Multilayered Vulnerability Assessment : Kerkennah Archipelago - Tunisia

Climate, Urban, and Biodiversity Dimensions

Under the Resilient Settlements for the Urban Poor (RISE UP) Flagship Programme

APRIL 2025

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About the Cover Illustration

This hand-drawn style cover graphic is a tribute to the essence of Kerkennah, blending elements of its cultural heritage, natural landscape, and community resilience. The visual was developed to accompany the Multi-layered Vulnerability Assessment (MVA) for the Kerkennah Archipelago and serves as a symbolic introduction to the territory and its challenges.

Key Elements Illustrated:

Element N	Key Feature	Description
1	Traditional Fishing	The fisherman and the charfia (palm-trunk fish trap) represent the island's artisanal fishing heritage and reliance on marine ecosystems.
2	Biodiversity Symbols	Blue crab, flying birds, palm trees, and coastal plants reflect the rich biodiversity facing climate and urbanization pressures.
3	Coastal Architecture	The white-domed building represents a traditional shrine (ولي صالح) deeply rooted in Kerkennah's spiritual and cultural identity, reflecting community heritage and resilience.
4	Intergenerational Farming	A youth and elder planting together underline the passing down of agricultural knowledge and care for the land.
5	Environmental Fragility	The fluid sea lines and low-lying coastline hint at Kerkennah's vulnerability to erosion and rising sea levels.


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Multi-layered Vulnerability Assessment for Kerkennah Archipelago, Tunisia

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RISE UP for Sustainable Urban Resilience

Multi-layered Vulnerability Assessment for Kerkennah Archipelago

United Nations Human Settlements Programme

Foreword from Head of UN-Habitat Tunisia Office

Communities across Tunisia are increasingly gaining awareness about the impacts of climate change through rising sea levels, coastal erosion, water scarcity, and extreme weather events. These risks threaten both livelihoods and ecosystems, particularly in vulnerable territories such as the Kerkennah archipelago. UN-Habitat Tunisia is committed to strengthening climate resilience in urban and peri-urban areas, focusing on communities most at risk, including the urban poor, women, youth, and local civil society.

The Multilayered Vulnerability Profile for the Municipality of Kerkennah represents a key milestone in our efforts to promote sustainable, inclusive, and climate-resilient urban development. Developed under UN-Habitat's RISE UP flagship programme with the support of the Spanish Agency for International Development Cooperation (AECID), this profile offers an integrated, evidence-based understanding of climate, urban and biodiversity vulnerabilities in Kerkennah.

Known for its rich heritage, unique ecosystems, and coastal identity, Kerkennah faces pressing challenges such as high soil salinity, sea-level rise, and irregulated urban development. Based on a data-based scientific methodology and a tailored participatory process involving National authorities, regional authorities, and local authorities lead by the Municipality of Kerkennah who coordinated with the local civil society and community, and alongside technical experts, Kerkennah MVA sheds light on local climate impacts and provides a foundation for targeted climate-resilient and nature-based interventions.

This assessment followed a collaborative, cross-sectoral approach, combining spatial analysis, fieldwork, and stakeholder engagement. It offers practical insights for authorities on different scales, planners, researchers and decision-makers to integrate climate risks into urban strategies.

We believe these findings will guide immediate action and help catalyze long-term partnerships and investment. We invite donors, institutions, and private actors to make a good use of this profile as a guiding framework to support Kerkennah archipelago and similar territories across Tunisia.

UN-Habitat Tunisia office expresses its full appreciation to AECID (Spanish Agency for International Development Cooperation), national and local authorities, and our dedicated partners for their collaboration. Together, we can build a more resilient and sustainable urban future for all Tunisians.

