in shape to the leaves, old leaves are yellow and red and fall off in winter.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in embryonic and mobile dunes and sand meadows, where they appear as an almost pure group with high coverage, prefer sunny locations, and are resistant to trampling and wind Picture 18 illustrates *Tetraena fontanesii.*

Source: Photograph by the researcher, field study, 8/2018.

Picture18. *Tetraena fontanesii*

3.2.6. Scientific name: *Medicago marina*

Family: Fabaceae.

Biological form: height between 10-25 cm. Non-succulent type, flat and creeping, pale green to grey, inconspicuous wood trunk, cylindrical branches, interchangeable and collected leaves; The flowers are large yellow in clusters.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical type of moving and stable dunes and coarse sand meadows, it appears in the form of domes that are contrasting and homogeneous with the direction of the wind, prefers sunny and open locations, and resists trampling and direct exposure to the sea. Picture 19 illustrates the *Medicago marina.*

Source: Photograph by the researcher, field study, 3/2018.

Picture 19. *Medicago marina*

3.2.7. Scientific name: *Crucianella maritima.*

Family: Rubiaceae.

Biological form: Biological form: height 10-35 cm, non-succulent, radial branched upright, with woody branches at the base, erect overlapping stem leaves, ending with a spiny head, a clear yellow star and small terminal flowers.

L.D: Per.

kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: They appear on stationary dunes, sandy meadows and sandstone debris as individuals spaced with high coverage or mixed with other species, prefer sunny and dry locations, resist trampling, and are resistant to direct exposure to the sea. Picture 20 illustrates *Crucianella maritima.*

Source: Photograph by the researcher, field study,7/ 2018.

Picture 20. *Crucianella maritima*

3.2.8. Scientific name: *Euphorbia paralias.*

Family: Euphorbiaceae.

Biological form: Height varies from 20 to 70 cm, non-succulent, erect, brilliant green, branched at the base, alternating stem leaves, monochromatic thin flowers of red-yellow colour at the top of the branches, triangular fruits welded with grey spherical seeds in the middle of a clear line.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in semi-stable and stable dunes and coarse sand meadows, it spreads in rocky sites, prefer sunny and dry sites, has spatial dominance in sandy meadows, invades degraded sites quickly, resists trampling and fires, is unpalatable for grazing and does not resist inundation while tolerating direct exposure to the sea. Picture 21 illustrates *Euphorbia paralias.*

Source: Photograph by the researcher, field study, 3/2018.

Picture 21. *Euphorbia paralias*

3.2.9. Scientific name: *Euphorbia peplis.*

Family: Euphorbiaceae.

Biological form: Biological form: non-succulent species, dark green, creeping, flat, carpet-like up to more than 30 cm2, short red twigs, simple contrasting leaves, leathery green, pale at the bottom of the leaf, small spherical small flowers.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A specialized and pioneering species in the dune environment, monitored in the embryonic, mobile and stable dune ranges, appears as spaced individuals, prefers sunny and dry locations, does not resist treading, and resists burial and direct exposure to the sea. Picture 22 illustrates *Euphorbia peplis.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 22. *Euphorbia peplis*

3.2.10. Scientific name: *Heliotropium curassavicum*

Family: Boraginaceae.

Biological form: Biological form: flat creeping, pale green, extending more than 50 cm, cylindrical branches, thick replacement leaves, small white flowers drooping, double in rows, bell-shaped.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species that spreads on moving and stable dunes and sand meadows, spreads at the edges of seasonal swamps, appears as dense cover in disturbed areas, and sometimes mixed with other species. It does not resist trampling and resists direct exposure to the sea. Picture 23 illustrates *Heliotropium curassavicum.*

Source: Photograph by the researcher, field study,8/ 2019.

Picture 23. *Heliotropium curassavicum*

3.2.11. Scientific name: *Matthiola sinuata.*

Family: Brassicaceae.

Biological form: height between 15 and 40 cm. Non-succulent green type, vertical radial and branched, woody at the base, smooth cylindrical branches covered with tiny cilia, long wavy basal leaves, light violet-like umbrella flowers on a long neck.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes and meadows that spreads on sandy rock debris, appears as few and spaced individuals, prefers open sunny locations, and resists trampling and direct exposure to the sea. Picture 24 illustrates *Matthiola sinuata.*

Source: Photograph by the researcher, field study, 3/2019.

Picture 24. *Matthiola sinuata*

3.2.12. Scientific name: *Sporobolus virginicus.*

Family: Poaceae.

Biological form: height 10-35 cm, flat green, short leaves alternating in two rows, small purple flowers in clusters.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A pioneering species specializing in shifting dunes, and seasonal swampy edges, observed on gravel beaches, palatable to grazing, resistant to burial and trampling, and direct exposure to the sea, should be distinguished from the *Elytrigia juncea* species. Picture 25 illustrates *Sporobolus virginicus.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 25. *Sporobolus virginicus*

3.2.13. Scientific name: *Glaucium flavum.*

Family: Papaveraceae.

Biological form: height 10-30 cm, pale green and grey, wavy and thick leathery leaves, dense at the base, yellow disc-shaped flowers, cylindrical stems covered with a small margin, long leafless branches, blooming at the beginning of summer and then turning into a pod, in which there is a bunch of seeds in two rows.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical type in moving and stable dunes, it spreads on sandy rock debris on high beaches and sandy meadows, covered with a waxy layer that helps to collect water droplets; it looks mixed with other species, tolerates direct exposure to the sea, trampling, unpalatable to grazing, does not progress inland. Picture 26 illustrates *Glaucium flavum.*

Source: Photograph by the researcher, field study, 4/2019.

Picture 26. *Glaucium flavum*

3.2.14. Scientific name: *Cyperus capitatus.*

Family: Cyperaceae.

Biological form: height between 5-15 cm, herbaceous branched type, straight cylindrical stem, dark green leaves at the top, red at the base, polygonal, triangular lying like a fan, flowers clustered like a spike, brown at maturity.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species, widespread on sand fans, it appears as groups with high spatial dominance, preferring sunny locations and mixing with a few species, such as *Centaurea pumilio* and *Cichorium spinosum*. Irresistible to direct exposure to the sea and severe trampling. Picture 27 illustrates *Cyperus capitatus.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 27. *Cyperus capitatus*

3.2.15. Scientific name: *Centaurea pumilio.*

Family: Compositae.

Biological form: height between 10-15 cm, spiny type non-succulent, grey to pale green, broad wavy leaves, covered with thin cilia, large white to solitary purple flowers in the form of a crown carried by a short, muscular neck, ending in spiny teeth.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species in dry sand meadows and stable dunes, it has a high spatial dominance; it is irresistible to trampling but resists burial, preferring dry, sunny sites away from the direct influence of the sea. Picture 28 illustrates *Centaurea pumilio.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 28. *Centaurea pumilio*

3.2.16. Scientific name: *Cakile maritima.*

Family: Brassicaceae.

Biological form: height between 15 to 40 cm, radial type, green branched from the base, leaves are glossy green, white to purple flowers, pod fruits with 2 tiny brown seeds, floated with water.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A pioneering and typical species on moving and stable dunes and sand meadows, it appears as mixed individuals with other species that withstand trampling and tolerate salt spray and partial immersion. Picture 29 illustrates *Cakile maritima.*

Source: Photograph by the researcher, field study, 7/2019.

Picture 29. *Cakile maritima*

3.2.17. Scientific name: *Echium angustifolum.*

Family: Boraginaceae.

Biological form: Non-succulent type, pale green, creeping and branched extending to 40 cm, tiny white cilia covering most parts of the plant, short stem, simple, alternate wavy leaves, flowers in dense purple clusters that change to dark red when opened.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: Spread on stable dunes, meadows and slopes with rock debris, prefers sunny locations, and does not resist trampling or direct exposure to the sea. Picture 30 illustrates *Echium angustifolum.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 30. *Echium angustifolum*

3.2.18. Scientific name: *Ononis natrix.*

Family: Leguminosae.

Biological form: height 20 to 45 cm, non-succulent, brilliant green, semi-round, and woody at the base, covered with thin cilia, articulated branches, simple yellow single flower. It has many scarlet stripes and fruits in a short pod with seeds.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical type on stationary dunes, coarse and dry sand meadows, and rocky sites, appear single or mixed with other types of Maquis formation, prefer dry sites, and resist trampling and marine exposure. Picture 31 presents *Ononis natrix*.

Source: Photograph by the researcher, field study, 9/2019.

Picture 31. *Ononis natrix*

3.2.19. Scientific name: *Lotus halophilus.*

Family: Fabaceae.

Biological form: Non-succulent, branched and creeping up to 30 cm, weak cylindrical branches, small opposite leaves, yellow flowers, and horn-shaped fruits, brown at maturity, with many spherical golden seeds.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species that spreads on stable dunes and sand meadows prefers sunny places, resists trampling and marine exposure, is palatable to grazing, and in terms of the form, should not be confused with Medicago species such as (*Medicago marina* - *Medicago liturales*). The apparent difference is in the colour tone, fruit shape and flowering time. Picture 32 presents *Lotus halophilus.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 32. *Lotus halophilus*

3.2.20. Scientific name: *Lycium arabicum.*

Family: Solanaceae.

Biological form: height between 0.7 and 2.25 m, intertwined and thorny succulent type; strong grey trunk; woody branches with short sharp spines; simple small green leathery leaves; individual white bell flowers are green, orange and red spherical fruits with a sweet taste, containing spherical and brown seeds.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species that spreads on the edges of salt marshes and stable dunes, appears as individuals spaced or mixed with other species, can stabilize the sand, prefers sunny sites with low clay and sand, resists fires, is palatable to grazing, and tolerates direct exposure to the sea. Picture 33 presents *Lycium arabicum.*

Source: Photograph by the researcher, field study, 9.2019.

Picture 33. *Lycium arabicum*

3.2.21. Scientific name: *Juncus acutus.*

Family: Juncaceae.

Biological form: height between 0.3-1.2 m, non-succulent, radial semicircular, dark green, cylindrical branches, with a pointed spiky end, leaves very close to the branches, small crimson flowers compounded to green on the axis of the branch at the top, but they do not bear flowers.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable and moving dunes, observed on the edges of swamps, lakes, depressions, and ditches, has a role in sand stabilization, prefers sunny sites, tolerates seasonal floods, and has direct exposure to the sea. Picture 34 *presents Juncus acutus*.

Source: Photograph by the researcher, field study, 7/2018.

Picture 34. *Juncus acutus*

3.2.22. Scientific name: *Achillea fragrantissima.*

Family: Compositae.

Biological form: height between 20-50 cm, non-succulent, covered with white wool, branched and woody at the base, woody, broad leaves dense at the bottom, thick grey, yellow flowers in the form of longitudinal to oval discs. It should not be confused with *Teucrium polum*.

L.D: Per.

Kind: forbs.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes and meadows, it appears mixed with other species, spreads on sandy rock debris, prefers sunny locations, tolerates trampling, and is not resistant to direct exposure to the sea. Picture 35 presents *Achillea fragrantissima.*

Source: Photograph by the researcher, field study,7/2018.

Picture 35. *Achillea fragrantissima*

3.2.23. Scientific name: *Polygonum maritimum.*

Family: Polygonaceae.

Biological form: height between 10-40 cm. Non-succulent green glossy type with crimson rings, which become copper-coloured when dry, branched from the base, solid crimson branches, without twigs, small white-pink flowers, in clusters of the axis of the branch and the base of the leaves, spherical fruits like hazel, clear and shiny.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A pioneering and specialized type of moving and stable dunes closest to the sea, appearing in groups slightly deviated from the level of tidal waves, prefers sunny and low locations, contributes to the accumulation of sand grains, resists wind and trampling, is palatable to grazing, and tolerates direct exposure to the sea. Picture 36 presents *Polygonum maritimum.*

Source: Photograph by the researcher, field study, 4/2019.

Picture 36. *Polygonum maritimum*

3.2.24. Scientific name: *Polygonum equisetiforme.*

Family: Papaveraceae.

Biological form: height between 25-75 cm, branched at the base, with a short and woody solid stem, erect ascending branches, short leathery leaves, colourful flowers, pinkish-white axils with shiny black fruits.

L.D: Per.

Kinds of grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specializing in stable dunes, spreading on sandy rock debris and roadsides, appearing as mixed individuals with other species that prefer wet sunny locations, palatable for grazing resists trampling and direct exposure to the sea. Picture 37 presents *Polygonum equisetiforme.*

Source: Photograph by the researcher, field study, 4/2019.

Picture 37. *Polygonum equisetiforme*

3.2.25. Scientific name: *Limonium cyrenaicum (Rouy) Brullo.*

Family: Plumbaginaceae.

Biological form: height between 20 - 50 cm. Green with green cylindrical long branches, small purple flowers, smooth leaves, one leaf per node, densely appearing in the lower part.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes and rocky slopes, spread on sandy rocks, appear as individuals spaced over large areas, mixed with other species on moving dunes, prefers salt depressions, resists trampling and direct exposure to the sea. Picture 38 presents *Limonium cyrenaicum.*

Source: Photograph by the researcher, field study, 3/2018.

Picture 38. *Limonium cyrenaicum*

3.2.26. Scientific name: *Suaeda vera* Forssk.

Family: Amaranthaceae.

Biological form: height 10-60 cm, branched woody type, simple leaves that do not separate in the manner of one leaf per node along the stem, branches covered with dense leaves, red and orange flowers.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on settled dunes, it spreads on sandy meadows, appearing as mixed individuals with other species in areas of sandy rocks and salt marsh edges. It resists trampling, prefers sunny locations and tolerates direct exposure to the sea. Picture 39 presents *Suaeda vera* Forssk.

Source: Photograph by the researcher, field study,8/2018.

Picture 39. *Suaeda vera* Forssk

3.2.27. Scientific name: *Suaeda mollis.*

Family: Amaranthaceae.

Biological form: height between 15 - 40 cm, succulent type branched from the base, brown colour, flat and short cylindrical leaves, small inconspicuous green flowers in the leaf axils.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specialized in stable dunes, it is widespread in sand meadows, sandy rock debris and swampy edges, prefer low, sunny sites, and resists trampling and marine exposure. Picture 40 presents *Suaeda mollis.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 40. *Suaeda mollis*

3.2.28. Scientific name: *Crucianella aegyptiaca.*

Family: Rubiaceae.

Biological form: height between 10-25 cm, non-succulent branched type, green, with densely leaved branches, stem leaves, creamy white solitary flowers, as a small bell.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: Typical species in sedentary meadows and rocky sites appear as individuals mixed with other species, palatable to grazing, and resistant to trampling and marine exposure. Picture 41 presents *Crucianella aegyptiaca.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 41. *Crucianella aegyptiaca*

3.2.29. Scientific name: *Limoniastrum monopetalum.*

Family: Plumbaginaceae.

Biological form: height between 0.3-1 m. A robust short stem with bare branches at the bottom, simple leaves and articulated stems with a cottony texture, large funnel-shaped purple flowers with a long neck, and transparent yellow petals.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species that spread on the edges of swamps, and rocky slopes of ancient dunes, prefers sunny and humid locations, appears as a pure variety in seasonal swamps, unpalatable for grazing, and resists fire, trampling submersion, and marine exposure. Picture 42 presents *Limoniastrum monopetalum.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 42. *Limoniastrum monopetalum*

3.2.30. Scientific name: *Sporobolus pungens.*

Family: Poaceae.

Biological form: height between 10-30 cm, green branched type, with a widespread creeping brown stem, straight and articulated sequential branches, closely spaced leaves, copper flowers. Like nails.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in stable and moving dunes, swamps and meadows, spreading on sandy rock debris, preferring low, sunny locations. It has high coverage and resists trampling and direct exposure to the sea. Picture 43 presents *Sporobolus pungens.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 43. *Sporobolus pungens*

3.2.31. Scientific name: *Alkanna tinctoria.*

Family: Boraginaceae.

Biological form: height between 10-25 cm, flat non-succulent, green covered with cilia, branched at the base, small coloured calyx flowers at the apex, exposed to the cutting of roots in the fall.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species that spread on old and sedentary dunes and meadows, prefer sunny sites over semi-shade, is palatable for grazing, and is resistant to trampling and direct exposure to the sea. Picture 44 presents *Alkanna tinctoria.*

Source: Photograph by the researcher, field study, 4/2019.

Picture 44. *Alkanna tinctoria*

3.2.32. Scientific name: *Centaurea melitensis.*

Family: Compositae.

Biological form: height between 15-90 cm, spiny non-succulent, greyish-green, strong cylindrical branch, covered with cilia, the inflorescence is solitary yellow.

L.D: Ann.

kind: forbs.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species widespread on ancient and sedentary dunes and slopes, appearing mixed with other species, spreading as individuals on roadsides, neglected fields, ditches, and quarry sites, prefer sunny sites, and is not resistant to direct exposure to the sea. Picture 45 presents *Centaurea melitensis.*

Source: Photograph by the researcher, field study, 4/2019.

Picture 45. *Centaurea melitensis*

3.2.33. Scientific name: *Verbascum sinuatum.*

Family: Scrophulariaceae.

Biological form: height between 20-75 cm, non-succulent, green in the first year with alternate, basal rosette leaves. The following year, it grows erect cylindrical stems, green and crimson branched at the top, its flowers are yellow, its leaves are covered with short cilia, spherical fruits containing several seeds, covering thin cilia.

L.D: Per (once every two years).

Kind: forbs.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species spread in several locations on ancient and stable dunes, low rocky and gravel beaches, prefers sunny sites, spreads in neglected fields, appears as mixed individuals with other species, and is resistant to trampling and marine exposure. Picture 46 presents *Verbascum sinuatum.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 46. *Verbascum sinuatum*

3.2.34. Scientific name: *Salicornia europaea.*

Family: Amaranthaceae.

Biological form: height between 15-35 cm, succulent, leathery to the touch, has short stems, compressed leaves with an inconspicuous margin, small green triangular solitary flowers, changing to dark red in autumn.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in seasonal salt marshes, perennial swamp edges and sandy meadows, it appears as a carpet covering a wide area and resisting inundation and, trampling, direct exposure to the sea. Picture 47 presents *Salicornia europaea.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 47. *Salicornia europaea*

3.2.35. *Scientific name: Ononis vaginalis.*

Family: Fabaceae.

Biological form: height between 15 - 50 cm, shrub with a short and robust stem, dense green intertwined, many-branched leaves, flowers terminal yellow. Lobed or sail-shaped, growing from the axils of the leaves in clusters from 1 to 3, the fruits of cylindrical pods containing several seeds.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in stable and moving dunes, sand meadows, and sandy slopes with sandstone debris, has an exceptionally high spatial dominance in sandy meadows, is rarely found with other species, prefers dry, sunny locations and is resistant to severe trampling and direct exposure to the sea. It is uprooted in the autumn season for medicinal uses. Picture 48 illustrates *Ononis vaginalis.*

Source: Photograph by the researcher, field study,4/ 2018.

Picture 48. *Ononis vaginalis*

3.2.36. Scientific name: *Juncus subulatus.*

Family: Juncaceae.

Biological form: height between 30 - 90 cm, branched at the base, sharp cylindrical branches at the top, cylindrical leaves solitary flowers, spaced brown to small crimson at the top.

L.D: Per.

Kinds of grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in perennial and seasonal swamps, lake edges, and sunny and wet sandy meadows. It looks like a pure pool that takes up much space, stabilizes sand, reduces the trampling effect, and withstands immersion and marine exposure. Picture 49 illustrates *Juncus subulatus.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 49. *Juncus subulatus*

3.2.37. Scientific name: *Thymelaea hirsuta.*

Family: Thymelaeaceae.

Biological form: height between 0.5 - 2 cm, non-succulent, green, short cylindrical branches bearing intertwined and regular clusters of young leaves alternating around the branch, yellow plates clustered in clusters, long.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A common species on stable and moving dunes and cracked rock sites less than 10 m from the sea, it spreads in disturbed sites, rarely forms a pure agglomeration and spreads quickly, prefers sunny sites, unpalatable for grazing, resists fires, trampling, and marine exposure. Picture 50 illustrates *Thymelaea hirsuta.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 50. *Thymelaea hirsuta*

3.2.38. Scientific name: *Salsola vermiculata.*

Family: Amaranthaceae.

Biological form: height between 0.2 - 1 m, branched, densely leafy, with thin cilia, white branches, narrow leaves, solitary flowers in the leaf axon, crimson to copper, fruits green to grey.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stationary dunes and sand meadows, it spreads on perennial and seasonal swampy edges, appears as a well-covered community or as mixed individuals with other species, has a sand-stabilizing role, is palatable to grazing, prefers low, sunny locations, resistant to trampling, salt accumulation, and marine exposure. They have observed that it returns to growth after cutting or grazing. Picture 51 illustrates *Salsola vermiculata.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 51. *Salsola vermiculata*

3.2.39. Scientific name: *Stipa tenacissima.*

Family: Poaceae.

Biological form: height between 20-70 cm, non-succulent type, branched, green to grey, cylindrical branches; tough replacement leaves, long golden spikes of the flower.

L.D: Per.

Kinds of grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specialized in moving and stable dunes, rocky slopes, and dry sandy meadows, and appears as dense individuals or concentrations, palatable to grazing, and resistant to trampling. Picture 52 illustrates *Stipa tenacissima.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 52. *Stipa tenacissima*

3.2.40. Scientific name: *Sedum rubens.*

Family: Crassulaceae.

Biological form: height between 10 - 15 cm, succulent type, initially green, then red, branched from the base, cylindrical branches, alternate leaves, flowers are white star-shaped, small star-flat fruits appear.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: Species predominating on ancient dunes, rocky debris sites and cliffs, appear as individuals in large areas and grow near trees and shrubs, prefer semi-sunny and dry sites, do not tolerate trampling, and are not resistant to direct exposure to the sea. Picture 53 illustrates *Sedum rubens.*

Source: Photograph by the researcher, field study, 7/2019.

Picture 53. *Sedum Rubens*

3.2.41. Scientific name: *Pharagmitis australis.*

Family: Poaceae.

Biological form: height between 1 - 3 m, green, straight and creeping stems, non-woody, leaves wide and long, and may be located in the form of a floating mat from which stems grow. Long brown flowers appear on the stems, growing in late summer and early autumn.

L.D: Per.

Kind: forbs.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species in swamps, lakes, lowlands and humid locations near the sea, covering the edges of permanent swamps and ponds in areas of rocks and ditches. This species blocks light on other plants; the roots grow deep and robust. Fire resistance is an invasive type controlled by cutting or grazing. Picture 54 illustrates *Phragmites australis.*

Source: Photograph by the researcher, field study, 7/2019.

Picture 54. *Pharagmitis australis*

3.2.42. Scientific name: *Nicotiana glauca.*

Family: Solanaceae.

Biological form: height between 1.2 - 3 m, woody green branched from the base, long cylindrical branches bearing succulent leaves covered with a waxy coating, yellow flowers like long bells in hanging clusters, small capsule fruits with many seeds.

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads at roadsides, trenches, quarries, abandoned fields, the edges of seasonal swamps and valleys heading towards the sea, spreads rapidly, appears as separate individuals, resists direct exposure to the sea, and resists inundation. Picture 55 illustrates *Nicotiana glauca.*

Source: Photograph by the researcher, field study,8/ 2018.

Picture 55. *Nicotiana glauca*

3.2.43. Scientific name: *Phillyrea latifolia.*

Family: Oleaceae.