Dr. Aida Robbana

Head of Programme

UN-Habitat Tunisia Office

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Abbreviations

AKDDCL – Kerkennah Association for the Sustainable Development of Culture and Leisure
AMCP – Marine and Coastal Protected Areas
APAL – Coastal Protection and Planning Agency
CATU – Land Use Planning and Urban Development Code
CRDA – Regional Commissariat for Agricultural Development
ASP/DB – Specially Protected Areas and Biological Diversity in the Mediterranean
DGEQV – General Directorate for Environment and Quality of Life
DGPA – General Directorate for Fisheries and Aquaculture
ESA – European Space Agency
IPCC – Intergovernmental Panel on Climate Change (GIEC in French)
GPM – Global Precipitation Measurement
IBA – Important Bird Area
INM – National Institute of Meteorology
INS – National Institute of Statistics
LST – Land Surface Temperature
MVA – Multilayered Vulnerability Assessment
NASA – National Aeronautics and Space Administration
NDWI – Normalized Difference Water Index
OECD – Organisation for Economic Co-operation and Development
NGO – Non-Governmental Organization
PAU – Urban Development Plan
UNEP – United Nations Environment Programme (PNUE in French)
RAMSAR – Convention on Wetlands of International Importance
RGPH – General Population and Housing Census
RCP – Representative Concentration Pathway
USAID – United States Agency for International Development
VISIT – Voluntary Initiatives for Sustainability in Tourism
IBA (ZICO in French) – Important Bird Area

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Executive Summary

This report is part of the "Accelerating the implementation of the Paris Agreement by building the climate resilience of the urban poor in Bolivia, Colombia, Ethiopia, Jordan, and Tunisia" RISE UP project. It presents a comprehensive analysis of the vulnerability profile of (city in country). The RISE UP project, implemented in collaboration with the Spanish Agency for International Development Cooperation (AECID), seeks to confront the multifaceted and interrelated challenges posed by climate change, urbanization, and biodiversity loss, which are particularly acute in urban areas of the Global South.

As cities grapple with the escalating impacts of climate change — such as rising temperatures, increased flooding, and more frequent extreme weather events — it is crucial to assess the vulnerabilities faced by their inhabitants. Urban areas often exhibit complex socio-economic dynamics and infrastructure limitations that heighten these vulnerabilities, especially for the urban poor in informal settlements. This report focuses on selected secondary and tertiarty cities within these five countries to highlight local contexts of multilayered vulnerability and identify critical intervention areas for enhancing climate resilience.

The selected cities were chosen due to their significant exposure to climate-related risks and the urgent need for enhanced adaptive capacity, particularly among the urban poor residing in informal settlements. By addressing the unique challenges faced by these communities, this analysis serves as a foundation for developing targeted strategies that foster systemic resilience, mobilize and allocate resources, and meaningfully engage stakeholders in coordinated adaptation actions.

By highlighting the current vulnerability landscape, the report aims to equip local and subnational governments, community organizations, and international partners with the data, insights and understanding needed to implement targeted and effective interventions that safeguard urban populations, infrastructure, and ecosystems , and promote sustainable urban development. The findings are anticipated to inform broader climate adaptation policies and practices, ultimately contributing to the long-term sustainability and resilience of urban environments.

General Context

The Kerkennah Archipelago, located in the Mediterranean and belonging to Tunisia, faces multiple economic, social, and environmental challenges. Climate change, rapid urbanization, and biodiversity loss interact in concerning ways, amplifying threats to the archipelago's development viability. For example, urbanization leads to the destruction of natural habitats, thereby intensifying biodiversity loss. At the same time, climate change worsens coastal erosion and flooding, making urban infrastructure more vulnerable and jeopardizing local livelihoods. Rising sea levels, dwindling water resources, and the intensification of extreme weather events further exacerbate these vulnerabilities. The need for a sustainable and integrated approach is therefore essential to ensure the resilience of both the population and the environment.

Geographic and Demographic Situation

Kerkennah is a semi-arid archipelago with low topography, which makes it particularly vulnerable to the effects of climate change. The local population largely depends on artisanal fishing and agriculture, although structural changes in the economy are underway. The territory suffers from rural exodus, especially among young people, due to limited economic opportunities and precarious living conditions.

Economic Sectors

Kerkennah's economy relies mainly on traditional fishing and agriculture, but new sectors are emerging, such as hydrocarbon exploitation and tourism. As a result, all of the island's economic sectors are either vulnerable to climate change or represent an additional risk factor.

Environment and Biodiversity

Kerkennah hosts a unique ecosystem, distinguished by its extensive seagrass meadows of Posidonia, often referred to as the lungs of the Mediterranean. However, this ecosystem is under severe threat:

- **Posidonia seagrass meadows**: They play a vital role in stabilizing the seabed and serve as critical habitats for numerous marine species.
- **Local fauna**: The island is home to emblematic species such as gilt-head bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), and grouper (*Epinephelus spp.*), as well as threatened species like the loggerhead sea turtle (*Caretta caretta*) and the common dolphin (*Delphinus delphis*).
- **Environmental pressures:** Pollution, sea level rise, increasing sea temperatures, ocean acidification, drought, soil and water salinization, and loss of natural

habitats represent major challenges to the preservation of this fragile ecosystem.

Vulnerabilities and Challenges

The archipelago faces several major vulnerabilities, grouped into three main categories: challenges related to urbanization and infrastructure, environmental and climate threats, and biodiversity preservation. Each of these issues requires tailored responses to ensure the territory's resilience.

- **Urbanization and infrastructure:** Uncontrolled urban growth and the lack of adequate infrastructure increase vulnerability to natural disasters.
- **Climate change:** Sea level rise and desertification pose direct threats to local resources and livelihoods.
- **Biodiversity at risk:** The degradation of marine and terrestrial ecosystems negatively affects the local economy and ecological balance.

Vulnerability Hotspots

The core of the analysis is based on the identification of areas with high multidimensional vulnerability, referred to as hotspots. These areas were validated through a participatory process including local consultations, a validation workshop, and coordination with the steering committee. The main identified hotspots are as follows:

1. **The southern coasts of the island,** where the majority of the coastal population, facilities, and infrastructure are concentrated, face significant risks of flooding and sea level rise.
2. **The eastern coasts of the island,** stretching from Ataya in the south to Ennajet in the north. A zone relatively preserved from urbanization, this area—relatively rich in terms of biodiversity—is vulnerable due to human activity, which heavily impacts the local ecosystem. The foreshore is particularly affected by eutrophication caused by the altered tidal flow, slowed down by the bridge connecting Ennajet to Kraten..
3. **Kraten, located at the extreme north of the island,** where scattered urbanization has traditionally coexisted with natural environments (wetlands, agricultural zones, intertidal areas), has experienced rapid densification of construction and accelerated anthropization in recent years. As a relatively isolated area with limited access to public services, social vulnerability combines with climate and environmental vulnerability.
4. **The gulf extending from Cape Bounouma to Sidi Founkhal on the northern coast of the island.** This area, historically free of any occupation, has recently seen rapid urban expansion (notably in Bounouma) and the emergence of new tourism projects (future touristic zone of Sidi Founkhal). The gulf is also impacted by the landscape and environmental effects of the salt flats, which have significantly disrupted the marine current system by closing the intertidal zone that once connected the sea to the north and south of the island.
5. **The center of Gharbi Island,** particularly the two sebkhas (salt flats) of Henchir Salem and Ejlija, which are directly affected by sea level rise.
6. **The southwestern coast of Gharbi Island,** from Sidi Youssef to Ras Essmoum. This area is relatively untouched by urbanization and features a succession of agricultural and wetland zones along a coastline that offers natural shelters for the small boats of local fishers.

Outlook and Recommendations

To ensure the sustainable development of the archipelago, it is essential to adopt an integrated and participatory approach:

1. Strengthen infrastructure and coastal defenses: Protect coastlines and sebkhas, and develop efficient drainage systems.
2. Transition to a sustainable economy: Promote structured sustainable tourism and develop environmentally friendly income-generating activities.
3. Ecosystem protection: Enforce environmental laws and implement strict regulations to preserve biodiversity, while raising community awareness about the importance of conservation.
4. Climate change adaptation plan: Integrate climate risks into local policies and develop effective mitigation strategies.

Conclusion

Kerkennah represents a unique territory with numerous assets, yet it remains highly vulnerable to climate, economic, and social pressures. However, these challenges also present opportunities—particularly in developing a green and circular economy, promoting ecotourism, and fostering innovation in sustainable fishing and agricultural practices. Proactive and sustainable management is essential to secure the archipelago's future, ensure the well-being of its inhabitants, and preserve its exceptional environment.