Biological form: height between 0.75-2 m, non-succulent, dark green, short solid branches, opposite leaves, white flowers in short clusters, spherical fruits, black at maturity, with tiny spherical seeds.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It is widespread on stable dunes, mixed with other species, prefers sunny locations and resists direct exposure to the sea. Picture 56 illustrates *Phillyrea latifolia.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 56. *Phillyrea latifolia*

3.2.44. Scientific name: *Cressa cretica.*

Family: Convolvulaceae.

Biological form: height between 15-30 cm, non-succulent, grey branched at the base, short and spreading alternate leaves, small white solitary flowers, oval capsule fruits with one seed.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on sandy meadows mixed with mud and swampy edges, appears mixed with other species, resists trampling, and does not resist direct exposure to the sea. Picture 57 presents *Cressa cretica.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 57. *Cressa cretica*

3.2.45. Scientific name: *Sedum sediforme (Jacq) Pau.*

Family: Crassulaceae.

Biological form: height between 15-40 cm, succulent green type, branched from the base, strong branches, thick cylindrical alternate leaves, small pale-yellow flowers.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on ancient dunes, it appears as isolated or mixed individuals with other species that prefer semi-sunny locations, tolerate trampling, and are not resistant to direct exposure to the sea. Picture 58 presents *Sedum sediforme.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 58. *Sedum sediforme*

3.2.46. Scientific name: *Halocnemum strobilaceum.*

Family: Amaranthaceae.

Biological form: height between 25-90 cm, succulent green, oval in shape, branched at the base, short cylindrical branches and intertwined, small opposite leaves and leathery, flowers in clusters resting on the tip of the branch, large bushes of it show the joints of the branches in golden colour.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specializing in swampy edges, salt lakes and ditches, observed on moving dunes exposed to tidal waves, prefers wet and salty sunny locations, withstands trampling, direct exposure to the sea, and seasonal inundation. Picture 59 presents *Halocnemum strobilaceum.*

Source: Photograph by the researcher, field study, 7/2019.

Picture 59. *Halocnemum strobilaceum*

3.2.47. Scientific name: *Traganum nudatum.*

Family: Amaranthaceae.

Biological form: height between 25 - 60 cm, branched green succulent, strong grey or white branches, alternate needle-like green leaves, inconspicuous copper flowers, both with a branched axis.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on moving and stable dunes, widespread in rocky sites and slopes, appears as isolated or mixed individuals with other species, palatable to grazing, prefers sunny locations and resists direct exposure to the sea. Picture 60 presents *Traganum nudatum.*

Source: Photograph by the researcher, field study, 3/2018.

Picture 60. *Traganum nudatum*

3.2.48. Scientific name: *Tetraena geslinii* (Coss.) Beier & Thulin.

Family: Zygophyllaceae.

Biological form: height between 25-50 cm, light green succulent, branched at the base, short woody branches, simple leaves, stellate white solitary flowers, small ribbed pear-shaped fruits, resting stem at the top.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on moving and stable dunes and sunny and humid sandy meadows, spread on sandstone debris near the sea, appears in small numbers or mixed with other species, is not resistant to trampling and resists direct exposure to the sea. Picture 61 presents *Tetraena geslinii.*

Source: Photograph by the researcher, field study, 3/2018.

Picture 61. *Tetraena geslinii*

3.2.49. Scientific name: *Drimia maritima (Arum cyrenaicum).*

Family: Asparagaceae.

Biological form: height between 15-30 cm, non-succulent, broad basal leaves emerging from compound tubers, slender cylindrical stem, bearing small white flowers. Fruits are small succulent berry capsules. Its leaves appear in autumn, wither after the fruits bloom, ripen in late spring, and germination begins in early autumn.

L.D: Ann.

kind: forbs.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specializing in stable dunes and degraded sites in ancient dunes. The leaves wither in the summer, and part of the tubers appears on the surface of the sand. It is attached to the root of the flagella. This species extends to the depth, an indicator of deterioration of the formation of Mediterranean Maquis due to fires, and many individuals seem to mix with other plant communities. It is a dormant species in summer and active in autumn and winter. Picture 62 presents *Drimia maritima.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 62. *Drimia maritima*

3.2.50. Scientific name: *Rhus tripartite.*

Family: Anacardiaceae.

Biological form: height between 0.75 - 2.50 m, thorny shrub, leaves with three dark green serrated leaves, short branches, brown and red, with short and challenging spines; The fruits are green grapes. It has a dark red colour at maturity.

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specialized in moving and stationary dunes and has a role in sand stabilization. This species appears as differentiated or mixed individuals with *Juniperus phoenicea* and *Pistacia lentiscus*. Resists direct exposure to the sea and has a role in stabilizing sand. Picture 63 presents the *Rhus tripartite.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 63. Rhus tripartite

3.2.51. Scientific name: *Cichorium spinosum.*

Family: Compositae.

Biological form: height between 10-25 cm, thorny woody, small and straightforward leathery leaves, medium blue flowers concentrated in the upper part of the plant. The upper branches are not flowering and have short, stiff, woody spines.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes, rock terraces and rocky beaches, it spreads as scattered individuals in rocky sites and sandy rock debris. It tolerates direct exposure to the sea, especially on rocky beaches, while retreating to stable dunes. On low sandy beaches, it prefers sunny sites, often spotted on coastal roadsides. Picture 64 presents *Cichorium spinosum.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 64. *Cichorium spinosum*

3.2.52. Scientific name: *Camphorosma monspeliaca.*

Family: Amaranthaceae.

Biological form: height between 20-50 cm, greyish-green with a solid brown stem, densely branched leaves, simple green leaves covering high branches. Tiny and inconspicuous flowers.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on ancient dunes and high rocky beaches, it appears as individuals on the edges of swamps and sandy meadows, forms a high cover in open locations and prefers sunny sites exposed to the sea directly on high rocky beaches. Picture 65 presents *Camphorosma monspeliaca.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 65. *Camphorosma monspeliaca*

3.2.53. Scientific name: *Suaeda vera* Forssk.

Family: Amaranthaceae.

Biological form: height betwee15 - 60 cm, woody succulent at the base, cylindrical branches, simple thick leaves not separated, red and orange flowers in clusters with tiny black seeds.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes and dry swamps, it appears as a pure pool or as mixed individuals with other species on salt marsh edges, prefers sunny, low-humidity locations, and withstands trampling and direct exposure to the sea. Picture 66 presents *Suaeda vera* Forssk.

Source: Photograph by the researcher, field study, 8/2018.

Picture 66. *Suaeda vera* Forssk

3.2.54. Scientific name: *Limbarda crithmoides.*

Family: Compositae.

Biological form: height between 15-75 cm, woody succulent, shiny straight stems, long stem leaves cascading, spaced, yellow flowers carried by long stems surrounded by brown cilia.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on settled dunes, seasonal inundation areas, appear as isolated individuals or aggregations, in rocky locations on high beaches or as transverse lines in sandstone debris on low beaches, observed on seafront cliffs and salt marsh edges. Picture 67 presents *Limbarda crithmoides.*

Source: Photograph by the researcher, field study,7/ 2018.

Picture 67. *Limbarda crithmoides*

3.2.55. Scientific name: *Scirpus holoschoenus.*

Family: Cyperaceae.

Biological form: height between 15 - 60 cm, non-succulent dark green, radially branched from the base, serrated leaves, thread-like, brown opposite flowers, growing at the top, oval in shape, short spiny branches, with horizontal stems.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A specialized species for wet sandy meadows and salt marshes. It looks like a pure assembly characterized by high spatial coverage that resists partial immersion. A small part remains on the earth's surface in dry times, and roots may appear. It has a role in stabilizing dunes and resists trampling and sea exposure. Picture 68 presents *Scirpus holoschoenus.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 68. *Scirpus holoschoenus*

3.2.56. Scientific name: *Torilis nodosa.*

Family: Apiaceae.

Biological form: height between 10-30 cm, non-succulent, divided compound leaves, cylindrical stems, white flowers at the ends located on a small hard spiny capsule, fruits located in a solid brown spiny capsule at maturity.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on the slopes of ancient dunes, sandstone debris, dry sandy meadows, neglected fields, ditches, and roadsides, appears as mixed individuals with other species that prefer sunny locations, is not resistant to trampling, and withstands marine exposure. Picture 69 presents *Torilis nodosa.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 69. *Torilis nodosa*

3.2.57. Scientific name: *Stipagrostis libyca.*

Family: Poaceae.

Biological form: height between 15 - 35 cm, non-succulent cylindrical, light articulated branches covered with tiny white cilia, narrow leaves of long green filaments, flowers loose spikes, double with solid cilia and pointed tip, the top of the branches appear as clusters.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species specialized in stable dunes, and coarse and dry sand meadows, contributes to sand stabilization, prefers sunny sites, palatable to grazing, and resists trampling and marine exposure. Picture 70 presents *Stipagrostis libyca.*

Source: Photograph by the researcher, field study, 3/2019.

Picture 70. *Stipagrostis libyca*

3.2.58. Scientific name: *Phleum arenarium.*

Family: Poaceae.

Biological form: height between 10-20 cm, herbaceous short-branched at the base, pale green and brown, very few basal leaves or filamentous, resembling flowers at the top.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on moving and stationary dunes and sand meadows, it spreads on roadsides towards the sea in a few coarse sand accumulations with tufts of vegetation remaining on the surface waiting for the following spring. This species does not tolerate trampling or direct exposure to the sea. Picture 71 presents the *Phleum arenarium.*

Source: Photograph by the researcher, field study, 8/2018.

Picture 71. *Phleum arenarium*

3.2.59. Scientific name: *Reichardia tingitana.*

Family: Compositae.

Biological form: height between 10-20 cm, bright green herbaceous, branched from the base, weak cylindrical branches, erect and long extended leaves, bearing yellow flowers like an umbrella.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on ancient and sedentary dunes, it spreads as isolated individuals covering large areas, or mixed with species, prefers sunny locations and is not resistant to trampling and direct exposure to the sea. Picture 72 presents *Reichardia tingitana.*

Source: Photograph by the researcher, field study, 3/2019.

Picture 72. *Reichardia tingitana*

3.2.60. Scientific name: *Echinops spinosissimus.*

Family: Compositae.

Biological form: height between 20-60 cm, spiny non-succulent, cylindrical branches, broad leaves, matte white and blue flowers, appearing as an umbrella with long and hard spines.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on ancient and settled dunes and sand meadows, appears on rocky slopes as individuals mixed with other species, prefer sunny sites, does not tolerate direct exposure to the sea, and is palatable for grazing. Picture 73 presents *Echinops spinosissimus.*

Source: Photograph by the researcher, field study, 7/2019.

Picture 73. *Echinops spinosissimus*

3.2.61. Scientific name: *Teucrium polium.*

Family: Lamiaceae.

Biological form: height between 20-60 cm, non-succulent pale green, branched at the base, woody cylindrical branches and simple opposite leaves, covering branches and leaves.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on ancient and sedentary dunes and rocky beaches with little, appears as isolated or mixed individuals with other species who prefer dry, sunny sites, and resists trampling and direct exposure to the sea. Picture 74 presents *Teucrium polium.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 74. *Teucrium polium*

3.2.62. Scientific name: *Stipagrostis pungens.*

Family: Poaceae.

Biological form: non-succulent, green, slender cylindrical branches approximately equal to the base, basal leaves, oblique brown copper flowers at the top

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on stable dunes and dry sand meadows, appears as a pure or mixed pool with other species, has a role in stabilizing sand, prefers sunny places, and resists trampling and direct exposure to the sea. Picture 75 illustrates *Stipagrostis pungens.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 75. *Stipagrostis pungens*

3.2.63. Scientific name: *Citrullus colocynthis.*

Family: Cucurbitaceae.

Biological form: height between 15-25 cm, creeping stems of the plant reach more than 1 m. They are herbaceous, creeping, pale green, and have a short and pronounced stem. Wavy divided leaves from 3 to 7 lobes, single glossy yellow flowers, solid green medium-sized fruits, turning yellow-brown at maturity, with many tiny seeds.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on old and stable dunes and sand meadows, appears on roadsides and paths, dries and accumulates plant leaves and spreads its seeds in the summer season, prefers sunny sites, and does not tolerate direct exposure to the sea. Picture 76 illustrates *Citrullus colocynthis.*

Source: Photograph by the researcher, field study, 3/2019.

Picture 76. *Citrullus colocynthis*

3.2.64. Scientific name: *Limonium virgatum.*

Family: Plumbaginaceae.

Biological form: height between 20-50 cm, non-succulent branched from the base, one leaf per node, densely visible in the lower part, green cylindrical branches, small purple flowers.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on old and stable dunes, it spreads on sandy rocks and appears as individuals separated by large areas, and appears mixed with other species in moving dunes, does not prefer salt depressions, tolerates trampling and direct exposure to the sea. Picture 77 illustrates *Limonium virgatum.*

Source: Photograph by the researcher, field study, 7/2019.

Picture 77. *Limonium virgatum*

3.2.65. Scientific name: *Mesembryanthemum nodiflorum.*

Family: Aizoaceae.

Biological form: creeping type (stretching more than 2 m) covering large areas in the form of a carpet, opposite succulent leaves; short branched branches, lobed terminal white flowers, black seeds in clusters; they stick to clothing and wool.

L.D: Ann.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecology: It is widespread and invades diverse habitats, is observed in all habitats except embryonic dunes and swamps and covers large areas on piers very close to the sea. It prefers sunny places, palatable to grazing, and is resistant to trampling and direct exposure to the sea. Picture 78 presents *Mesembryanthemum nodiflorum.*

Source: Photograph by the researcher, field study, 4/2018.

Picture 78. *Mesembryanthemum nodiflorum*

3.2.66. Scientific name: *Sarcopoterium spinosum.*

Family: Rosaceae.

Biological form: height between 15 - 40 cm, shiny green spiny, short woody stem with many branches at the base of its compound leaves, with small triangular red-brown flowers. It loses leaves in the dry season and becomes prickly, turning grey.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: It spreads on ancient and stable dunes and high rocky beaches, has a role in stabilizing sand, spreads its seeds, waits for rain, appears as mixed individuals with other species, prefers sunny sites, and resists direct exposure to the sea. Picture 79 illustrates *Sarcopoterium spinosum.*

Source: Photograph by the researcher, field study,8/ 2018.

Picture 79. *Sarcopoterium spinosum*

3.2.67. Scientific name: *Cynodon dactylon.*

Family: Poaceae.

Biological form: height between 10-30 cm, non-succulent, green with hollow cylindrical stems, alternate leaves, small white-brown solitary flowers, an essential type in the construction and stability of dunes.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species in salt marshes and stable dunes, spreading on dry and rocky slopes near the sea, forming a dense mat with spatial dominance and very high coverage, turning brown and stopping growing in winter. Picture 80 illustrates *Cynodon dactylon.*

Source: Photograph by the researcher, field study,8/ 2018.

Picture 80. *Cynodon dactylon*

3.2.68. Scientific name: *Atriplex halimus.*

Family: Amaranthaceae.

Biological form: height between 0.4 - 2 m, radial spreading from the base, dense green leaves and branches, smooth erect branches, entire oval replacement leaves, green and white flowers.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical type of moving and stable dunes and salt depressions, spreading on sandstone debris near the sea, necessary in the stabilization of dunes, palatable for grazing, tolerates trampling and direct exposure to the sea. Picture 81 illustrates *Atriplex halimus.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 81. *Atriplex halimus*

3.2.69. Scientific name: *Solanum elaeagnifolium.*

Family: Solanaceae.

Biological form: height between 25-75 cm, non-succulent grey or silver, covered with brown spines, branched at the base, isolated pivot flowers have purple petals in the form of a long yellow star, spherical fruits appear between yellow and orange at maturity in winter, then turn brown. The seeds are small, oval, vigorous, invasive, and unpalatable for grazing.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specialized in stable dunes, sand meadows, roadsides and trenches, it spreads in rocky sites near the sea, appears as mixed individuals with other species, does not prefer swamps, spreads in open sunny locations, is unpalatable for grazing, multiplies due to trampling, and is not affected by direct exposure to the sea. Picture 82 illustrates *Solanum elaeagnifolium.*

Source: Photograph by the researcher, field study,3/ 2019.

Picture 82. *Solanum elaeagnifolium*

3.2.70. Scientific name: *Crithmum maritimum.*

Family: Apiaceae.

Biological form: height between 15 - 40 cm, woody green succulent branched at the base, thorny stems zigzag, thick leaves feathery, covered with a waxy coating, dense yellow flowers at the top like umbrellas, turn brown when dry, small oval blueberry fruits, seeds like barley plant.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes and rocky slopes, it spreads on rocky sites and piers near the sea in the form of separate individuals, while on sandy sites, it appears mixed with other species. It has a role in stabilizing dunes, prefers sunny locations, and resists trampling and direct exposure to the sea. Picture 83 illustrates *Crithmum maritimum.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 83. *Crithmum maritimum*

3.2.71. Scientific name: *Halimione portulacoides.*

Family: Amaranthaceae.

Biological form: height between 25-60 cm, erect succulent, grey to silvery, branched at the base, cylindrical, woody branches, opposite leaves, small inconspicuous flowers.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specializing in salt marshes and dunes exposed to the influence of tidal waves, spreading in low locations very close to the sea, appears as a carpet and prefers seasonal immersion sites. Low, semi-sunny sites are palatable for grazing, not advancing towards inland dunes. Picture 84 illustrates *Halimione portulacoides.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 84. *Halimione portulacoides*

3.2.72. Scientific name: *Suaeda mollis.*

Family: Amaranthaceae.

Biological form: height between 15 - 40 cm, green or red succulent, very branched, leaves short, very dense and thick, small green flowers inconspicuous in the axils of the leaves, have an essential role in the stabilization of dunes.

L.D: Per.

Kinds: grass.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A species specialized in sand meadows and stable dunes, it spreads on sandy rock debris and swampy edges of all kinds, prefer low and sunny sites and resists trampling and marine exposure. Picture 85 illustrates *Suaeda mollis.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 85. *Suaeda mollis*

3.2.73. Scientific name: *Retama raetam.*

Family: Leguminosae.

Biological form: height between 0.5-1.5 m, non-succulent green, with short branched stems, white flowers with a base and thin purple stripe, appear in spring as a white umbrella, green oval fruits, tiny scattered seeds.

L.D: Per.

Kind: shrub.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on stable dunes, it is widespread on sandy rocks with coarse and dry sand accumulations, prefers sunny locations, is palatable for grazing, and resists marine exposure and trampling. Picture 86 illustrates *Retama raetam*.

Source: Photograph by the researcher, field study, 7/2019.

Picture 86. *Retama raetam*

3.2.74. Scientific name: *Acacia farnesiana.*

Family: Leguminosae.

Biological form: height between 2 - 3 m, prickly shiny green tree species with a clear stem, coarse purple to grey bark, short and robust branches, small and dense leaves, yellow head flowers, appear in late winter, fruits such as pods, dark brown to black, with brown seeds in two thick oval rows

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical type on ancient dunes, observed in minimal numbers on stable dunes and sand meadows, prefers sunny sites, contributes to the stability of dunes, and is not resistant to direct exposure to the sea, a rare species threatened with cutting and grazing. Picture 87 illustrates *Acacia farnesiana.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 87. *Acacia farnesiana*

3.2.75. Scientific name: *Phoenix dactylifera.*

Family: Arecaceae.

Biological form: height between 3 - 9 m, a tree with one unbranched stem, thick and robust brown, covered with the remains of old frond bases, which appear prominent and sometimes cover dense leaf stems. At the top, a stellar crown with palm fronds more than 2.5 m long has alternate narrow, pointed leaves on both sides ending in a solid thorn, white flowers in dense clusters, and cylindrical fruits of bright yellow to brown colour.

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species that spread on old and settled dunes as individuals or mixed with other species, prefers low locations and stable dune edges, stabilises dunes and tolerates marine exposure. Picture 88 illustrates *Phoenix dactylifera.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 88. *Phoenix dactylifera*

3.2.76. Scientific name: *Tamarix arborea.*

Family: Tamaricaceae.

Biological form: height between 1.5-2.7 cm, densely branched pyramidal green at the base, inconspicuous stem, short and robust, solitary smooth flowers, fire-resistant, prefers wet sites, and its leaves have a high density of salt secretions.

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: A typical species on the front coastal dunes, appearing in direct contact with seawater, forming a natural barrier to the wind, and contributing to the stability of sand, with which leading species adapted to critical conditions spread. Picture 89 illustrates *Tamarix arborea.*

Source: Photograph by the researcher, field study, 8/2019.

Picture 89. *Tamarix arborea*

3.2.77. Scientific name: *Tamarix africana* Poir.

Family: Tamaricaceae.

Biological form: height between 1.8 - 2.8 cm, arboreal with a strong branched stem, alternating and dense green leaves, regular white flowers arranged in spikes.

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: The species is widespread on the edges of swamps, lakes, stable dunes and rocky shores. Prefers sunny, humid and low-lying locations; appears as a pure assembly; resists wind, fire, and sea exposure. Picture 90 illustrates *Tamarix africana* Poir.

Source: Photograph by the researcher, field study, 4/2018.

Picture 90. *Tamarix africana* Poir

3.2.78. Scientific name: *Juniperus oxycedrus L. subsp. macrocarpa L.*

Family: Cupressaceae.

Biological form: height between 0.5 - 2.30 m, green tree with a solid branched stem, triangular leaves around the twig, up to 2.5 cm, linear, ending in a small brown thorn, dioecious flowers, red-brown to orange fruits at maturity, bisexual type; it bears both male and female flowers.

L.D: Per.

kind: tree.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												

Ecologia: Atypical and pioneering species on stable dunes and meadows are essential for stabilizing the dunes and providing a stable substrate for other species. Prefers sunny locations, coarse sand meadows and ancient dunes, it is a rare and very threatening species in the region. He was included in the Red List and is currently considered a settler. It is endemic and geographically isolated. It advances inland through ancient dunes not exceeding 100 meters above sea level, necessitating its placement within a nature reserve. Picture 91 illustrates *Juniperus oxycedrus.*

Source: Photograph by the researcher, field study, 7/2018.

Picture 91. *Juniperus oxycedrus*

A diverse plant community of trees, shrubs, and herbs grows and develops on a solid substrate of fine soil and sand grains and a layer of rocks of varying sizes spread on its surface. Among the pebbles and stones, this habitat is the coastal boundary of the

Maquis Formation, which represents a severely degraded mixed-species arboreal community of Mediterranean forests covering large areas of El-Jabal El-Akhdar and the coastal plain.

In some locations, such as broad valleys, rocky cliffs, and elevated beaches, we find mixed plant species among several plant formations, such as the Old Forest Formation, the Maquis Formation, and the Batha Formation, with which significant types of dune environments may overlap, which have retreated inward due to human activities and loss of natural habitats. The ancient dunes are considered a transitional zone between the plant species of the Maquis and Batha formations, and typical types of dune plants may overlap with them. Table 19 demonstrates data on these plant species.

Table 19. Ancient dunes are transitional zones between plant community types

Scientific name	Family	L.D	Kinds	Flowering
Pistacia lentiscus	Anacardiaceae	Per	Shrub	3 - 4
Chlamydophora tridentata	Compositae	Ann	Grass	3 - 4
Convolvulus lupinus	Convolvulaceae	Per	Grass	4 - 5 - 6
Phlomis floccosa	Lamiaceae	Per	Shrub	3 - 4
Rosmarinus officinalis	Lamiaceae	Per	Shrub	3 - 4 - 5
Olea europaea	Oleaceae	Per	Tree	2 - 3
Pinus halepensis	Pinaceae	Per	Tree	3 - 4
Avena barbata	Poaceae	Ann	Grass	4 - 5 - 6
Artemisia campestris	Compositae	Per	Grass	6 -7 - 8 - 9
Euphorbia dendroides	Euphorbiaceae	Ann	Shrub	3 - 4
Onopordum arenarium	Compositae	Ann	Forbs	3 - 5
Launaea angustifolia	Compositae	Ann	Grass	2 - 4

Collected from sources: field study data 2018 - 2019 and (*Flora of Libya*, 2020)

Invasive species in coastal dune habitats

There are invasive, transformative, or exotic invasive species of plants. The species may be invasive in one area while being indigenous in another.

These species can change the qualitative composition and lead to a shortage of the original or main species in their natural environment, reducing plant diversity in different habitats.

Invasive species compete with native species in their natural habitat, reproduce in large numbers by seeds, roots, creeping stems, or other forms of reproduction, and invade natural or semi-natural ecosystems.

There are transformative invasive species that can transform, which consists of a subset of invasive plants that can transform biotic and abiotic conditions and the nature of ecosystems.

When a species is outside its natural habitat, reproduces and expands in a new environment, it is called an invasive alien species. The spread of invasive species (animals, plants, and insects) is the biggest threat to biodiversity.

A potential danger of invasive species is that, if successful in out-competing native flora, there will be an overall impoverishment and homogenization of vegetation communities and ecosystems, which might reduce their productivity and stability (Woodward, 2009).

The spread of invasive species alters the composition. It threatens the habitat, as is the case in the western part (Tolmeta Castle), where *Carpobrotus acinaciform* is spread over large continuous areas despite the different substrate and geomorphology of the sites, whether they are sandy, rocky, depressions or solid waste.

It is a strange naturalized species of the family Aizoaceae, it follows the genus Caryophyllales, a type of creeping plant characterized by green colour with red stripes, and its colour turns to shiny brown in the summer season when its flowers gather and converge together. Spread over rock debris, solid waste, rocky soil, sandy clay, saline soils and abandoned sites, the seeds of this species are numerous and scattered over great distances.

Animals that eat these seeds help spread this type, which covers large areas and does not leave opportunities for the growth of other species in areas of coverage that often reach 100%.

Locally called "Moses' stick", this native South American species belonging to the Solanaceae family of the genus Solanales is over 2 meters high, many branching, not woody, wind-resistant, spotted on roadsides of all kinds, deserted fields, dry swamps.

In the following presentation, we present a general description of two of these types:

- *Carpobrotus acinaciformis.*

  Family: Aizoaceae.

Native to: South Africa.

Its natural habitat is coastal dunes. It is a succulent, perennial, spreading, creeping, with opposite and thick triangular leaves and purple flowers, while Carpobrotus edulis has yellow flowers. It contains a medium-sized fruit with many tiny black seeds inside it. It quickly invades sites and competes fiercely. Other species, spread over large areas and covered by more than 80%, were observed on sand, rocks and solid waste accumulations.

- *Nicotiana glauca:*

Family: Solanaceae.

Native to: South America.

It grows in various habitats, including roadsides, ravines, and deserted areas, and can reach a height of 3 m. It has branched and flexible stems, thick rubbery leaves, and tall funnel-shaped yellow flowers blooming from August to October.

The spread of these species seriously affects biodiversity and leads to reduced plant diversity and competition with indigenous and local species.

These exotic species do not belong to the Mediterranean flora; *Carpobrotus acinaciformis* and *Nicotiana glauca* are widely distributed in coastal habitats.

Euphorbia peplis, Limonium virgatum and Phragmites australis are species classified within the Mediterranean flora and are considered paramount in dune habitats. They are characterized by their rapid spread and dominance over fully or partially degraded habitats and rarely allow other species to grow with them, particularly *Phragmites australis*. We previously described the two species within the biodiversity of dunes.

Invasive species cause a decrease in biodiversity from the lack or extinction of native flora and fauna and even insect species. Pictures show invasive species in the area (92 to 95).

Source: Photograph by the researcher, field study,8/ 2019.

Picture 92. *Carpobrotus acinaciformis*

Source: Photograph by the researcher, field study, 3/2019.

Picture 93. *Limonium virgatum*

Source: Photograph by the researcher, field study,4/ 2018.

Picture 94. *Heliotropium curassavicum*

Source: Photograph by the researcher, field study, 7/2018.

Picture 95. *Nicotiana glauca*

Resisting invasive species and limiting their spread is very difficult, and it is best to contain these species and locate them accurately. Then a comprehensive and selected eradication process is carried out by systematic methods.

Some of them must be mechanical, and others may be chemical, to eliminate the source of the spread of these species and ensure the environmental rehabilitation of dune habitats.

Figures 41 to 43 show the number of plant species per family in coastal dunes, the types of annual and semi-annual plants, and the classification of plants by shape.

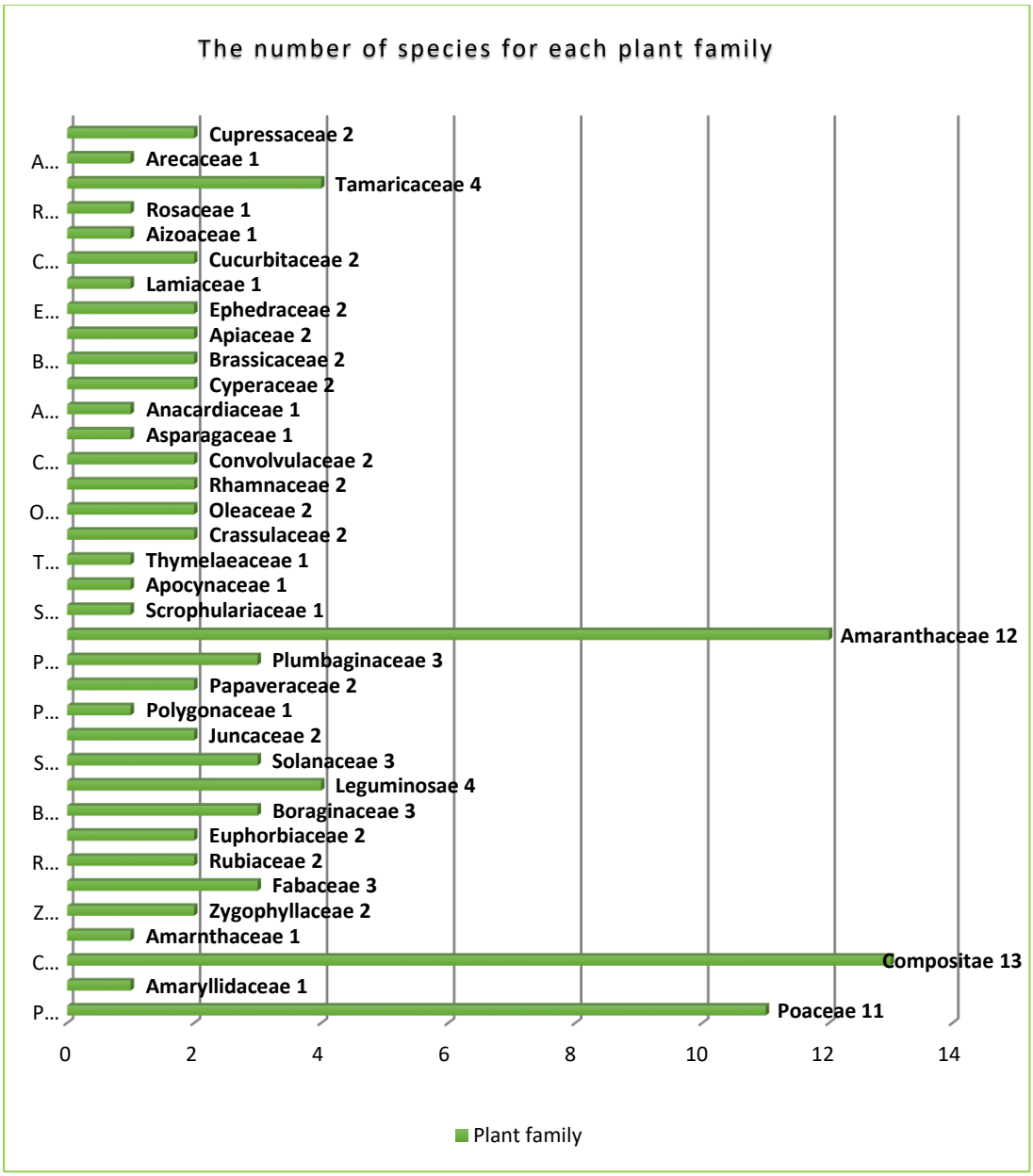


Figure 41. The number of species for each plant family

The study of Figure 41 shows a decrease in the number of species for a large group of plant families, while the plant species of the families Compositae, Amaranthaceae and Poaceae are the most numerous.

Although the family Poaceae is dominant in most coastal habitats, there has been a marked decline in species due to the negative impact of human activities, mainly sand scraping, mechanical beach cleaning, and grazing. The continuation of these activities makes restoring species and rehabilitating coastal habitats challenging, time-consuming, and costly. Classification of plant species in terms of life form in Figures 42 and 43.

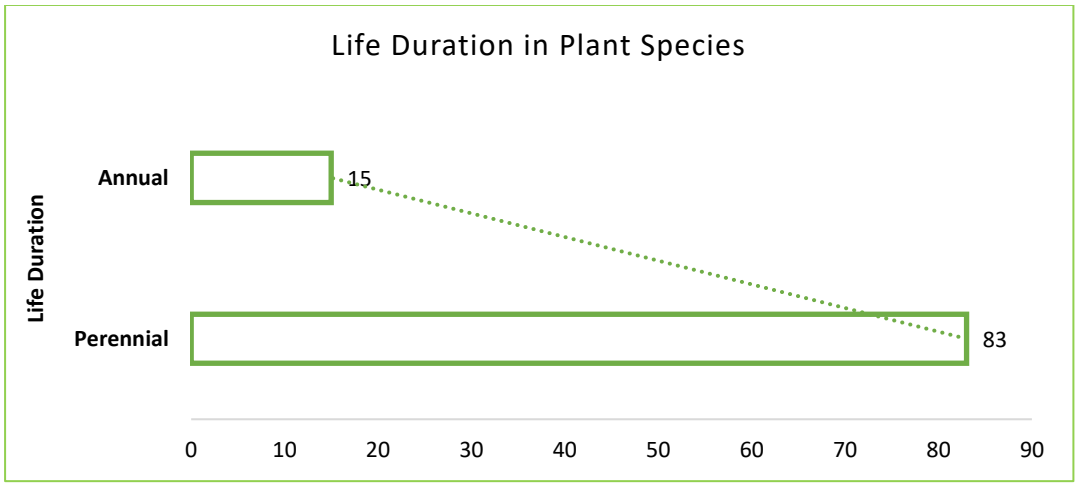


Figure 42. Life Duration in Plant Species

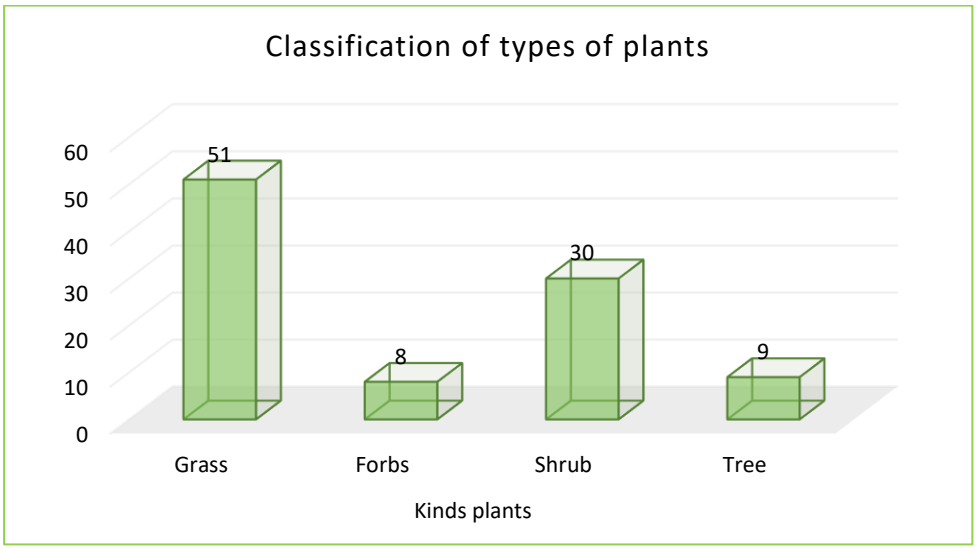


Figure 43. Classification of types of plants

It is clear from Figures 42 and 43 that annual and semi-annual plant species are significantly reduced due to the instability of the sandy substrate and its susceptibility to erosion, wind influence, severe trampling, expansion of resorts and mechanical cleaning of beaches.

Figure 43 shows the degradation of Forbes and the tree, a major coastal habitat component. Although the harsh conditions of these habitats exist, a group of plants adapts to these conditions in terms of form and function, such as the type of leaf and its appearance, plant height, plant area, growth direction, habitat, and history of human activity.

It is clear from Figures 44 to 46 that most of the flowering period in sandy habitat plants extends between March and September. In other species, it extends from October to February.

Flowering duration is influenced by geomorphology, geographic location, microclimate, habitat condition and type, plant species, and human activities.

During the field study and follow-up literature in various environments, it was found that some species, such as Order Poales in the family Poaceae, reproduce by roots and contribute to the stability of the sandy substrate. Some species are semi-annual, but they flower only under particular environmental conditions.

Some perennial herbaceous species, such as *Echium angustifolium*, are buried in the sand and stop flowering. *Euphorbia peplis, Lotus halophilus*, and *Pancratium maritime* are three other annual and semi-annual seed-propagating species, the seeds of which can lie dormant for a very long period pending favourable conditions.

Variation in flowering periods among plant species in coastal dunes needs specialized study.

Some data on the description of plant species were collected and verified after studying a group of publications; for more information and data, see: (Flora of Libya, 2022), (Home — The Plant List, 2022), (The IUCN Red List of Threatened Species, 2022), (Al-Sghair & Mahklouf, 2017), (Brullo & Furnari, 1979), (De Natale & Pollio, 2012), (Cuccuini et al., 2016), (Cuccuini et al., 2015), (Raimondo, Greuter and Domina,2016), (North African Medicinal and Aromatic Plants, 2020), (International Plant Names Index, 2020), (Saaed et al., 2019).

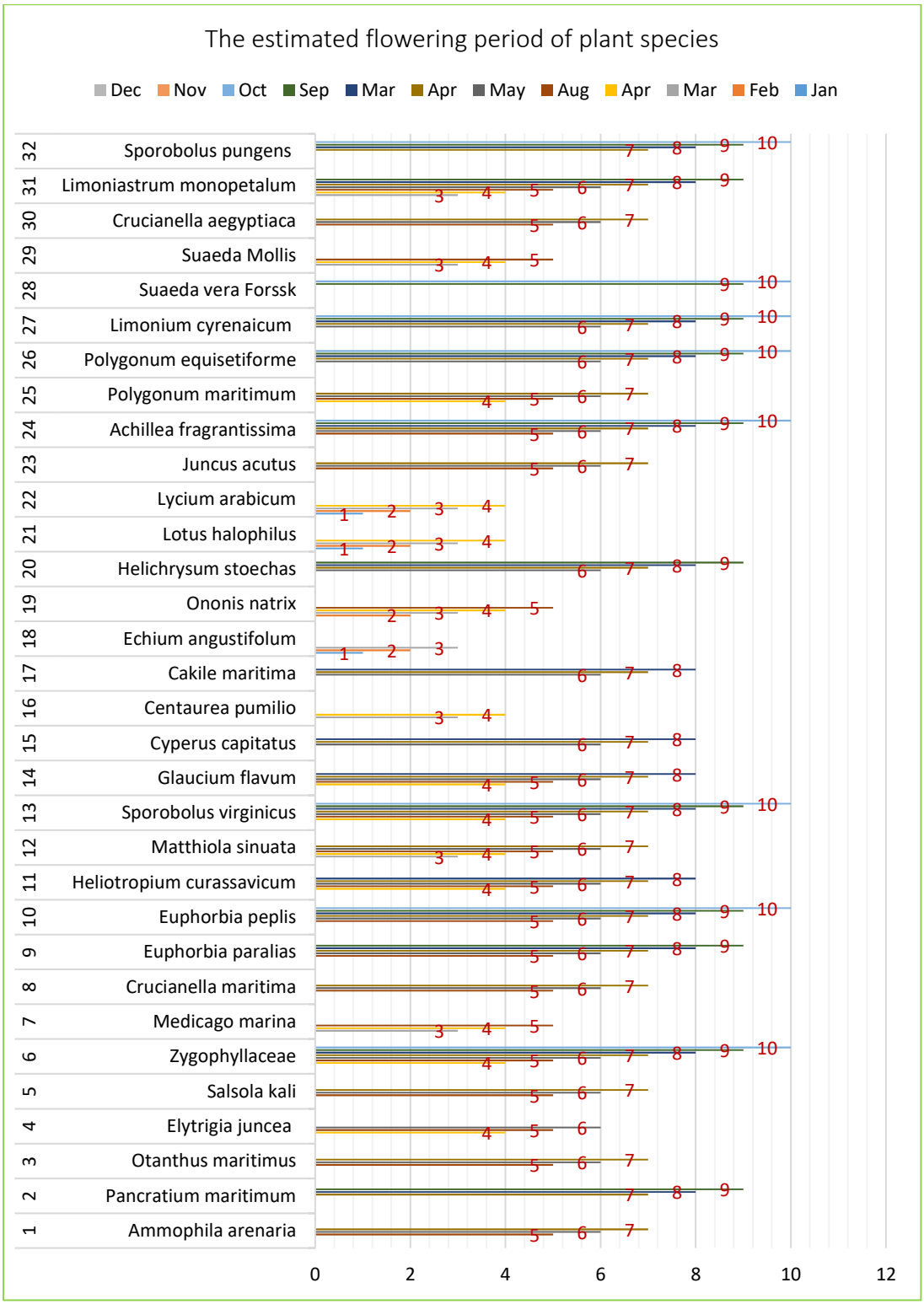


Figure 44. The estimated flowering period of plant species

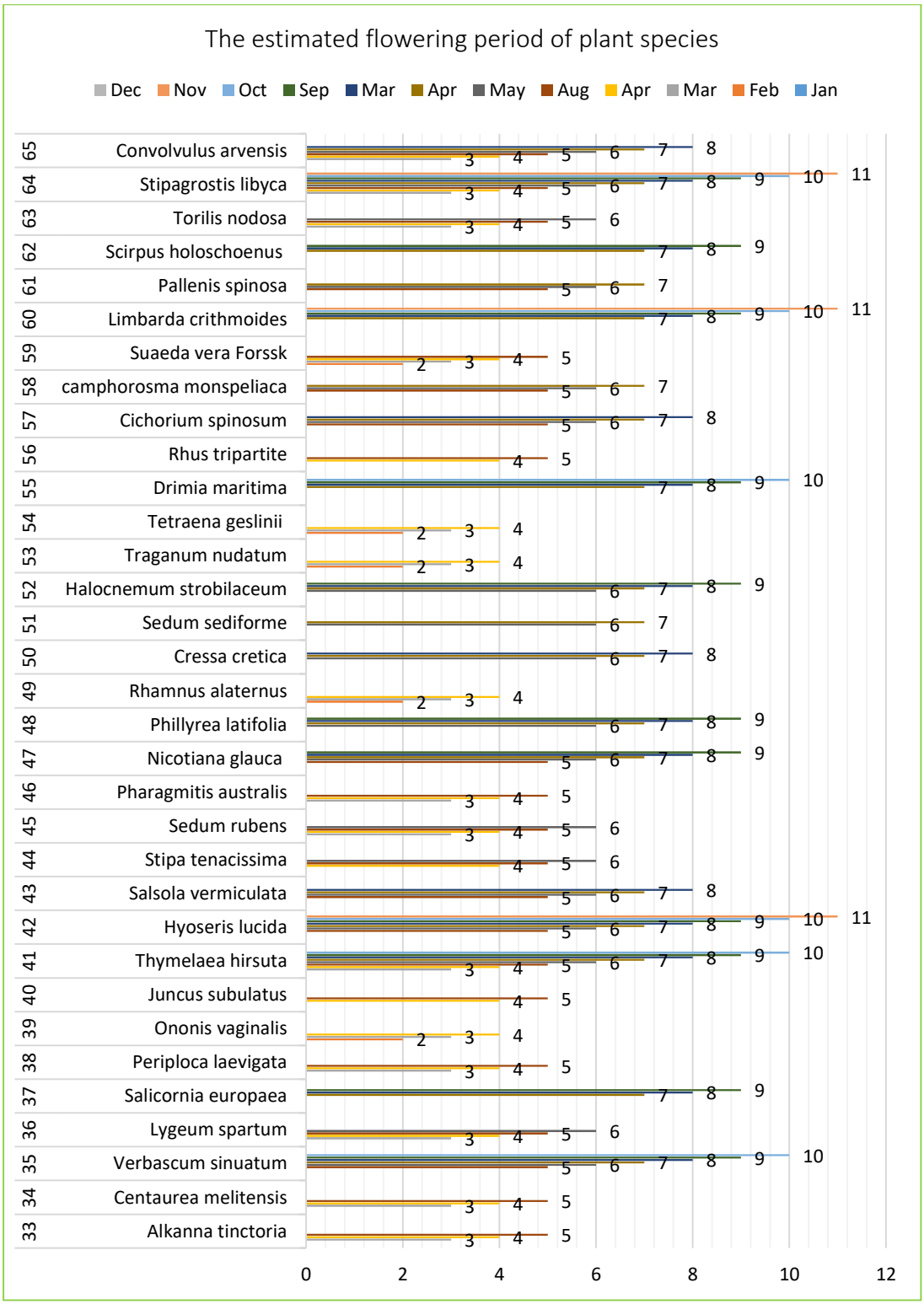


Figure 45. The estimated flowering period of plant species

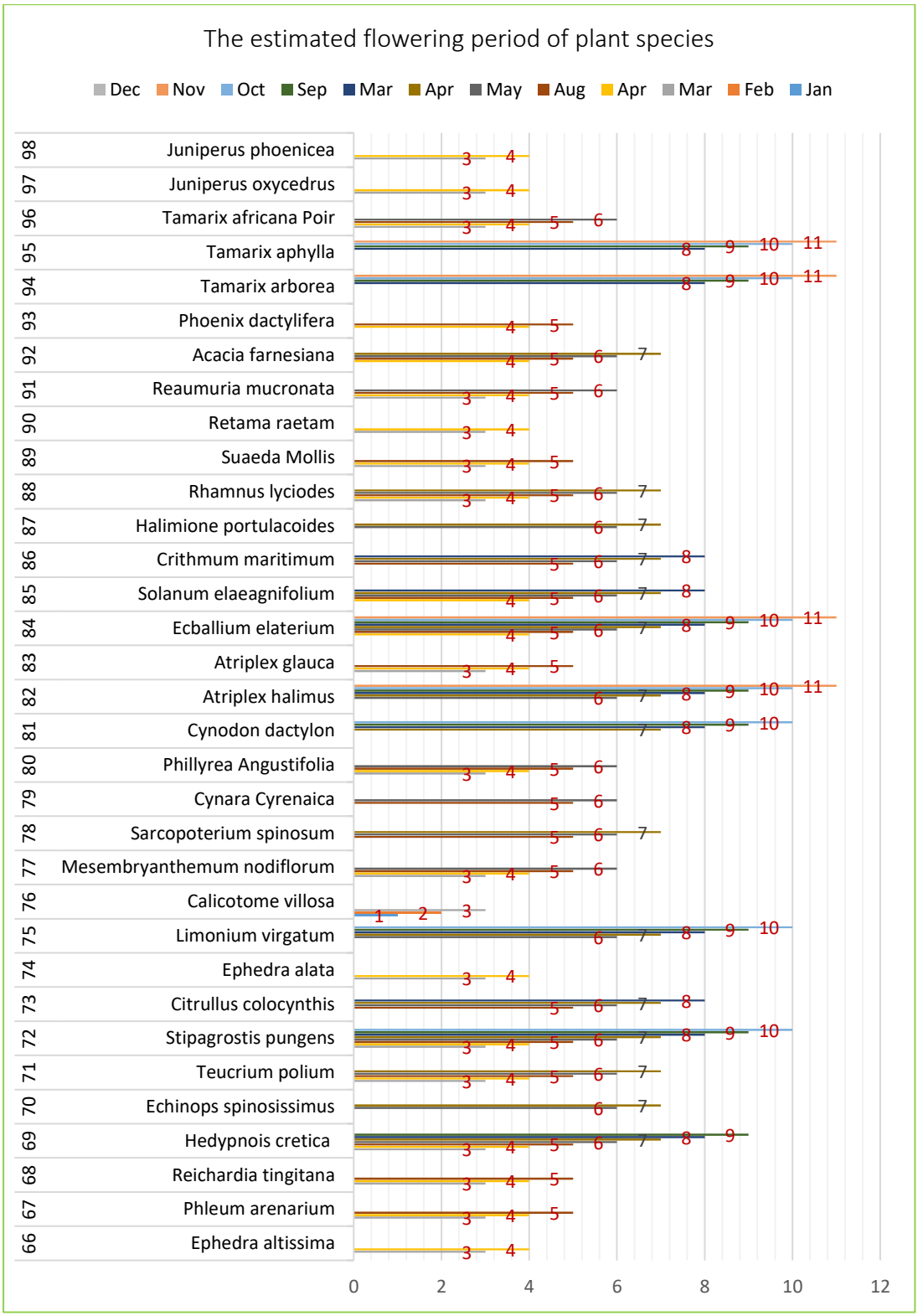


Figure 46. The estimated flowering period of plant species

Features that can provide information about habitats and plant life, such as height, growth status, roots, type of flower, and leaves, have been compiled and are the beginning of a database containing records of families, genera, and species.

As a result of field analysis and observations, it was found that the leading and specialized coastal dune plants usually have a semi-permanent, herbaceous or semi-annual growth form, with an average height of 50 cm, mostly yellow or purple flowers, thick leaves containing succulents, and are adapted to sand movement, salt accumulation, and inundation water.

4. HUMAN ACTIVITIES AND CONSERVATION PROBLEMS ON COAST DUNES ON THE RESEARCH SITE

In this section, we will present the impact of human activities on coastal dunes in terms of the nature and degree of this impact, its geographical distribution in the region and the coastal habitats most vulnerable to these activities, as well as protection and management issues in coastal dunes.

4.1. Human activities on coastal dunes

Coastal dunes are particularly fragile and sensitive environments, and many natural and human threats vary in severity and impact on these habitats. Like other environments, coastal dunes are affected by natural and human factors.

Coastal dunes are exposed to many threats due to human interventions, the most dangerous of which is mechanical cleaning and sand dredging, followed by pollution. In addition to meteorological, hydrodynamic, structural, topographic, and historical factors, it is necessary to know the influence of human activities on vegetation on coastal sands (Olsson-Seffer, 1909). Random human activities disrupt the relationships and interactions between the properties and components of ecosystems. Ecosystem classifications depend largely on vegetation but need to consider changes brought about by humans and climatic and geographical variables (Heywood & Watson, 1945).

Plant communities in the Mediterranean are vulnerable to the influence of environmental factors, especially human disturbances. Vegetative, soil and geomorphic factors are closely linked in a causal chain (Daehyun & Keun, 2008). 75% of the coastal dunes of the Mediterranean have been damaged or destroyed in the past 30 years (Cooper & Jackson, 2021).

Among the human activities of a short-term positive character are the cultivation and introduction of exotic plants, either for afforestation campaigns near dunes or protection of tourist facilities or for decorative purposes. These efforts contribute to modifying the status quo, but the extent of the impact of these inputs and alien species on the surrounding environment is often not taken into account; how is their growth trend, their ability to self-reproduce, the possibility of invading other habitats, threatening native species, threatening species.

Humans attempt to modify, rehabilitate, or maintain some plant habitats, including alien species that often become invasive at the expense of the original species. Biological processes may occur that result in other naturalized species spreading in geographical areas that did not have the natural conditions for growth and spread in this environment.

One of the most prominent examples of this is the spread of strange and random species in the barley crop farms, which were mistakenly entered with the imported seeds, the precise and organized relationships between the components of biotic and abiotic ecosystems do not accept the entry of alien species, plants, animals, insects, or microorganisms. They lead to scarcity, biological vulnerability, or extinction in the long run. We mean disturbances such as changing food chains, biological or microbiological change, weakness in species resistance, and loss or migration of diverse elements. At least one million animal and plant species are now threatened with extinction, many within decades. More than at any time in human history, the average abundance of native species in most major land habitats has declined by at least 20%, most recently since 1900 (IPBES, 2020).

Several types have also been introduced as windbreaks and for ornamental or fodder purposes, and all of them have an unobservable effect on dune habitats. Several exotic species have been monitored that invade the coastal area in the dune environment in all its ranges, including *Nicotiana glauca - Ricinus communis - Carpobrotus edulis - Carpobrotus acinaciformis - Cestrum parqui.*

Loss of biodiversity makes ecosystems less resilient and more vulnerable to stress, reducing their ability to provide services. Parts and components of habitats and ecosystems are naturally connected and form a complex network system with their ecological surroundings. The potential harm to these systems is fragmentation and separation or impeded connectivity due to agriculture, urbanization and other human uses. The situation requires response options among their objectives, the ecological connectivity of these systems, the creation of protected areas and sustainable resource management.

The threats that affect the habitats of coastal dunes are mechanical scraping (sand dredging), random urban expansion, especially tourist resorts, trampling of various

kinds, sports activities, waste of all kinds, and the introduction of exotic plants, and the inevitable result of all this is very stressful and threatened habitats.

To avoid overdoing it, we can consider trampling and introducing plant species to have a slight effect; they change the botanical structure. At the same time, stress factors can alter a particular habitat; stresses such as cutting and burning always give rise to alternative communities. On the other hand, the settlement of dunes and modification of their geomorphology results in alternative, possibly invasive, communities of low environmental value, particularly at tourist facilities or other activity sites.

Human activity is the most influential factor in changing coastal habitats; with these human pressures, there is a complex plant response consisting of different plant communities in small spaces.

Human influences on coastal dunes and their habitats have modified the natural picture, affected coastal dynamics, topographic variance, habitat fragmentation, and reduced diversity (Lithgow et al., 2013)

Furthermore, understanding the current picture in many sites is complex and intertwined. Conservation and attempting to restore these habitats are critical as they contain high ecological diversity.

The morphology of dunes is likely closely related to changes in coastal vegetation areas and fragmentation of the most widespread types of communities (Acosta et al., 2007). The change in coastal vegetation generally affects the shape of coastal dunes through increased wind speed, sand encroachment, high tide, severe erosion, etc. These factors affect the distribution of plant species, which, in turn, changes the morphology of coastal dunes.

Coastal habitats, due to their nature, are more vulnerable to exotic species that represent a biological invasion; for example, many logs, pieces of wood and various waste are scattered on the beaches of the region. These things often transmit types of seeds, insects, bacteria or microorganisms. These inputs may affect the ecosystem over time (this needs particular study).

Many variables, such as salinity rate, water level, organic matter content, and substrate type, affect plant communities' distribution and naturally change between

seasons, and plant species adapt with them. The pressure from harmful human activity leads to the rapid dismantling of the habitat, there is no opportunity for plant species to adapt to it, so we often notice a change in the distribution and composition of species. For example, the type Ammophila arenaria may appear in the area alone on the front and back beaches in the form of scattered chains, and the absence of other leading species indicates the occurrence of severe trampling and grazing. The endurance and strength of this species make it one of the types approved for the restoration and construction of coastal dunes.

There are simple and effective measures to reduce the degradation and disintegration of sandy habitats, including wooden fences, bridges, rocky paths, information boards, and various pegs to prevent cars from entering; this contributes to alleviating the impact of accidental trampling, preserving biological diversity and giving aesthetic value to the sites.

Other measures, such as dune reconstruction, landscaping, and various windbreak systems of various types and shapes, protect and conserve the coastal environment in general and coastal habitats in particular.

The pioneer plants on the shore are more susceptible to natural stresses from water shortage, salinity, sandstorms, burial, and intense insolation and have been able to adapt to them by developing morphological and physiological capabilities. The leading causes of coastal habitat degradation are human interventions, the most important of which are erosion, coastal urbanization, human trampling, movement of various mechanisms, littering, roads, and paths. It should be noted that rebuilding the shore by transferring the deposited sand to the drift zone and injecting it into the marine drift zone has good results(Shibutani et al., 2013).

The resulting pressures on beach ecosystems require research on the tolerance of beach plants to disturbances by humans, as the study showed that beaches with a lower frequency of visitors and less movement are more diverse and stable.

Figure 47 illustrates a model of superficial relationships between different activities and their impact on sandy habitats in the area.

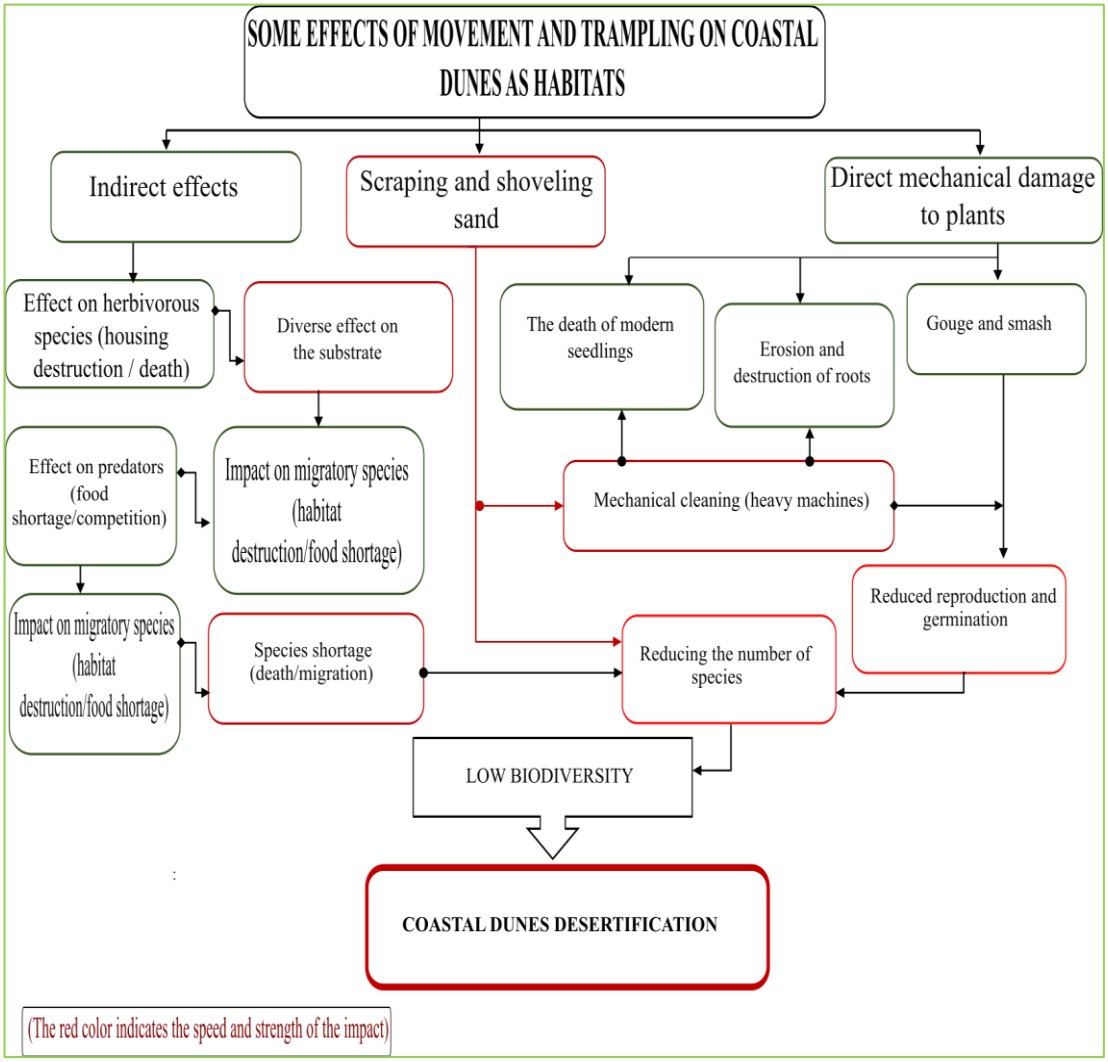


Figure 47. A model of some environmental effects of movement and trampling on coastal habitats. Data from the 2018-2019 field study and related literature research

Figure 47 shows impacts on coastal habitats, depending on coastal geomorphology, proximity to human settlements, and contact with paved roads, and there is a difference between sites in the degree of impact caused by human trampling and large-scale beach cleaning. The area between West Derna and Ras El-Hamamah is less affected by human stress than sand scraping and mechanical cleaning. The reason is the geomorphology factor, where the beaches are narrow and scattered.

The coast's geomorphology, the beach's nature, and the proximity of paved roads and urban centres all determine the type of human activity in the area. Narrow cliffs and beaches mitigate trampling; extensive swamps reduce urbanization, protect the

foreshore from erosion, and distance from urban centres reduces coastal habitat degradation.

Figures 48, 49, and 50 show human activities in the areas, sectors, and sub-elements most affecting coastal habitats.

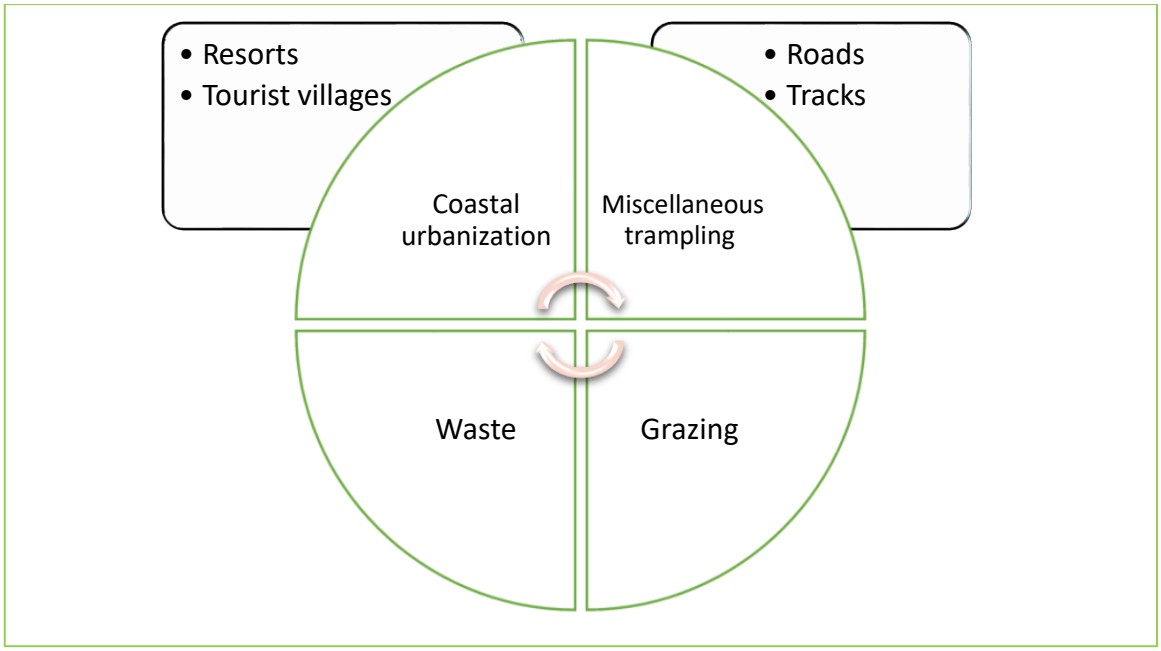


Figure 48. Human activities most threatening coastal dune habitats between West Derna and Ras El-Hamamah

In this sector, geomorphology protects the species by steep slopes and small bays, and no wide beaches increase the chances of trampling, scraping, and dredging.

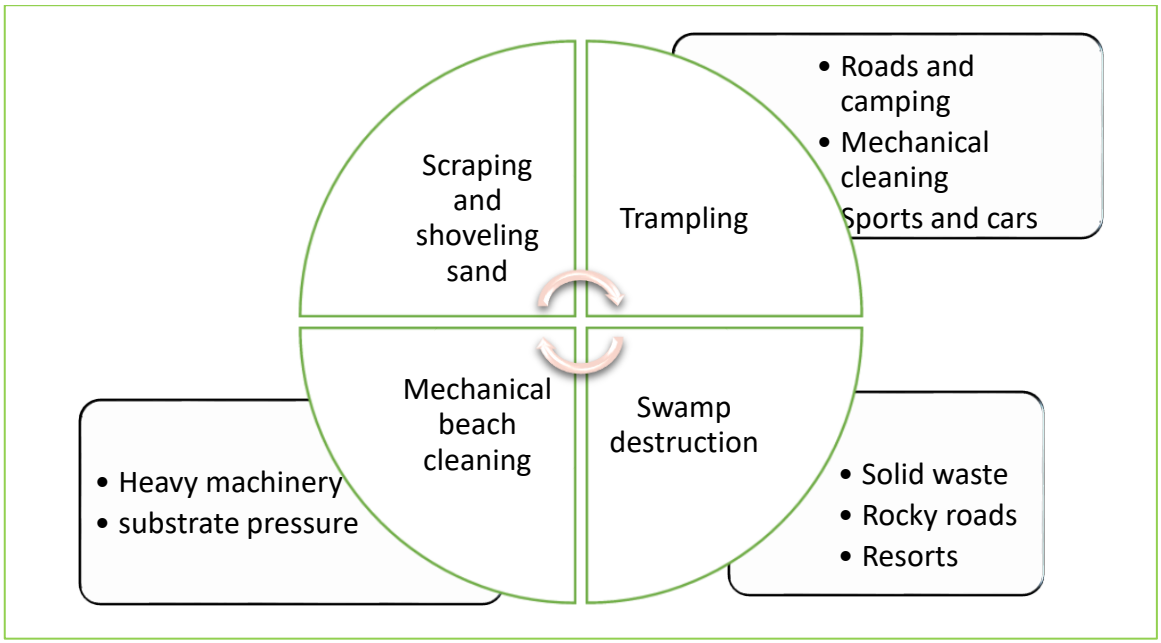


Figure 49. Human activities most threatening coastal dune habitats between El-Hamamah and Tolmeta

In this sector, the beaches are more comprehensive and profound, the cliffs lower, a network of paved roads appears along the coast, and towns, villages, and farms are scattered, increasing the effect of various trampling and abrasion of sand and waste.

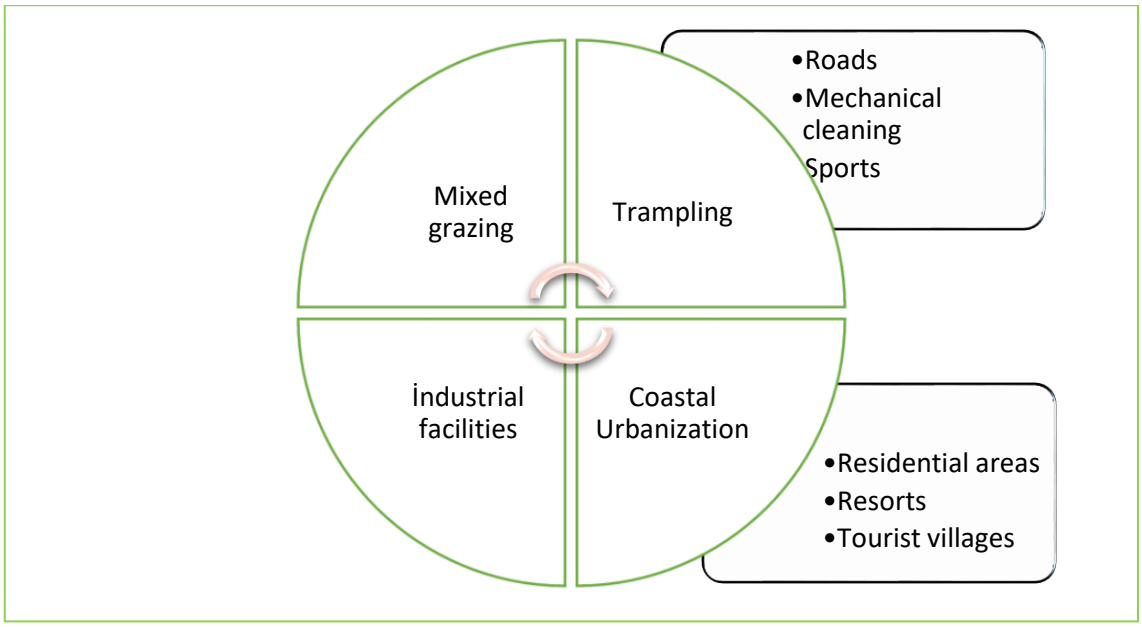


Figure 50. Human activities most threatening coastal dune habitats between Tolmeta and El-lthamh

In this sector, which includes a broad coastal plain, long and deep beaches, and various swamps, geomorphology has contributed through extensive swamps to protecting sandy habitats. The spread and expansion of small towns, villages, resorts, farms, industrial facilities, and other activities increase the disintegration of sandy habitats.

The coastal areas, which represent only 4% of the land, contain about a third of the world's population(Avcı, 2017); the geographical distribution of the population in Libya is concentrated on a narrow strip on the coast. The region comprises cities and villages distributed randomly on or near the coastal strip. Industrial waste and wastewater are scattered along the boundaries of various facilities, such as desalination plants, ports and quarries, ending in dunes and sea. Many tourist facilities appear randomly, and some are neglected after a while.

The geomorphological appearance changes as a natural result of sand scraping, swamps expanding and seawater moving inland, coming directly into contact with other plant formations degraded by diverse grazing. Environmental and legal controls determine optimal use but are always overridden by the local authority represented by the tribe. Picture 96 presents land use in the Benghazi Plain and shows the random expansion of all types of land.

Frontal dunes and semi-fixed dunes are the most susceptible to erosion in the area, and this explains the decline of the leading and ideal species necessary for the construction and repair of dunes.

These pioneer species are sensitive to damage from diverse tramplings, such as indiscriminate pedestrian access, motor vehicle use, or camping and motorsports, all of which damage habitats and species, increase substrate disintegration, and spread invasive species, affecting diversity.

The geomorphological situation is one of the contributing factors in sand harvesting (scraping) operations between Tolmeta and El-lthamh. Massive dunes develop and grow in front of extensive swamps, making extracting these quantities very difficult, dangerous, and expensive, it is difficult for heavy tankers to pass through this natural barrier even in the dry season.

Trampling in various degrees causes a preference for annual and semi-annual species that return to growth and complete their life cycle, while perennial species may not have the opportunity to do so. They must develop and repair the root, build a substrate and return to growth without short, medium and small plant species, including *Pancratium maritimum*. Pictures 96 and 97 show part of the land use between Tolmeta and El-lthamh in the Sidi Klifah area.

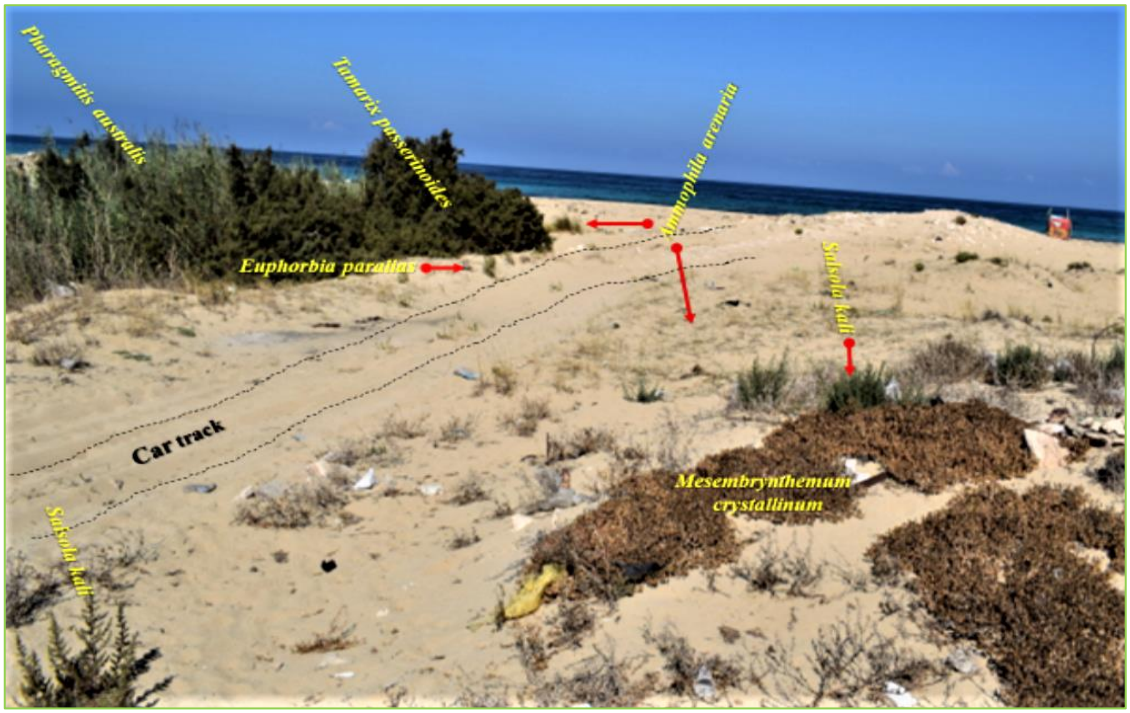
Picture 96. Land use between Tolmeta and El-lthamh - Sidi Klifah area

The combined effect of each element of the surrounding environment, whether climatic, lithological, geomorphological, or anthropogenic, modifies coastal habitats and their components, but the human impact on these sensitive habitats is faster and more severe than natural factors combined, and the speed of impact makes adaptation difficult, especially on plants.

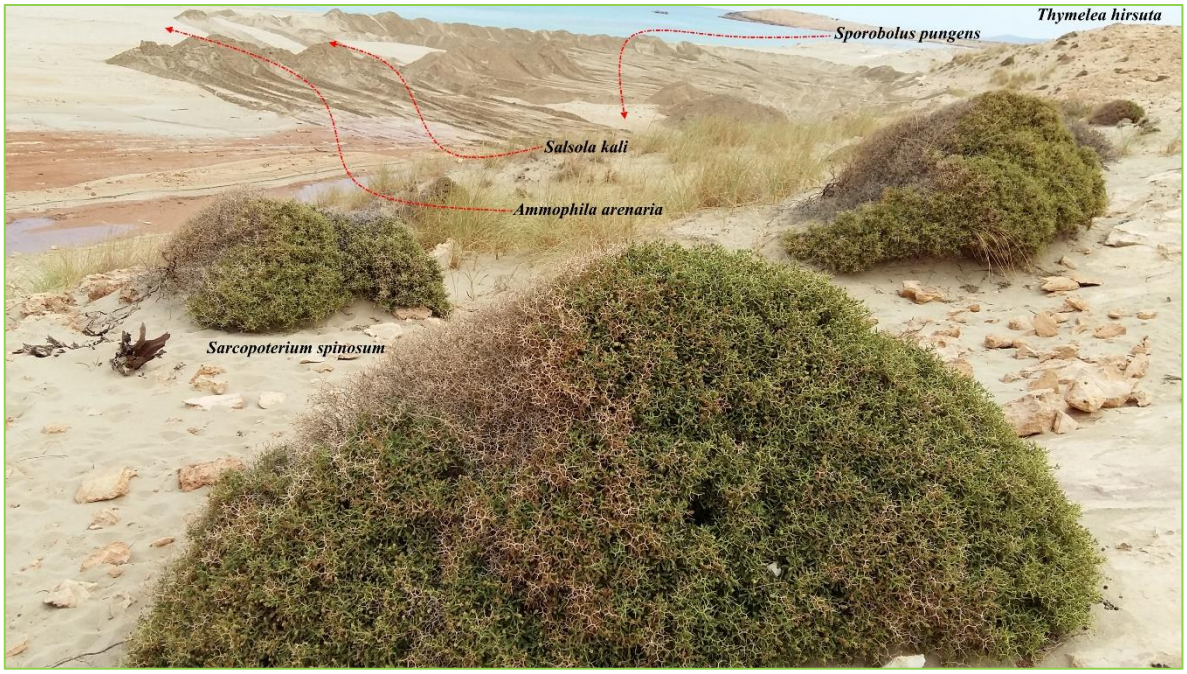
Picture 97. Coastal urbanization causes the disintegration of plant communities and the burial of swamps

There is a land use intensity in the Benghazi plain area, especially coastal urbanization, such as resorts, tourist villages, farms, industrial facilities, etc. These activities include levelling land and beaches, digging wells and demolishing fixed dunes. Moreover, bury swamps, create roads and paths, and introduce exotic plant species. These activities have affected coastal habitats of all kinds.

The continuation of the trampling process leads to an increase in the disintegration of habitats, the mixing of species from different communities, and the loss of species that are not resistant to trampling, in addition to a change in the distribution pattern of plants, as shown in Picture 98, where the species mix and distribution changes, the diversity decreases, and the spread of local and exotic invasive species. Sand scraping is the most severe threat to coastal habitats and biodiversity in the region. Picture 99 shows the deterioration caused by human activities.



Picture 98. Diversity decreased, and invasive species spread as a result of trampling



Picture 99. Sand scraping is the most severe threat to coastal habitats

In Picture 99, when tracing the geographical distribution of this particularly accelerating phenomenon since 2013, we find it is confined between El-Hamamah and the beach of Jarjr-oma for several reasons. It can be summarized as follows:

- The absence of oversight and protection after 2011.

- Rapid and unplanned urbanization has made the sand a resource in increasing demand.
- Expansion of coastal villages and cities at the expense of dune lands.

Accumulations of thin sand are confined to the narrow and small bays between West Derna, and Ras El-Hamamah, which are narrow beaches very close to paved roads from which transporting sand is a simple and inexpensive business.

The phenomenon of the spread of shower facilities, random roads, sports and recreational activities, parking lots, and multiple access corridors to beaches All of them, to different degrees, contribute to the disintegration and destruction of habitats, compaction of the substrate, and disturbance of the balance of formation and development of dunes.

The spread of resistant species, such as *Cynodon dactylon* and *Thymelaea hirsuta*, can cover large areas as an alternative community for specialized species. Invading archetypal sites, hard-tolerant species such as *Euphorbia terracina* return to growth and propagation faster than other archetypes. Bury or cut plant species in the flowering stage.

The trampling process marks the beginning of erosion at the top of the dunes, which opens the path to the winds for transport and dune fragmentation. The process of cleaning and levelling the beach due to the accumulation of solid waste and the use of heavy mechanical means is a factor that leads to a change in the geomorphological appearance, the degradation of the substrate and the complete disappearance of plant communities.

On the other hand, all kinds of waste represent a serious and dangerous threat. The disposal of waste that results directly or indirectly from human activities often reaches the dune environment or ends up in the sea and accumulates on the beaches. The sea represents their final destination, whether intentionally or unintentionally. These solid, liquid, natural, or chemical materials move with currents and waves, accumulating in another natural storage site. It should be noted here that the issue of human waste on the beaches represents a real threat to the ecosystems as a whole. This threat is not apparent and is of a degree of severity that needs detailed study. Also, fires are considered a threat, mainly affecting stabilized dunes systems and components.

Sharp stresses cause habitat disintegration, random dispersal, and species loss, leaving sand under the influence of wind erosion and providing weak points from which the wind enters and begins the erosion process.

The plant gradient appears irregular and scattered. For example, we find Pancratium on embryonic dunes where other species are absent or move to fixed dunes with species such as *Tamarix*.

The plant pictures may consist of species such as *Eryngium bourgatii* and *Ammophila littoralis*.

A mixed community appears, including *Pancratium maritimum, Lotus cytisoides, and Euphorbia paralias*. This structure falls between embryonic, mobile, and sedentary dune types. In the range of stable dunes, species such as *Sporobolus pungens* and *Ammophila littoralis* may appear with them.

Some species can adapt differently, including *Matthiola sinuata* and *Otanthus maritimus*, such as stunting, cilia, and pale colour.

Some may appear as a ground layer with tree species, as in between West Derna and Ras El-Hamamah, where the plant community consists of *Pancratium maritimum, Salsola kali, Ammophila arenaria*, and *Juniperus oxycedrus*. Because of these pressures, some species become isolated in new locations with different growing conditions, necessitating a detailed study of plant succession in this environment: pictures 100 to 104 show essential human activities and their impacts on sandy habitats and plant diversity.

Source: Photograph by the researcher, field study, 2018,2019.

Picture 100. Destruction of sandy habitats due to sand dredging.

We observe the processes of dredging, collecting, and transporting sand. The picture at the top right presents a seawater advance of about 30 metres in 6 years, at a rate of 5 metres per year.

These destructive activities are the main factors responsible for the degradation of sandy habitats and the consequent sharp decline in biodiversity.

Source: Photograph by the researcher, field study, 2018 - 2019.

Picture 101. Activities such as grazing, trampling and sewage pollution

Mixed grazing, trampling, agriculture, chemical pollution, and waste impact the coastal environment, sandy habitats, and biodiversity differently.

These activities' effects are the decline of species and the spread of mixed and non-native plant communities. The species that were palatable for grazing decreased, and other less palatable species multiplied, whether whole or part of a plant, such as *Echinops spinosissimus* and *Phleum arenarium*, destruction or damage to trampled species, such as *Pancratium maritimum*, helps spread invasive species in sandy habitats, whether native invasive species such as *Euphorbia paralias* or exotic species such as *Mesembryanthemum nodiflorum.*

The sewage swamps create new habitats for tree species such as *Tamarix tetragyna* Ehrenb, *Phragmites australis* and *Ecballium elaterium.*

Water wells bring animals in large numbers in the dry season, resulting in a lower level of fresh water and higher salinity, making some species unable to thrive with continued trampling and higher salinity.

Source: Photograph by the researcher, field study, 2018 - 2019.

Picture 102. Sand dredging and trampling are factors that destroy sandy habitats

Irrational interventions and overexploitation destroy the coastal environment, its components and habitats, in particular the disintegration of plant communities, which are the first lines of defence against diverse coastal hazards, and the restoration of destroyed habitats is very complex, as it can create new habitats and significantly affect plant diversty

In the absence of plants, the sand dries faster and moves more quickly; encroachment reaches great distances and covers coastal lands, farms, villages, and coastal plant communities in the Maquis Formation, where may find an admixture of leading species in the dunes foreground, such as *Pancratium maritimum* with coastal species from the Maquis.

Heavy trampling stresses the substrate and becomes a hard layer covered with salts or clay, making species growth or succession a complicated (if not impossible) process.

Source: Photograph by the researcher, field study, 2018.

Picture 103. The disintegration of dunes accelerates the erosion of sand layers and the degradation of plant species

Trample and erosion by wind or rainwater and torrential rain, in turn, increase the speed of sand movement and the disintegration of habitats, one of the outcomes of these processes is the emergence of sandy clay domes with some plant species having solid roots, and this is one of the most common problems encountered in the region.

Source: Photograph by the researcher, field study, 2018 - 2019.

Picture 104. Extreme sand dredging and swamp destruction are activities that affect the ecosystem in general and plant diversity in particular

The area extending west of El-Hamamah to the Jarjr-oma Valley's sandy habitats is subjected to erosion and abrasion over several years, affecting the coastal environment.

We noticed a change in the geomorphological features of some beaches, the introduction of seawater, the inundation of lands that were once covered with deep and wide sandy beaches became red beaches due to the appearance of a layer of soil and red clay, which can be seen in Picture 107. In this process, heavy machinery collects large quantities of sand from the foreshore and mowing area, then is transported and sold due to increased demand. As mentioned earlier, this is one of the most dangerous activities for the region's coastal environment; coastal dunes are a sensitive and unique ecosystem, like other ecosystems. If the cultural understanding of preserving the ecosystem and sustainability in societies are not achieved, ecosystems will fall apart and lose their functions(Coşkun et al., 2017).

In terms of the geographical distribution of this problem, we noted that the geomorphology of the coast affects the spread and distribution of this process; the beaches, behind which lie vast and permanent swamps of ancient petrified dunes; and the lands with rugged terrain, constitute natural protection. A solid obstacle to this process is in the area of Tenslokh and the swamp of Al-Koz.

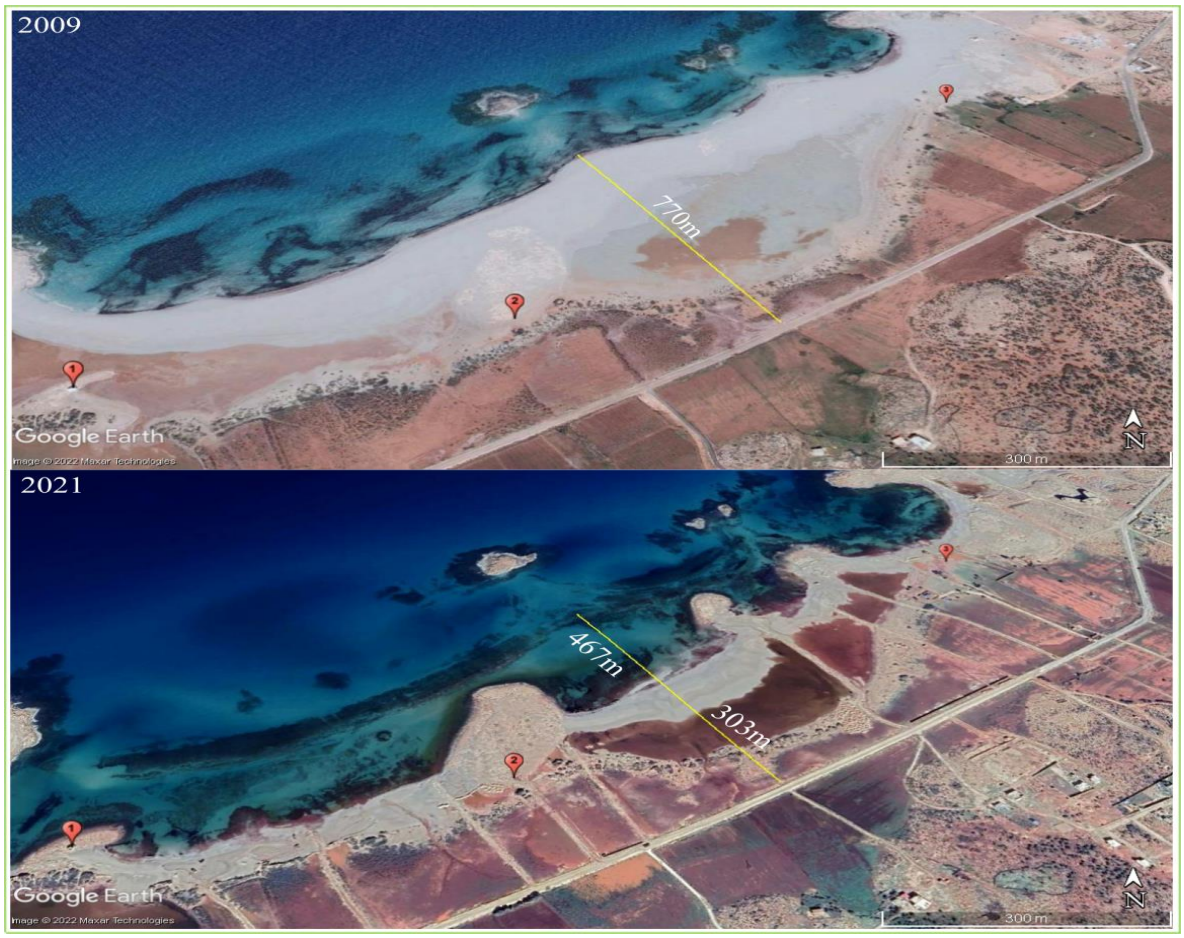
The effect of the dredging process on beach shape and coastal dune ecology illustrates in Pictures 105 to 107. The visuals represent three periods in March 2009, 2014, and 2016, a recent photo taken on the 12th of 2021, and a field visit in 2018 and 2019. It was found to show a significant change in the shoreline.

The lands were biologically and geomorphologically diverse dunes, and after intense dredging and backfilling of seasonal swamps, the sea waters overwhelmed and inundated those lands.

The red dots are located at different distances measured in 2009. The data for the dots was as follows: Point (1) 247 m, Point (2) 249, and Point (3) 294 with gradient rates ranging from 0.0 to 0.2%; Figure 51 presents the section of topography between points 1 and 3. Table 20 illustrates the data for the measurement points given in Picture 106.

Source: ArcGIS Earth and field study 2019.

Picture 105. Coastal dune erosion due to extreme sand dredging between 2009 and 2021



Source: ArcGIS Earth and field study 2019.

Picture 106. Back off and put the coast

Table 20. Illustrates the data for the measurement points given in picture 106

Point (no)	Geographical coordinates	Elevation (m)
Point 1	N: 32°48′58.696″ E: 21°28′50.015″	**4.52**
Point 2	N: 32°49′4.839″ E: 21°29′12.024″	**6.26**
Point 3	N: 32°49′24.859″ E: 21°29′37.621″	**7.65**

Source: Computed by ArcGIS Earth.

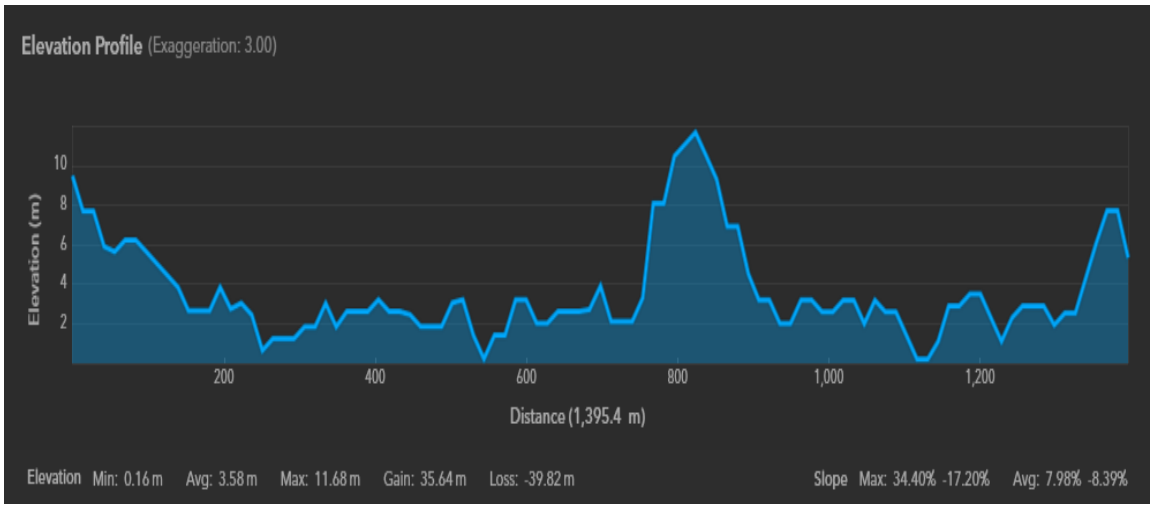


Figure 51. The topographic section between points 1 and 3.

Source: Google Earth Engine Landsat 8 2021 and field study 2019.

Picture 107. Dredging operations, as shown by Landsat 8 and documentation in the field visit to the site

The results of severe erosion of the sandy layers lead to the emergence of the subsoil, destruction of habitats, erosion of dunes, and a sharp decrease in plant diversity.

It was changing the patterns of the swamps by filling them entirely or partially and cutting them with rocky roads that facilitate the transfer of sand from the collection sites to the beaches.

The coastal zone often produces a complex vegetation profile and is challenging to interpret because human interventions put habitats under intense and rapid pressures, affecting the ecosystem with all its components.

It is clear from picture 108 that the coastal urbanization and resorts and the products of this process from various wastes lead to the spread of invasive species and the decline of plant diversity.

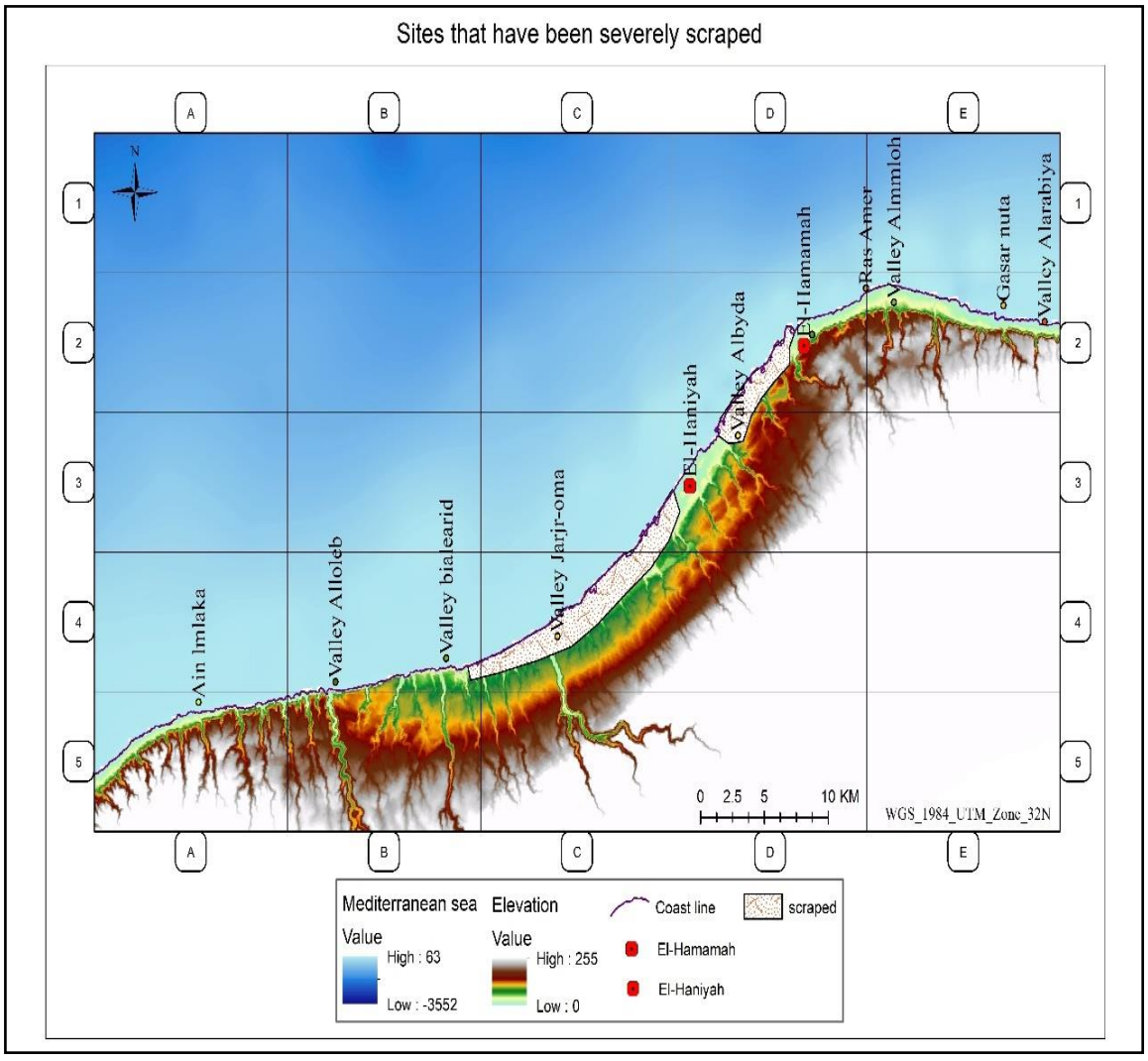
Source: Photograph by the researcher, field study, 2019.

Picture 108. Resorts and waste of all kinds are activities that affect plant diversity and increase the chances of the growth of invasive species.

Random urbanization and the accompanying mechanical cleaning of beaches, destruction of diverse habitats, and accumulation of solid and liquid waste results in habitat degradation or desertification, where leading or prominent plant species are found in sandy habitats, and native and exotic invasive species are common.

Magus and Batha formations may become the most threatening activity for coastal habitats, in general, is sand scraping; illegal extraction of sand poses a grave threat to dunes, as it destroys dune meadows (Yılmaz & Serbest, 2005).

Map 19 illustrates the most vandalized sites between El-Hamamah and Tolmeta. These activities were monitored by visiting the affected sites and creating archives of photos and videos of the sites. The primarily destroyed area also appears in the satellite images, as we will show later.



Map 19. It illustrates most sites that have been exposed to sand erosion and swamp degradation

Over more than 7 years, severe and continuous erosion of sand from various sandy habitats has been observed at these sites. Several circumstances helped in this, the most important of which was the absence of supervision and protection after 2011,

the proximity of paved and dirt roads, and the spread of the phenomenon of random construction.

Accordingly, the severe degradation of sandy habitats and the threat to biodiversity on beaches and dunes result from these ill-advised interventions, as significant and major plant species have diminished. Some marine organisms, such as turtles breeding in these sites, migrated along the shoreline and progressed inland, threatening the roads, cities and villages adjacent to the beaches, industrial facilities and farms. The lands of seasonal swamps were also destroyed, and stone roads were built through them to reach the sand, which negatively affected this ecosystem and its components.

4.2. Conservation Issues on Coastal Dunes

Coastal habitats occupy a small world area but are very dynamic and sensitive. Coastal dunes perform many functions. They act as barriers to storms, waves, sand encroachment, and erosion of remote areas, providing a unique habitat for many organisms. Coastal dunes are an essential resource and a forward line of defence.

This resource is of medical, economic, and social importance and must be protected from degradation to preserve its original diversity and ecological functions.

Some ecological functions of coastal dunes (CSD) include protecting the coastal lands from the advance of the sea and the encroachment of sand; sediment storage; rainwater purification; aquatic habitat provision; and habitat for plants and many microorganisms, including birds, animals, and sea turtles. It has become a habitat that includes rare and threatened species and is of scientific interest.

Coastal dunes are found on the edge of the sea. They are made up of sand, soil, and plants. Coastal dunes are essential because they help to protect coastlines from erosion and waves.

A lot of conservation work needs to be done on coastal dunes. Coastal dunes have been disappearing at an alarming rate due to human activities such as development, agriculture, mining and other activities.

Coastal dunes are a diverse and complex ecosystem that is a critical part of the coast. They provide essential habitats for many species, protect against erosion, and offer recreational opportunities. In recent years, coastal dunes have been threatened by human activities such as development, recreation, and overgrazing. Coastal dune plants also face threats from invasive species that outcompete them for space and nutrients.

Coastal habitats are essential to the health of the ocean. They provide shelter for many species and help filter out pollutants from the water.

The construction process can cause erosion, which destroys these natural barriers and leaves coastlines unprotected from storms. Other human activities that destroy coastal dunes include recreational activities such as beach volleyball, surfing, fishing, and camping in these areas, as well as farming near the coasts.

Coastal dunes are an essential habitat for many endangered species and are naturally protected by plants that provide a natural barrier against coastal storms.

Coastal dunes are one of the most threatened habitats in the world. This is because human activities destroy coastal dunes, and coastal dune plants cannot survive these activities.

One of the most common human activities that destroy coastal dunes is sand mining. Sand mining is a very profitable activity that has happened for hundreds of years. This activity happens when people mine sand from a river or beach with heavy equipment such as dredges or suction pipes.

These machines are then used to take the sand to a different location where it can be sold as a construction material, such as concrete, or for other purposes, such as water filtration. This process leaves behind an area with no vegetation, leading to erosion.

This is because human activities destroy coastal dunes, and coastal dune plants cannot survive these activities.

One of the most common human activities that destroy coastal dunes is sand mining. Sand mining is a very profitable activity that has happened for hundreds of years. This activity happens when people mine sand from a river or beach with heavy equipment such as dredges or suction pipes. These machines are then used to take the sand to a different location where it can be sold as a construction material, such as

concrete, or for other purposes, such as water filtration. This process leaves behind an area with no vegetation, leading to erosion.

Coastal dunes are an essential part of the ecosystem that protects the coastline from erosion and provides habitats for many coastal plants and animals. Coastal dune plants have adapted to survive in harsh conditions such as dryness, salty air, strong winds, high-temperature fluctuations, and periods of drought.

These dunes and their vegetation play an important role in beach dynamics, particularly in the natural cycles of dune erosion and restoration that occur on sandy beaches(Dahm, Nomos, and Jenks, 2005).

Dunes are essential to reduce the risk of coastal erosion and flooding, act as a natural barrier that can absorb the effect of erosion, and have the ability to self-repair and remodel.

Due to its unique nature, vegetation cover is a good indicator of overall biodiversity, and the concept of coastal zone management is generally accepted nowadays.

What are the ways to preserve this resource? How should these habitats be managed so that their geomorphological and ecological systems are maintained?

The collective and individual scientific efforts in biodiversity conservation lack good coordination and planning. It is not classified geographically and botanically in the country and its surroundings and appears as a group of sites, points and areas that are often overlapping and sometimes brief. Maximizing the biodiversity of coastal dunes is a fundamental goal of successful protection and management. Globally, the conservation of plant diversity is a powerful driver of coastal dune management.

This mosaic of diverse habitats is not static. The structure and composition of the vegetation may change due to natural dynamism, but the overall biodiversity should not decrease.

For example, in coastal dunes, storms, strong waves, and winds change the movement and budget of sediments of all kinds, the dispersal of seeds, and the geographical distribution of some coastal dunes.

There are ways to reduce habitat degradation in coastal dunes, including dune farming, reintroduction, burning and mowing, tracking invasive species, and controlling human activity.

Dune habitats, like other habitats, have environmental, economic, and aesthetic value. This calls for their preservation like other habitats, and the consequences for the ecosystem are often devastating and irreversible.

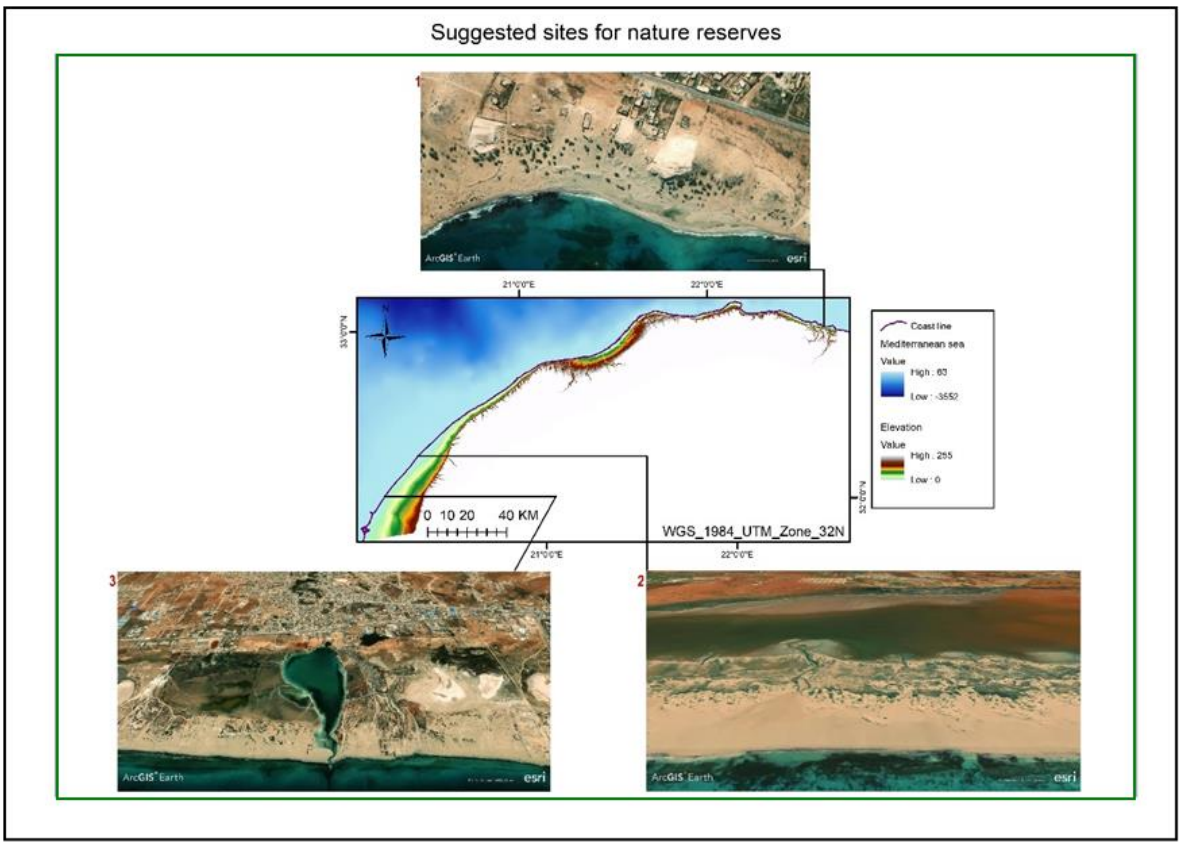
The most severe threat to dune habitats is the extensive removal of the sandy substrate. This phenomenon is particularly prevalent in low-lying beach areas with a thick sandy substrate, and it starts from a distance of not less than 10 m into the seawater. Dredging and scraping operations continue in the area of fixed dunes or obstacles such as swamps.

Although many coastal plant species are adapted to the harsh, poor dune environment, the survival of the species cannot tolerate human threats and is rapidly affected, changed, or lost. The vegetative restoration strategies of coastal dunes still lack a systematic scientific vision.

Plants have great potential to reduce dune erosion under wave and impulse attacks. Once we better understand the role of vegetation in coastal dune resilience, we may be able to improve the protective capabilities of restored dunes(Sigren et al., 2014).

In addition, poor management makes these habitats vulnerable to invasion and a significant decline of native species.

Coastal dune habitats have characteristics that make them a critical plant habitat in the region; the most important sites that carry a distinct ecological diversity and a natural gradation of plants in sandy habitats, as well as a range of endemic plant species, are documented, as shown in map 20.



Map 20. Presents sites recommended as nature reserves due to their ecological diversity

The map presents locations with the best sandy habitats, high plant diversity, several species, and a gradation of natural vegetation from the strandline to old moving, fixed, and old dunes.

These sites contain scarce species that are in danger of extinction. Some species are trees of Mediterranean forest composition, such as *Juniperus oxycedrus L. subsp. macrocarpa L.*, *Acacia farnesiana (L)* Willd, *and Phillyrea latifolia L.*

These sites include typical and pioneering dune species such as *Ammophila arenaria (L)* Lin, *Limonium cyrenaicum* (Rouy) Brullo, *Pancratium maritimum*, *Otanthus maritimus (L)* Hoffmgg. Et Link, *Salsola kali*, and other species.

The sites between Tolmeta and El-lthamh include the most extensive and essential swamps (permanent and seasonal), Swamp Alkuz and Ain Ziyana Lake, a brackish lake in direct contact with the sea.

With a significant impact on natural biodiversity, ecosystem monitoring is not just an ordinary observation but a complex process of searching, tracking, data,

information, and interlocking chains that need to be organized, linked, analyzed, and based on geographical location.

From a botanical point of view, the time factor gives accurate results about the different and interrelated behaviours between the elements and components of the environment. It is impossible to build a correct conception of the behaviour of ecosystems with mere field observations and randomized rapid experiments.

Instead, it should consider previous experiences and follow-ups, such as the history of photography, such as photographs and satellite visuals, as well as ancient studies representing the present at the time and trying to anticipate their future; Who is present today?

In short, long-term research is a mainstay in planning and managing ecosystems, providing a scientific reference base, illustrating trends, changes, developments, and options, and adequately assessing the state and behaviour of various elements and components of various systems.

Dunes are sensitive and fragile ecosystems, and the implementation of monitoring and control plans is of great importance for the implementation of conservation and monitoring of biodiversity variables and to achieve the goal of deepening and clarifying knowledge of species, genera, and natural habitats. Moreover, discover the various threat factors.

Looking at the environmental policy in the country, we find that it states that land management is an integrated system and that protecting habitats and their types is an essential part of this system! However, it is just text. Coastal dune destruction is a global problem that can be solved by protecting these habitats.

The geographical location of the coastal dunes makes this settlement a point of varied and rapid changes caused by natural and human pressures, which range from several days to a few years. If these activities continue at their current pace and sandy habitats are not rehabilitated, a new term will result: the desertification of coastal dunes.

Finally, biodiversity is not just an inventory of species; inventory does not provide a fair idea of diversity. Do we know how many individuals are within each family, and are the species rare, threatened, or expected? What factors influence these numbers?

5. RESULTS - DISCUSSION AND RECOMMENDATIONS

5.1. Results And Discussion

The area selected as a research area is characterized by habitat diversity and the resulting plant diversity and is one of the most critical coastal dune areas in northern Libya. Plant diversity in sandy habitats was discussed in this study, some climatic and geomorphological characteristics of the coast were analyzed, and coastal dunes were explained as plant habitats.

In this critical environment, the distribution of vegetation cover between different habitats depends on the surrounding conditions and the ability of the species to adapt to them.

However, salinity, burial, immersion, unstable substrate, and nutrient poverty have made plants develop their morphological and physiological abilities, such as the type of roots, leaves, and cilia that cover plant length, the flexibility of movement, stem, and plant colour.

Plant specimens were collected and classified into families through four field studies in the area and several exploratory visits. Endemic, threatened, invasive and alien species have been in the area.

In such dune areas, productivity is related to moisture, while humidity is related to the coastal sand's fine-grained and organic matter content. The complex interactions between abiotic and biotic factors cause a complex ecological gradient from the sea to the interior.

There are generally three areas of vegetation that form on coastal dunes, varying in the rate of salinity, salt spray, storms, flooding, and burial; in the first zone (the front dunes), there are weeds and other herbaceous plants that can withstand exposure to high salt spray.

In the second zone (the back dunes), the communities and species of trees, shrubs, and grasses mix; in the third zone, we find species adapted to lower salinity rates, characterized by trees and shrubs of the forest and Maquis composition. Because of

human activities that break up the habitats, we rarely find a good gradation of these communities in the study area.

With increased organic matter and capacity to hold water, vegetation appears in the foreshore area, diversifying and transforming from grassy to shrub and tree (Yılmaz, 2021).

The sandy coasts' reduction, fragmentation, and levelling-off significantly decreased the species richness of coastal plants.

The study reached a set of results related to plant species, namely

- ***Euphorbia spreads*** around a large shrub that can be considered the source, expands with seeds, proliferates and invades open sites, competing with other species.
- ***Sporobolus pungens*** is one of the most important plant species that maintains sandy substrate stability and is highly threatened in the region.
- ***Drimia maritima*** indicates the degradation of the Mediterranean Maquis formation due to fires and cutting, covers large areas, and may appear as a pure community among the different plant communities.
- ***Limbarda crithmoides*** is a species that appears as a homogeneous community, giving high density in sites where sandy rock debris is mixed with little clay.
- ***Sarcopoterium spinosum*** is a species that has an essential role in sand stabilization, resists direct exposure to the sea, covers large areas, and stays away from shaded areas and under trees. Its seeds spread and grow densely after rain or torrential rain.
- ***Ecballium elaterium*** is a species that grows densely in disturbed sites and on the edges of sandy and dirt roads. It invades sites quickly and indicates human activity, such as road construction and sand transportation. It does not appear in salt depressions or sites that are exposed to inundation.
- ***Heliotropium curassavicum***, a species native to America, appears as an aggressive weed that quickly colonizes new areas, especially disturbed areas.
- ***Solanum elaeagnifolium Cav*** is a deep-rooted, summer-growing perennial plant native to the Americas but now widely naturalized beyond its native range. It spreads and reproduces due to trampling, especially by animals, which is toxic to cattle.

- ***Polygonum maritimum*** grows above the tidal line and in the lowlands and is a strong line of defence in sandy habitats, especially swamps, and this species can be used to create barriers, stabilize dunes, and restore habitats.
- ***Ononis vaginalis* Vahl** is a species whose long roots enable it to grow on rocky beaches with little sand and on the edges of swamps. It returns to growth after the stages of degradation of sandy habitats.
- ***Thymelaea hirsuta*** This species occupies degraded sandy habitats; it is widespread due to the severe erosion of sand.

Some *Tamarix* species are pioneer plants, first line on some wide beaches, resistant to direct exposure to the sea. In their surroundings, they form an attraction for herbaceous species such as *Pancratium maritimum* and *Salsola kali*.

After the sandy habitat is exposed to various pressures, annual species can return to growth and complete their life cycle, while perennial species may not be able to do so. They must develop and repair the root system, build a substrate and return to growth.

Absence of short, medium, and small plant species, including *Pancratium maritimum*. Spread of resistant species such as *Cynodon dactylon* and covering large areas as an alternative community to the main species.

Invading hard-tolerant trampling species such as *Euphorbia terracina* to pioneer and model species positions, they are re-growth and propagate faster than other archetypal species. The process of burying or cutting plant species in the flowering stage leads to the species' decline.

The visible part of dune plants is represented by the stems, short branches, and leaves, often covered with short white hair-like cilia, protecting the plant from the surrounding wax layer. Not complete insulation, providing adequate ventilation and reducing plant perspiration, such as *Medicago marina - Centaurea pumilio*.

In the semi-stabilized dunes, some leading species rise to about 120 cm and appear as stripes and denser. Semi-erect stems, and branches from the base characterize them. The leaves are short-necked, close to the branch, broad and jagged, and covered with short cilia on both sides.

Most of these species are distinguished by a spreading rootstock. Trampling is a significant problem, causing destruction and loss of sandy habitats due to rapid wind erosion.

Salicornia europaea species-S. mollis and *S. vera* are among the species with spatial dominance on periodically flooded sands.

As well as some perennial species scattered over large areas, such as *Juncus acutus, Sporobolus virginicus, Sporobolus pungens, and Halocnemum strobilaceum Phragmites* are standard on the edges of salt lakes and permanent and temporary swamps.

Low species diversity and difference in plant composition; sandy habitats in the western part show their richness and uniqueness compared to the central and eastern parts.

As a result of the rapid erosion of dunes caused by irrational human interventions, there is a structural and qualitative change in the number of species and families in the intermediate part.

Dune plants include many rare and threatened species compared to the more significant part of the land covered by other plant communities in El-Jabal El-Akhdar and the Benghazi Plain. Among these species are: *Elytrigia juncea, Centaurea pumilio - Echium angustifolum - Sedum sediforme - Phleum arenarium - Lemon bellidifolium.*

The coastal strip as an ecosystem is one of the most vulnerable and is still vulnerable to human influences.

In the vicinity of urban systems such as villages and cities, plant communities in sandy habitats are severely degraded, and there is a constant and diverse threat.

Dune plant mosaics are highly specialized and diverse plant communities coexisting in a relatively narrow area, regularly tracing each other to more stable inland regions, and thus are diverse and complex communities in structure and distribution, i.e., each with morphology and a limited range or subsector.

One of the most important species that has the lead in emergence and presence on the dunes after the Strandline region is *Cakile maritima,* which is similar to the annual type, and in winter, its seeds remain to wait for the spring season, as they begin to germinate early in the season.

The roots' length helps the species reach a little fresh water in depth, whose level varies with the seasons, and the species also has a comprehensive, intertwined root system that helps maintain a large amount of sand and some moisture.

In the outer range of a strandline, the sand is less humid, and transporting it by wind is more manageable, contributing to the formation of small accumulations of sand, which are embryonic dunes. These formations of embryonic dunes appear as bands or chains parallel to the coast.

Habitat diversity is not a prerequisite for the coexistence of endemic species under stable ecological conditions. This finding does not call into question the positive effects of spatial heterogeneity on endemism; spatial heterogeneity may be fundamentally significant for species survival.

Narrow strips of habitat extend along the coasts and are ancient habitats, some of which are endemic to dunes with their ecological gradations and others that appear on rocky shores and cliffs.

Species with morphological and physiological adaptations include Cakile maritima -Ephorbia paralias - Ephorbia peplis - Eryngium bourgatii - Medicago marina - Ammophila littoralis - Juncus maritimus - Artemisia campestris - Pancratium maritimum.

On the shore above the maximum tide line, where the seawater arrives intermittently, the first pictures of plants appear, which consist of widespread types, including *Cakile maritima*, an annual plant whose seeds remain in coverage of *Salsola kali* and *Euphorbia peplis* is as low as 7%.

In the posterior region of this range, a more stable accretion is continuing to develop. These are stabilized dunes characterized by *Ammophila arenaria*, a distinctive and specialized herbaceous species.

As it forms a conglomerate dense and compact, with a vast root network, long and strong branches with good coverage, and by nature resistant to light trampling and grazing, this species is essential in the process of dune development, meaning it can trap sand grains in all of its motion, whether it is hanging in the air, jumping, or crawling.

The roots of this species appear as a result of sand scraping due to human intervention, although these root masses are waiting for the right conditions. It grows back and continues the process of evolution.

Some higher species appear submerged by more than half of the sand. Initially, we can note the main types in this range: *Cyperus capitatus, Pancratium maritimum*, and *Medicago marina.*

These and other species create diverse plant communities, most of which are perennial, achieving 50–70% coverage, and the primary dunes are on display here.

This range follows a fixed (old) dune. At this advanced stage, the conditions are partially stable.

The finer grains of sand are mixed with the atoms and grains of clay and silt, so the growth chances are better as the moisture content of the substrate increases. The high coverage of plant species contributes to this.

Various plant groups are spread in this range, the most important of which are: *Crucianella marittima*, *Euphorbia paralias*, and *Otanthus maritimus*. These communities form more stable plant formations than those closer to the sea.

The change in the structure and composition of the dune community is due to events of human origin, a tiny part of which is marine.

In sandy habitats, plant species may overlap and form a structurally and physiologically heterogeneous plant community.

This is due primarily to random human intervention, the emergence of a community consisting of a herbaceous layer with a woody or arboreal species such as *Pancratium maritimum*, *Atriplex, and Tamarix*. Declining diversity and changing composition can be considered indicators of the degradation of dune habitats.

The spread of some random plant species also indicates the decline of a specific community of *Ammophiletum australis* and its replacement by such species as *Suaeda vera* Forssk, *Limbarda crithmoides*, and *Atriplex prostrata*. While the emergence of plant species as a chain indicates a more advanced evolutionary stage and communication among these species, the *Medicago marina*'s *Ammophila arenaria* firmly pushes the dunes' building and development process.

In the range of stable dunes, when sandy habitats were exposed to human intervention, we find the Crucianelletum maritime species at the top of sand accumulations in the form of a plant chain, accompanied by several types, including *Silene canescens, Vulpia fasciculata, Cutandia divaricate*.

As for the mature dunes, far from the influence of the sea, the most important species are concentrated, the most important of which are *Scrophularia ramosissima*, *Ephedra alata* Decne, *Crucianella maritima,* and *Ephedra distachya*.

This habitat is characterized by diversity and abundance with less human influence, and the presence of some species indicates moving to the next habitat, which is the old dunes where the substrate is stable and mature.

A mature plant community is formed, dominated by species such as *Crucianella maritima, Sedum sediforme, Sedum dasyphyllum,* and *Lygeum spartum*.

In this habitat, these species play an essential role in the dune evolution process; they contribute to the binding and consolidation of sand accumulations, protecting them from erosion.

When the slope begins inward and the substrate settles, other species appear, including *Camphorosma monspeliaca*, *Periploca laevigata,* and *Thymelaea hirsuta*.

The plant chain of diverse habitats continues to communicate, and woody and tree species spread, which are exposed in the dry season to partial immersion in these sands and lose their leaves from the direction of the sea. Because of its friction with the wind, carrying sand grains, these types include *Juniperus phoenicea, Pistacia atlantica*, and *Ziziphus lotus.*

The medium and coarse sand grains move by surface creep or jump. They accumulate close to the simple shore. Annual and perennial plant species characterize them.

There are many types in this society, the most important of which are: *Matthiola sinuata, Glaucium flavum, Matthiola tricuspidata*, and *Ononis serrata.* In habitats where the substrate mixes between sand, clay and gravel in dry depressions, some species are spread, such as *Ambrosia coronopifolia, Phleum arenarium,* and *Echium angustifolum*.

To adapt to insolation, all typical dune plants are pale in colour. A thick waxy layer wrapped like the skin appears on the leaves, representing protection from the

friction of sand and wind and reducing the number of stomata so as not to lose moisture, such as in Salsola kali-Medicago marina.

The thickness of their leaves distinguishes plants in this environment; To provide as much moisture as possible, such as *Cakile marittima -Tetraena fontanesii*.

There are transitional zones between different sandy habitats, characterized by notable plant species and representing a rapidly evolving habitat in which pioneer, main species, and other interceptor species mix. This habitat needs a detailed study.

He stated (Atalay, 2011) in many of his writings that it is imperative for soil to retain water, to use water and nutrients by plants, and for plant growth. For this reason, water is essential physiologically for plants. The water balance in the field is one factor that determines the plants' distribution areas. Sand has a low water holding capacity. This causes the sandy soil to dry out. Water retention occurs in the soil by the effect of two forces: adhesion and adhesion to water.

In a reconnaissance trip (2020) to the city of AMASRA, located on the Black Sea in northern Turkey, the severe impact of trampling on a group of beaches due to tourist activity was observed. Heading east to the village of Göçkündemirci, plant diversity and a natural gradation of species are observed on a small beach that meets an estuary, confirming reduced trampling, substrate stability, and water availability create typical coastal habitats. The village coast is shown in picture 109.

After several field visits, reviewing relevant studies in Turkey, and comparing the habitat condition of the dune habitat with the habitat condition in the study area, we noticed similarities between species. Nevertheless, there is severe degradation in the area due to the continuation of harmful human activities, and it leaves no opportunity for the return of species and vegetation succession in coastal dunes. The species spread on the foreshore is steadily declining, so we rarely encounter *Pancratium maritimum*, for example. We will not find embryonic dunes unless geomorphology protects them from destruction.

Source: Photo by researcher 7/2020.

Picture 109. Diversity and a natural gradation of plant species on the coast of the village of Göçkündemirci

It is complicated with the intervention of human activities to find a high plant diversity or natural gradation of species, even with water availability.

The results of vegetation sectors did not show any natural gradient in the region; although some species are widespread, others are rare or very degraded.

To adequately understand and analyze the distribution of species in coastal dunes, natural and human factors and the region's history must be studied.

In a study (Prieto, 2009), the plants' association *Otantho maritimi*, *Ammophiletum australis* predominates in a community dominated by Ammophila, with its optimum on the Atlantic coasts of the Iberian Peninsula. These formations include many taxa characteristic of the Ammophiletum communities; all psammophilous species; *Medicago marina, Pancratium maritimi, Otanthus maritimus, Eryngium maritimus, Euphorbia paralias, Calystegia soldanella, Echinophora spinosa, Lotus creticus, Cyperus capitatus, Sporobolus arenarius, Polygorum maritimum*.

In a study (Seer et al., 2016), the species composition of 15 beach areas on the southern Baltic Sea was studied using transects from the beach wall to the waterline during the summers of 2011 and 2012 2013. The results showed that freely accessible beaches have an increased proportion of ruderal species (A*rtemisia vulgaris and Molinia-arrhenatheretea elatioris*) and a decline in the typical beach plant class of *Honckenyo-Elymetea*. The work makes it clear that even minor human disturbances can have a sensitive effect on the beaches' flora and fauna and negatively affect the ecological functions of the beach as a dynamic habitat.

Pancratium maritimum was recently listed, according to IUCN data under Level (LC), as the slightest concern as critically endangered (Alicante, 2015).

According to field study data, this species was classified as Critically Endangered in the study area. The most concerning within level (N T) near threatened is threatened because very few habitats remain. They have migrated from their outposts, where moving dunes are abundant, to stationary dunes, where competition with other species is fierce.

Most beaches, the natural habitat of the sand lily, are used as beaches, and their flowers and bulbs are plucked as endangered (Akyel, 2019).

According to (*The IUCN Red List of Threatened Species*, 2022), more than 10 types of *Phleum* were included within the level (LC) and in the study area, a severe deterioration in the type of *Phleum arenarium* has been seen and can be classified within the level (N T) where habitats were destroyed as a result of sand scraping by heavy machines.

Also, *Crithmum maritimum* was rated at level (LC) in 2014. This species is severely threatened in the study area and can be included at level (VU) vulnerable. Few individuals have been observed on rock cliffs near the sea.

Likewise, *Sporobolus virginicus* was ranked at the LC level in 2020, and this type is severely threatened in the study area and can be included at the (NT) level, which deteriorated severely due to the destruction of habitats by scraping sand and corrosion after that.

Based on data (International. CABI, 2021) providing a compendium of invasive species, invasive species have been documented for the area. *Carpobrotus acinaciformis*

was mentioned in a study (Podda et al., 2018) as one of the most severe threats to coastal ecosystems, and it is one of the most widespread invasive alien species in the Mediterranean basin. This species is widespread in the study area and covers large areas of up to several square meters with a high density. It has been spotted in many sandy and rocky habitats, as well as solid waste sites.

A study (F. El-Mokasabi & El-Darier, 2014) reported that there are 365 flowering plants in the Al-Kouf Valley in Al-Jabal Al-Akhdar, Libya. The study referred to the type *Heliotropium corsavicum*. It has no local name and is not mentioned as an invasive species. This species is observed in two distinct climatic and botanical regions, which indicates that it invades many habitats. It has been widely observed in sandy habitats. In the same study, two species, *Limonium pruinosum* and *Limonium tubiflorum*, were mentioned, and they are not invasive in the region. We referred to a third species that spreads in sandy habitats, which is an invasive species, *Limonium virgatum*.

A study (F. M. El-Mokasabi et al., 2018) in northeastern Libya referred to Nicotiana glauca and reported its medicinal use. CABI data shows this species is native to northwest Argentina and Bolivia. It is a successful invasion of disturbed semi-arid regions, and this species has been observed in sandy habitats, seasonal swamps, and some narrow valleys near the sea.

A study (Thomson, 2022) indicated that on the New Zealand coastline, *Euphorbia paralias* is a highly invasive weed that can seriously threaten coastal environments. Populations around an adult plant are concentrated at the early stages of invasion. In the study area, this species is observed as a large-scale, homogeneous community that rapidly occupies disturbed sites. It includes individuals of different sizes and densities mixing with several species.

A study (Elshatshat, 2009) on the critical situation of the vegetation of the EL-Gabal EL-Akhdar area stated that the endemic plants were found in 23 species classified into 13 different families, and the star plants are the prominent family that includes 7 species. Some other families have revealed only a few species. In the study area, the family Compositae (Asteraceae) revealed 13 plant species in sandy habitats, the most numerous families.

In a study (Akyel, 2019) Yeşilırmak Delta (Çarşamba Plain) dune vegetation: Ecology and environmental assessment on the coastal dunes of the second-largest delta

in Turkey Yeşilırmak, the distribution of vegetation cover, climate, and topography were revealed to prove their influence on the distribution of plants, and it showed the species that are resistant to salt stress from the influence of the sea and indicated that the species *Pancratium maritimus* is significantly threatened. Farms, dams, and other activities threaten coastal dunes, and agricultural activities harm vegetation on the shore but bring economic benefits.

In a study (Yılmaz, 2021) entitled filyos deltasi kumul vejetasyonu, in the delta of filyos, the second-largest port in Turkey, in the western Black Sea region of the Siberian European geo-phyto-geographic region, after investigating the effects of the filyos port project on the dunes, it was found that the distribution areas of the dunes are shrinking due to many factors such as environmental degradation, human interventions, and changing climate. The river's course through human intervention and grazing and fishing activities in the lakes has led to an imbalance in the ecological balance.

5.2. Recommendations

What we need now is to work on the following areas

1. Rehabilitation and Restoration Programs
   - Windbreaks are made of natural materials, wooden fences and plastic nets. The formation of winding paths reduces the effect of wind and trampling
   - With the participation of residents and landowners, sustainable development is indispensable for protection, control, and reform programmes.
   - The use of native plants to restore the habitat provides tangible environmental benefits.
   - Evaluate the condition of the sites proposed in Map 15 and include them in protection and rehabilitation programs.
2. Design of coastal landscapes Coastal engineering works and operations are carried out while preserving the coast's geomorphological and aesthetic characteristics by using local rocks as natural barriers that outperform large concrete blocks.

- She is mapping the distribution of plant species and identifying nature reserves.

- They are conducting a comprehensive inventory of invasive species in the region and El-Jabal El-Akhdar and mapping their distribution and spread.
- Concentrating on planting and afforestation of eroded dunes helps in the process of rehabilitating different habitats.

3. Creating a modern database that collects research results and studies on the natural vegetation cover in El-Jabal El-Akhdar and the Benghazi Plain to save time and effort and avoid repetition, and working on directing conservation and rehabilitation programmes and conducting field surveys for sites that have not yet been studied.
4. Create tools, methods, or indicators for detecting human impacts on coastal dunes and their vegetative succession. Spring and summer are the best times to capture the significant plant diversity of coastal dune habitats.

REFERENCES

Ackerman, S., and Knox, J. (Eds.) (2012). *Meteorology Understanding the Atmosphere* (3rd ed.). Jones and Bartlett learning. www.blearning.com

Acosta, A., Ercole, S., Stanisci, A., Pillar, V. D. P., and Blasi, C. (2007). Coastal vegetation zonation and dune morphology in some Mediterranean Ecosystems. *Journal of Coastal Research, 2007*(236), 1518–1524. https://doi.org/10.2112/05-0589.1

Akyel, Ö. (2019). *Yeşilırmak Deltasının (Çarşamba Ovası) Kumul Vejetasyonu: Ekolojisi ve Çevresel Değerlendirilmesi* (Yayınlanmamış Yüksek Lisans Tezi). Karabük Üniversitesi, Sosyal Bilimler Enstitüsü, Karabük.

Al Banna, A. (1970). *The Foundations of Climatic and Plant Geography*. Arab Renaissance House for Printing and Publishing. Beirut.

Al Hanafi, M., and Nooh, S. (2012). Influence of Topography and Geological Structure on the Water Situation in Aljabal Alakhdar Basin. the first international conference on water resources of Al Jabal Al Akhdar. *Libyan Agriculture Research Center Journal international 3(S), 1168-1188.*

Alicante. (2015). IUCN Red List of Threatened Species: Pancratium maritimum. *IUCN Red List of Threatened Species*. https://www.iucnredlist.org/en

Al-Sghair, F. (2019). Species Diversity and Floristic Analysis of the Family Poaceae in Libya Depending on the Flora of Libya. *Advances in Bioscience and Bioengineering*, *7*(2), 13. https://doi.org/10.11648/j.abb.20190702.11

Al-Sghair, F. and Mahklouf, M. (2017). Floristic Analysis of the Family Asteraceae in Libya Depending on Flora of Libya. *American Journal of Life Science Researches*, *5*(4), 170–183. https://doi.org/10.21859/ajlsr-05046

Atalay, İ. (2011). *Toprak Oluşumu, Sınıflandırması ve Coğrafyası.* İzmir: Meta Basım Matbaacılık Hizmetleri.

Avcı, M. (2005). Çeşitlilik ve Endemizm Açısından Türkiye'nin Bitki Örtüsü. *Coğrafya Dergisi*, 13, 27-55.

Avcı, M. (2017). *Türkiye'nin Kıyı Kumulları, Bitki Örtüsü ve Önemi*. *International Symposium on Geomorphology 2017*. Fırat Üniversitesi Basımevi.

Avcı, M., Avcı, S. and Akkurt, S. (2015). Coastal dune vegetation in Turkey: a geographical perspective. *In International Conference on the Mediterranean Coastal Environment MEDCOAST* (pp. 6-10).

Barman, S. and Pramanik, B. (2019). *Changing pattern of Dune's shape in relation to wave dynamics of Western coast of India. 2236*, 7.

Brullo, S. and Furnari, F. (1979). Taxonomic and Nomenclatural Notes on the Flora of Cyrenaica (Libya). *Webbia*, *34*(1), 155-174. https://doi.org/10.1080/00837792.1979.10670168.

Buffa, G., Filesi, L., Gamper, U. and Sburlino, G. (2007). *Qualità e grado di Conservazione Del Paesaggio Vegetale Del Litorale Sabbioso Del Veneto (Italia settentrionale)*, *44*(1), 11.

Cakan, H. (2011). The Classification and Assessment of Vegetation for Monitoring Coastal Sand Dune Succession: The Case of Tuzla in Adana, Turkey. *Turkish Journal of Botany*, *35*, 697–711. https://doi.org/10.3906/bot-1001-300

Castillo, S. (1998). Analisis De La Flora De Dunas Costeras Del Litoral Atlantico De Mexico. *Analisis De La Flora De Dunas Costeras Del Litoral Atlantico De Mexico*, *45*, 55–80.

Castillo, S. and Casasola, M. (1996). Coastal Sand Dune Vegetation: An Extreme Case of Species Invasion. *Journal of Coastal Conservation*, *2*(1), 13–22.

Catullo, G., Bertrand de, M. and Radford, E. A. (2011). Important Plant Areas of the South and East Mediterranean Region Priority Sites for Conservation. In *Important Plant Areas of the South and East Mediterranean Region Priority Sites for Conservation* (Vol. 8, p. 117). IUCN, Gland, Switzerland and Malaga, Spain.

Cella, P. D. (1819). *Viaggio da Tripoli di Barberia alle frontiere dell'Egitto* (Tipografia di A. Poxthenier). Ponthenier; Fatto nel 1817 Dal D. P. Della-Cella.

Choowong, M. (2002). *The Geomorphology and Assessment of Indicators of Sea-Level Changes to Study Coastal Evolution from the Gulf of Thailand* (P. 17) [Paper Prepared For The International Symposium on Geology of Thailand]. Organised by the Department of Mineral Resources Bangkok. https://www.researchgate.net/publication/228556599

Cooper, A. and Jackson, D. (2021). Dune Gardening a Critical View of the Contemporary Coastal Dune Management Paradigm. *Area*, *53*(2), 345–352.

Coşkun, M., Coşkun, S. and Gök, M. (2017). A New Activity in Turkey's Agricultural Forestry: Truffle Mushroom Cultivation. *Journal of Forests*, *4*(1), 1–7.

Cuccuini, P., Nepi, C., Abuhadra, M., Banfi, E., Domina, G., Luccioli, E., Miranda, S., Pagitz, K., Thiv, M. and Véla, E. (2016). The Libyan Collections in FI (Herbarium Centrale Italicum and Webb Herbarium) and Studies on the Libyan Flora by R. Pampanini – Part 2. *Flora Mediterranea*, *26*, 81–143. https://doi.org/10.7320/FlMedit26.081

Cuccuini, P., Nepi, C., Abuhadra, M. and Cecchi, L. (2015). The Libyan Collections in FI (Herbarium Centrale Italicum and Webb Herbarium) and Studies on the Libyan Flora by R. Pampanini – Part 1. *Bocconea*, *27*. https://doi.org/10.7320/Bocc27.2.003

Daehyun, K. and Keun, B. Y. (2008). A Conceptual Model of Coastal Dune Ecology Synthesizing Spatial Gradients of Vegetation, Soil, and Geomorphology. *Plant Ecology*, *202*(1), 135. https://doi.org/10.1007/s11258-008-9456-4

Dahm, J., Nomos, E., Jenks, G. and Bergin, D. (2005). *Community-Based Dune Management for the Mitigation of Coastal Hazards and Climate Change Effects: A Guide for Local Authorities.* David Bergin Forest Research.

Dalyander, P. S., Mickey, R. C., Passeri, D. L. and Plant, N. G. (2020). Development and Application of an Empirical Dune Growth Model for Evaluating Barrier Island Recovery from Storms. *Journal of Marine Science and Engineering*, *8*(12), Article 12. https://doi.org/10.3390/jmse8120977

Davidson-Arnott, R. (2010). *An Introduction to Coastal Processes and Geomorphology* (First). Cambridge University Press. www.cambridge.org

De Molenaar, J. G. (1974). *Vegetation of the Angmagssalik District Southeast Greenland. I. Littoral vegetation*.

De Natale, A. and Pollio, A. (2012). A Forgotten Collection: The Libyan Ethnobotanical Exhibits (1912-14) by A. Trotter at the Museum O. Comes at the University Federico II in Naples, Italy. *Journal of Ethnobiology and Ethnomedicine*, *8*(1), 4.

De Simone, L. (2021). *Ecological Aspects of Plants İnhabiting Mediterranean Cliffs. Challenges and Prospects of Life in Vertical Environments* [Tesis doctoral, Universitat Politècnica de València].

Earle, J. C. and Kershaw, K. A. (1989). Vegetation Patterns in James Bay Coastal Marshes. III. Salinity and Elevation as Factors İnfluencing Plant Zonations. *Canadian Journal of Botany*, *67*(10), 2967–2974. https://doi.org/10.1139/b89-380

El-Darier, S. M. and El-Mogaspi, F. M. (2009). *Ethnobotany and Relative Importance of Some Endemic Plant Species at El-Jabal El-Akhdar Region (Libya)*. *5*(3), 353–360.

El-Mokasabi, F. and El-Darier. (2014). Floristic Composition and Traditional Uses of Plant Species at Wadi Alkuf, Al-Jabal Al-Akhder, Libya. *Environ. Sci.*, 13.

El-Mokasabi, F. M., Al-Sanousi, M. F. and El-Mabrouk, R. M. (2018). Taxonomy and Ethnobotany of Medicinal Plants in Eastern Region of Libya. *Journal of Environmental Science, Toxicology and Food Technology*, *12*(8), 14-23.

Elshatshat, S. (2009). Biological Conservation of the Endemic Arbutus Pavarii Pamp.: Seed Germination as Attempt. *Biological Conservation of the Endemic Arbutus Pavarii Pamp.: Seed Germination as Attempt*, *1*(1), 22–20.

Elshatshat, S. and Mansour, A. (2014). *Disturbance of flora and vegetation composition of Libya by human impacts: Costal Region of Al-Jabal Al-Akhdar area as model*. 7.

Elzouki, A. Y. and Elfigih, O. B. (2020). *Transportation of Sediments by Bloating Processes from Southern Europe to the Coastal Regions of Eastern Libya: Pumice Rock Fragments from at Tariyah and Qasr Libya coasts*. 7.

Environment Public Authority. (2010). *Fourth National Report on the Implementation of the Convention on Biological Diversity* (No. 4; p. 124). EPA.

Fagaras, M. (2015). *Embryonic Shifting Dunes on the Romanian Black Sea Coast*. *XLV 2015*(1), 8.

Flora of Libya. (2020). http://floraoflibya.services.ly/display.php?selected=Vegetation

Flora of Libya. (2022). http://floraoflibya.services.ly/index.php

Fouad, A., Hafez, R. and Hosni, H. (2019). Authentication of Three Endemic Species of the Caryophyllaceae from Sinai Peninsula Using DNA Barcoding. *Authentication of Three Endemic Species of the Caryophyllaceae from Sinai Peninsula Using DNA Barcoding*, *59*(2), 10.

Franks, S. J. (2003). Competitive and Facilitative İnteractions Within and Between Two Species of Coastal Dune Perennials. *Canadian Journal of Botany*, *81*(4), 330–337. https://doi.org/10.1139/b03-023

Gamper, U., Filesi, L., Buffa, G. and Sburlino, G. (2008). *Diversità Citocenotica Delle Dune Costiere Nord-Adriatiche 1 – Le comunità fanerofitiche*. 20.

García-Romero, L., Hernández-Cordero, A., Hernández-Calvento, L. and Hesp, P. A. (2017). Geophysical Research Abstracts. *Long-Term Analysis of the Role of Traganum Moquinii Plants in the Foredune Formation of an Arid Dunefield (Maspalomas, Gran Canaria, Canary Islands).*, *19*, 1.

Gawhari, A., Jury, S. and Culham, A. (2018). Towards an Updated Checklist of the Libyan flora. *Phytotaxa*, *338*(1), 1. https://doi.org/10.11646/phytotaxa.338.1.1

Goudarzi, G. H. (1970). *Geology and Mineral Resources of Libya- A Reconnaissance*. United States government printing office; Congress catalog-card No. 74-602243.

Hajjaji, S. A. (1969). *The Land Use Patterns and Rural Settlement in the Benghazi Plain* [Doctoral, Durham University]. http://etheses.dur.ac.uk/9644/

Hand, R. and Hadjikyriakou, G. (2009). Cynara makrisii (Asteraceae, Cardueae) a New Artichoke Species in Cyprus. *Willdenowia*, *39*(1), 77–81.

Harper, R. M. (1909). Some Coastal Plain Plants in the Piedmont Region of Georgia. *Bulletin of the Torrey Botanical Club*, *36*(10), 583–593. https://doi.org/10.2307/2479053

Heywood, V. H., and Watson, R. T. (1945). *Global Biodiversity Assessment: Ch 3 Magnitude and distribution of biodiversity*. Cambridge University Press.

Hilal, F. (1996). *Weather and Climate, "A Study of the Nature of the Atmosphere and Climate Geography*. Dar al-Maarifa al-Jami'a.

Hobohm, C. and Bruchmann, I. (2009). Endemische Gefäßpflanzen und ihre Habitate in Europa – Plädoyer für den Schutz der Grasland-Ökosysteme. *Endemische Gefäßpflanzen und ihre Habitate in Europa – Plädoyer für den Schutz der Grasland-Ökosysteme*, *21*, 142–161.

Hobohm, C., Janišová, M., Jansen, J., Bruchmann, I. and Deppe, U. (2014). *Biogeography of Endemic Vascular Plants – Overview* (pp. 85–163).

Home-The Plant List. (2022). http://www.theplantlist.org/International.

CABI.(2021).*International.CABI*.ttps://www.cabi.org/isc/search/index?q=Mesembryanthemum%20nodiflorum%20L.*International Plant Names Index*. (n.d.). Retrieved 25 May 2022, from https://www.ipni.org/

IPBES. (2020). *Media Statement: Nature's Dangerous Decline is 'Unprecedented'; Species Extinction Rates "Accelerated"*.

Jones, L., Rooney, P. and Rhymes, J. (2021). *The Sand Dune Managers Handbook* (No. 1; p. 90). UKCEH, Liverpool Hope University. https://core.ac.uk/reader/477976932

Kavgaci, A. (2007). Sand-Dune Vegetation of Igneada Coast in the Thracian Part of Turkey. *Hacquetia*, *6*(2), 171–182. https://doi.org/10.2478/v10028-007-0010-z

Kearney, T. H. (1904). *Are Plants of Sea Beaches and Dunes True Halophytes? 37*(6), 424–436. https://doi.org/10.1086/328507

Lithgow, D., Martínez, M. L., Gallego-Fernández, J. B., Hesp, P. A., Flores, P., Gachuz, S., Rodríguez-Revelo, N., Jiménez-Orocio, O., Mendoza-González, G. and

Álvarez-Molina, L. L. (2013). Linking Restoration Ecology with Coastal Dune Restoration. *Geomorphology*, *199*, 214–224.

LNMC. (2010). *Libyan National Meteorological Center* [Climate Department, Information Office].

Lomba, A., Alves, P. and Honrado, J. (2008). Endemic Sand Dune Vegetation of the Northwest Iberian Peninsula: Diversity, Dynamics, and Significance for Bioindication and Monitoring of Coastal Landscapes. *Journal of Coastal Research, 2,* 113–121. https://doi.org/10.2112/05-0610.1

Major, J. (1988). Endemism: A botanical perspective. In A. A. Myers and P. S. Giller (Eds.), *Analytical Biogeography: An Integrated Approach to the Study of Animal and Plant Distributions* (pp. 117–146). Springer Netherlands. https://doi.org/10.1007/978-94-009-0435-4_5

Marcenò, C., Guarino, R., Loidi, J., Herrera, M., Isermann, M., Knollová, I., Tichý, L., Tzonev, R. T., Acosta, A. T. R., FitzPatrick, Ú., Iakushenko, D., Janssen, J. A. M., Jiménez-Alfaro, B., Kącki, Z., Keizer-Sedláková, I., Kolomiychuk, V., Rodwell, J. S., Schaminée, J. H. J., Šilc, U. and Chytrý, M. (2018). Classification of European and Mediterranean Coastal Dune Vegetation. *Applied Vegetation Science, 21*(3), 533–559. https://doi.org/10.1111/avsc.12379

Martínez, L. M., Gallego-Fernández, J. B. and Hesp, P. A. (2013). *Restoration of Coastal Dunes*. Springer Science & Business Media.

Martinez, M. L., Moreno-Casasola, P. and Vázquez, G. (1997). Effects of Disturbance by Sand Movement and İnundation by Water on Tropical Dune Vegetation Dynamics. *Canadian Journal of Botany*, *75*(11), 2005–2014. https://doi.org/10.1139/b97-912

Martínez, M. L., Vázquez, G., White, D. A., Thivet, G. and Brengues, M. (2002). Effects of Burial by Sand and İnundation by Fresh- and Seawater on Seed Germination of Five Tropical Beach Species. *Canadian Journal of Botany*, *80*(4), 416–424. https://doi.org/10.1139/b02-027

Marzialetti, F., Giulio, S., Malavasi, M., Sperandii, M. G., Acosta, A. T. R. and Carranza, M. L. (2019). Capturing Coastal Dune Natural Vegetation Types Using a Phenology-Based Mapping Approach: The Potential of Sentinel-2. *Remote Sensing*, *11*(12), 1506. https://doi.org/10.3390/rs11121506

Mather, J. R. and Yoshioka, G. A. (1968). The Role of Climate in the Distribution of Vegetation. *Annals of the Association of American Geographers, 58*(1), 29–41. https://doi.org/10.1111/j.1467-8306.1968.tb01634.x

McLachlan, A. (1991). Ecology of Coastal Dune Fauna. *Journal of Arid Environments*, *21*(2), 229–243. https://doi.org/10.1016/S0140-1963 (18)30684-0

Mucina, L., Price, J. N. and Kalwij, J. M. (2014). *Biodiversity and Vegetation: Patterns, Processes, Conservation.* Kwongan Foundation.

Muñoz-Vallés, S. and Cambrollé, J. (2016). Dunes. In J. Harff, M. Meschede, S. Petersen, and Jö. Thiede (Eds.), *Encyclopedia of Marine Geosciences* (pp. 196–203). Springer Netherlands. https://doi.org/10.1007/978-94-007-6238-1_160

Nooh, S. (2007). *Climate and İts Effect on Vegetation in El-Jabal El-Akhdar* [PhD thesis]. League of Arab States (LAS).

North African Medicinal and Aromatic Plants. (2020).

Odum, E. P. and Barrett, G. W. (Eds.). (2005). *Fundamentals of Ecology* (5th ed.). Peer Marshall. ISBN 13: 978-0-534-42066-6 ISBN 0-534-42066-4

Olsson-Seffer, P. (1909). Relation of Soil and Vegetation on Sandy Sea Shores. *Botanical Gazette*, *47*(2), 85–126. https://doi.org/10.1086/329816

Page, N., Lilley, P., Walker, I. J. and Vennesland, R. (2011). *Status Report on Coastal Sand Ecosystems in British Columbia* (Status Report on Coastal Sand Ecosystems in Bc No. 7; p. 91). https://www.researchgate.net/publication/256373195

Podda, L., Santo, A., Mattana, E., Mayoral, O. and Bacchetta, G. (2018). *Inter- and İntra-Variability of Seed Germination Traits of Carpobrotus Edulis N.E.Br. And its hybrid C. affine acinaciformis.* Wiley.

Prieto, J. (2009). *2120Dunas Móviles de Litoral Con Ammophila Arenaria (dunas blancas)* (1st ed.). Ministerio de Medio Ambiente y Medio Rural y Marino. ISBN: 978-84-491-0911-9

Raimondo, F., Greuter, W. and Domina, G. (Eds.). (2016). *Flora Mediterranea*, *26*, 240.

Saaed, M., El-Barasi, Y. and Rahil, R. (2019). Our present knowledge about the history and composition of the vegetation and flora of Libya. *Webbia*, *74*(2), 325–338. https://doi.org/10.1080/00837792.2019.1669361

Santo, A., Mattana, E., Frigau, L. and Bacchetta, G. (2014). Light, Temperature, Dry After-Ripening and Salt Stress Effects on Seed Germination of *Phleum Sardoum* (Hackel) Hackel: Seed Germination of *Phleum Sardoum*. *Plant Species Biology*, *29*(3), 300–305. https://doi.org/10.1111/1442-1984.12018

Schlacher, T. A., Jones, A. R., Dugan, J. E., Weston, M. A., Harris, L., Schoeman, D. S., Hubbard, D. M., Scapini, F., Nel, R., Lastra, M., McLachlan, A. and Peterson, C. H. (2013). Open-coast sandy beaches and coastal dunes. In B. Maslo and J. L. Lockwood (Eds.), *Coastal Conservation* (pp. 37–94). Cambridge University Press.

Seer, F. K., Irmler, U. and Schrautzer, J. (2016). *Beaches under pressure – effects of human access on vegetation at Baltic Sea beaches*.

Shibutani, Y., Matsubara, Y. and Kuroiwa, M. (2013). *Effect of the Coastal Conservation Due to Beach Nourishment of Totori Sand Dune Coast*. 6.

Sigren, J. M., Figlus, J. and Armitage, A. R. (2014). *Coastal Sand Dunes and Dune Vegetation: Restoration, Erosion, and Storm Protection*. *82*(4), 9.

Stephenson, W. J. and Brander, R. W. (2003). Coastal Geomorphology into the Twenty-First Century. *Progress in Physical Geography: Earth and Environment*, *27*(4), 607–623. https://doi.org/10.1191/0309133303pp398pr

Stesevic, D. (2017). Distribution of Alien Species along Sand Dune Plant Communities Zonation. *Periodicum Biologorum*, *119*(4), 239–249. https://doi.org/10.18054/pb.v119i4.4917

The IUCN Red List of Threatened Species. (2022). IUCN Red List of Threatened Species. https://www.iucnredlist.org/en

Thomson, F. J. (2022). Measuring the Effective Dispersal of an Emerging Coastal Weed, Euphorbia Paralias (sea spurge), to Help Enform its Eradication. *Biological Invasions*, *24*(6), 1553–1559.

Tomaselli, G., Carullo, L. and Sciandrello, S. (2014). *Linee Guida per Pronteggiare l'erosione costiera Nelle Aree del Progetto Life Leopoldia* (LIFE11 NAT/IT/000232).

Turoğlu, H. (2009). *3621 Sayılı Kıyı Kanunu ve Onun Uygulama Problemleri*. *53*, 31–40.

Turoğlu, H. and Yiitbaşioğlu, H. (2017). Kıyı Mevzuatı ve Jeomorfolojik Değerlendirmesi. In *Yasal ve Bilimsel Boyutlarıyla KIYI* (pp. 45–62). Jeomorfoloji Derneği.

Uysal, I. (2010). An Overview of Plant Diversity of Kazdagi (Mt. Ida) Forest National Park, Turkey. *Journal of Environmental Biology*, *31*(1), 141–147.

Vecchio, S. D., Pizzo, L., and Buffa, G. (2015). The Response of Plant Community Diversity to Alien İnvasion: Evidence from a Sand Dune Time Series. *Biodiversity and Conservation*, *24*(2), 71–392. https://doi.org/10.1007/s10531-014-0814-3

Weakley, A. S. (2015). Coastal Plain Vascular Plant Endemics: Phytogeographic Patterns. *Coastal Plain Vascular Plant Endemics: Phytogeographic Patterns*, *66*(2–1), 50–82.

Woodward, J. (Ed.). (2009). *The Physical Geography of the Mediterranean*. Oxford University Press.

Yılmaz, Y. (2021). *Filyos Deltası Kumul Vejetasyonu* (Yayınlanmamış Yüksek Lisans Tezi). Karabük Üniversitesi, Lisansüstü Eğitim Enstitüsü, Karabük.

Yılmaz, R. and Serbest, D. (2005). *Saros Körfezi Kıyı Kumulları Üzerindeki Çevresel Etkilerin Araştırılması. Trakya Üniversitesi Fen Bilimleri Dergisi. 6*(2), 8.

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PICTURES

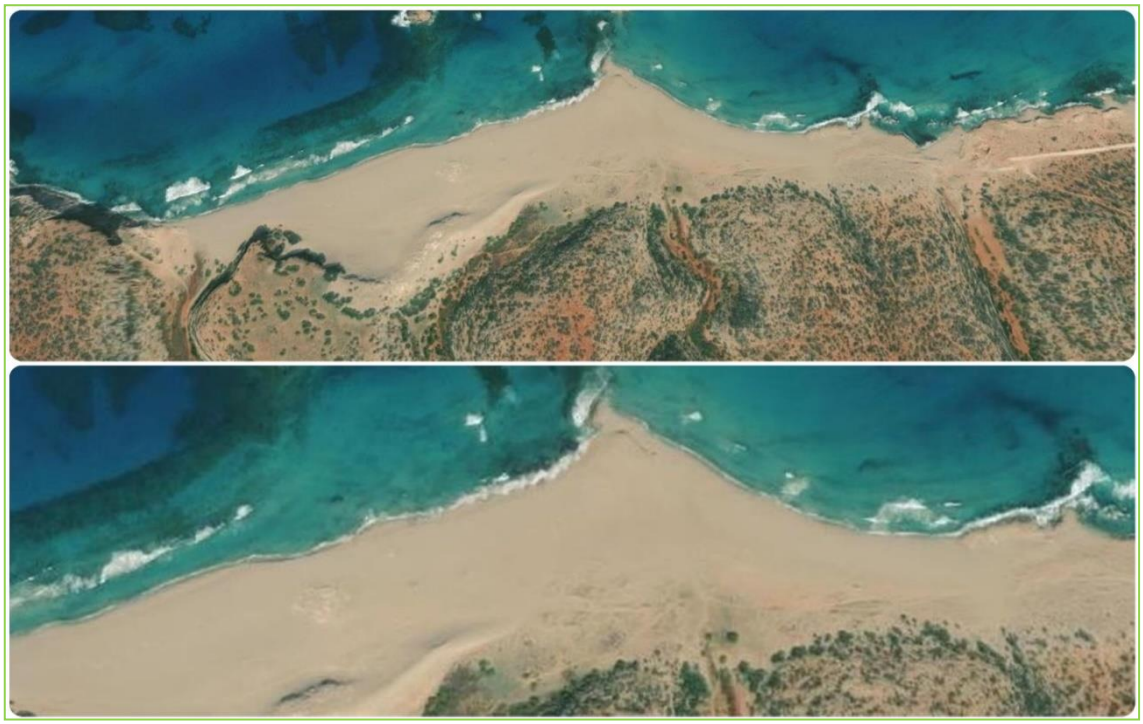
LIST OF SUPPLEMENTS

Supplement 1. Plant species spread on rocky beaches

Family	Scientific name	L.D	Kinds	Order
Cupressaceae	*Juniperus phoenicea L.*	Per	Tree	Pinales
Anacardiaceae	*Pistacia lentiscus L.*	Per	Tree	Sapindales
Lamiaceae	*Rosmarinus officinalis L.*	Per	Shrub	Lamiales
Ericaceae	*Erica multiflora L.*	Per	Shrub	Ericales
Oleaceae	*Phillyrea angustifolia L.*	Per	Shrub	Lamiales
Rhamnaceae	*Rhamnus lyciodes*	Per	Shrub	Rosales
Lamiaceae	*Phlomis floccosa* D. Don	Per	Shrub	Lamiales
Ephedraceae	*Ephedra alata* Decne	Per	Shrub	Ephedrales
Apiaceae	*Eryngium maritimum*	Per	Grass	Apiales
Compositae	*Bellis sylvestris var. cyrenaica.*	Ann	Grass	Asterales
Compositae	*Centaurea melitensis*	Per	Grass	Asterales
Plumbaginaceae	*Limonium cyrenaicum* (Rouy) Brullo.	Per	Grass	Caryophyllales
Araceae	*Arum cyrenaicum* Hruby	Per	Forbs	Alismatales
Compositae	*Carthamus lanatus var. longifolius* Pamp	Per	Grass	Asterales
Compositae	*Onopordum arenarium* (Desf.) Pomel	Per	Forbs	Asterales
Poaceae	*Stipa tenacissima*	Per	Grass	Poales
Zygophyllaceae	*Tetraena geslinii* (Coss.) Beier & Thulin	Per	Shrub	Zygophyllales
Asparagaceae	*Drimia maritima* (L.) Stearn	Ann	Forbs	Asparagales
Apiaceae	*Eryngium campestre L.*	Per	Forbs	Apiales
Rubiaceae	*Crucianella aegyptiaca L*	Ann	Grass	Gentianales
Poaceae	*Trisetaria macrochaeta* (Boiss.) Maire	Ann	Grass	Poales
Polygonaceae	*Polygonum maritimum L.*	Per	Forbs	Caryophyllales
Rhamnaceae	Rhamnus alaternus subsp. pendulus (Pamp.) Jafri	Per	Shrub	Rosales

Supplement 2. The number of plant species in each plant family

NO	Family	Plant family	NO	Family	Plant family
1	Poaceae	11	19	Thymelaeaceae	1
2	Amaryllidaceae	1	20	Crassulaceae	2
3	Compositae	13	21	Oleaceae	2
4	Amarnthaceae	1	22	Rhamnaceae	2
5	Zygophyllaceae	2	23	Convolvulaceae	2
6	Fabaceae	3	24	Asparagaceae	1
7	Rubiaceae	2	25	Anacardiaceae	1
8	Euphorbiaceae	2	26	Cyperaceae	2
9	Boraginaceae	3	27	Brassicaceae	2
10	Leguminosae	4	28	Apiaceae	2
11	Solanaceae	3	29	Ephedraceae	2
12	Juncaceae	2	30	Lamiaceae	1
13	Polygonaceae	1	31	Cucurbitaceae	2
14	Papaveraceae	2	32	Aizoaceae	1
15	Plumbaginaceae	3	33	Rosaceae	1
16	Amaranthaceae	12	34	Tamaricaceae	4
17	Scrophulariaceae	1	35	Arecaceae	1
18	Apocynaceae	1	36	Cupressaceae	2
					98



Supplement 3. The effect of the trampling of all kinds on coastal dunes appears devoid of vegetation

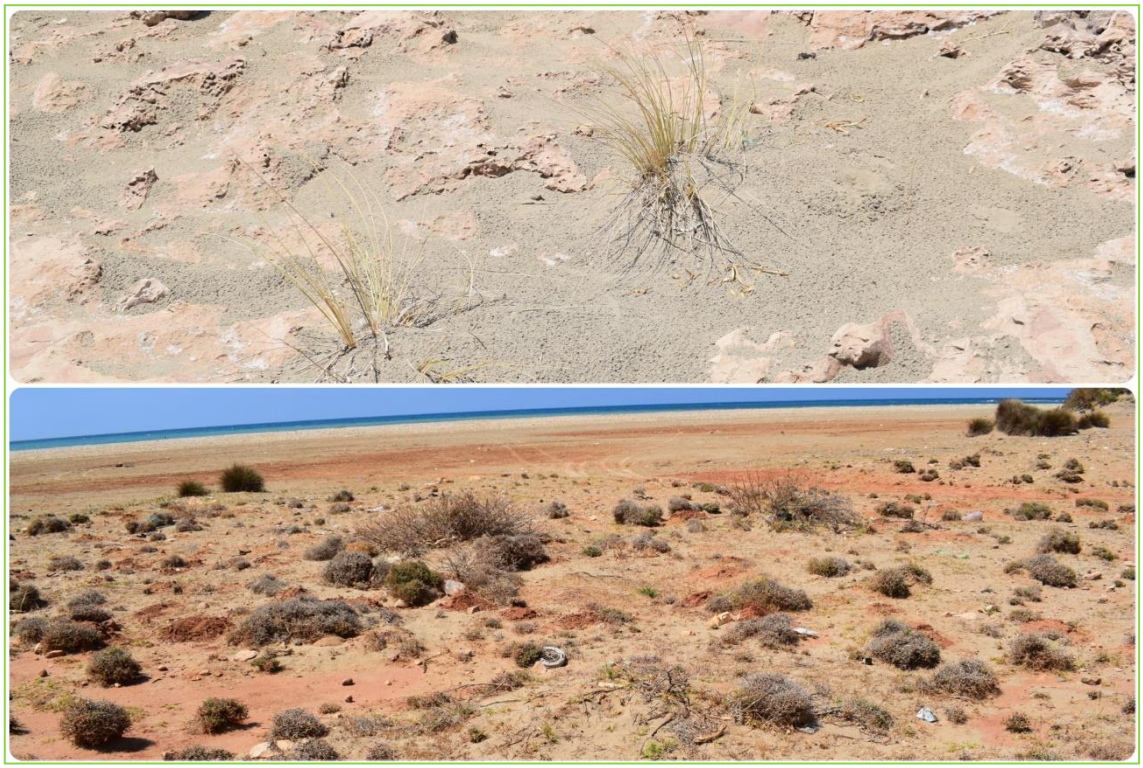
Supplement 4. Sand scraping and cutting of bogs and trails are factors that lead to the disintegration of sandy habitats and reduced plant diversity

Supplement 5. Indiscriminate construction is one of the factors that degrade sandy habitats

Supplement 6. Urban sprawl and agriculture are factors in the disintegration of sandy habitats and a decrease in plant diversity

Supplement 7. The spread of resorts and tourist villages on sandy and rocky beaches

Supplement 8. Resorts of all kinds are factors that disintegrate sandy habitats and decrease plant diversity



Source: Photograph by the researcher, field study, 2019.

Supplement 9. The spread of rocks and woody vegetation aids the growth of the species and increases plant diversity in sandy habitats

CURRICULUM VITAE

Awad G. Ghieth YOUNES received his primary education at Massa Primary School, his preparatory education at Abi Dhar Al Ghafari School for Boys, and his secondary education at Amr Ibn Al-Aas Secondary School. He received his education at Omar Al-Mukhtar University in Al-Bayda, studied at the Faculty of Arts, Department of Physical Geography, and obtained a BA in Geography in 1997. He was nominated as a demonstrator in the Department of Geography in 2000, and the decision was activated in 2004. He started in the postgraduate program at Garyounis University in Benghazi in 2006; he obtained a higher diploma in physical geography in 2007 and a master's degree in biogeography from Garyounis University in 2012. Member of the Preparatory Committee in the eleventh meeting of the Libyan Geographical Society in Al-Bayda 9-11/4/2007. He served as Head of the Geography Department at Omar Al-Mukhtar University between 2013 and 2015. He supervised a bachelor's research entitled Natural Vegetation Cover in Omar Al-Mukhtar Village in 2013. He has published research entitled Water Collection Techniques in the El-Jabal El-Akhdar Basin in the book of Dr Muhammad Ghazi Al-Hanafi, applied research and field studies in the geography and water resources of the El-Jabal El-Akhdar Basin in Libya, chapter fifteen, publications of Omar Al-Mukhtar University, Al-Bayda, Libya in 2019. He was a field research assistant and contributed to research groups on natural vegetation and hydrology in Jabal Akhdar. He was nominated for a PhD in 2015; in 2016, he joined Karabuk University in Turkey. He is working on a botanical atlas of plant species in the coastal dunes.