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INTRODUCTION

Background and Context

CLIMATE CHANGE, URBANIZATION AND BIODIVERSITY

The climate emergency is fundamentally an urban crisis, affecting every aspect of city life. With over 55% of the global population living in cities—expected to exceed 67% by 2050—urban areas face increasing vulnerability to climate change. Rising temperatures, sea levels, and extreme weather events are straining infrastructure, disrupting services, and impacting housing, livelihoods, health, and wellbeing. These pressures are exacerbated by rapid urbanization, population growth, migration, rising poverty, inequality, and biodiversity degradation. Addressing these interconnected issues through urban climate adaptation and resilience building remains one of the most significant challenges faced by cities, particularly in the global South.

Over 90% of cities lie within the world's 36 global biodiversity hotspots, where urban expansion threatens both biodiversity and climate resilience. The loss of natural habitats accelerates as human settlements expand, further exacerbated by climate hazards. Cities are increasingly recognizing the importance of spatial planning and urban land management in safeguarding ecosystems and natural assets. These strategies not only support biodiversity but also enhance climate resilience, delivering co-benefits for both people and nature. Effective spatial planning is crucial to prevent the degradation of settlements that rely on the ecosystem services that biodiversity provides. Targeted pro-biodiversity interventions are urgently needed, both within and beyond urban areas, backed by robust tools and strategies.

UN-Habitat emphasises the necessity of a multidimensional, multidisciplinary approach to understanding and addressing these overlapping challenges in cities, with a focus on building resilience for the one billion urban poor in informal settlements. These marginalized communities are particularly vulnerable to climate hazards and disaster risks, living in fragile areas where unplanned urban growth encroaches on natural habitats. Informal urbanization deepens their vulnerability, while also intensifying the challenges of climate change, urban poverty, and biodiversity loss.

Addressing urban poverty, spatial inequality, and informality is crucial to building systemic climate resilience and promoting sustainable urban futures.

RESILIENT SETTLEMENTS FOR THE URBAN POOR PROGRAMME

In a rapidly urbanizing world facing the climate emergency, RISE UP is UN-Habitat's flagship programme, driving critical investments to build climate resilience and create sustainable urban futures. Supported by key partners such as the Adaptation Fund, Green Climate Fund, the Spanish Agency for International Development Cooperation (AECID), and the Swedish International Development Cooperation Agency (SIDA), RISE UP has mobilized over USD 150 million to accelerate global climate action, particularly in cities most vulnerable to climate change.

RISE UP projects range from constructing flood-resistant infrastructure in South-East Africa to enhancing green spaces in Malaysia and restoring mangrove ecosystems in urban Cambodia. These efforts underscore the interconnectedness of climate resilience and biodiversity. Urban ecosystems like wetlands and green spaces play a critical role in mitigating climate impacts and providing essential services for human wellbeing. Since 2019, RISE UP has worked in over 28 countries, reinforcing UN-Habitat's commitment to urban resilience and biodiversity conservation.

ASSESSING MULTILAYERED VULNERABILITIES IN CITIES AND URBAN AREAS

Multilayered vulnerabilities in urban environments encompass various interconnected challenges that extend beyond physical infrastructure to include spatial, social, economic, climatic, environmental, political, and technological dimensions. Issues like income inequality, environmental degradation, inadequate housing, and insufficient emergency preparedness contribute to a city's multidimensional vulnerabilities.

In this context, multilayered vulnerability refers to the extent to which an urban system, community, or ecosystem is exposed to, sensitive to, and unable to cope with the adverse impacts of interrelated climate change, urbanization, and biodiversity loss. Factors such as geographical location, socio-economic status, infrastructure quality, and governance structures influence this vulnerability. The aggregation of multiple and cascading vulnerabilities exacerbates the overall susceptibility, risk, and adaptive capacity of people, infrastructure, and the environment.

Addressing these challenges to strengthen urban resilience requires comprehensive urban planning and management strategies. Policymakers and practitioners face several obstacles in conducting multilayered vulnerability assessments, including:

The fragmentation of climate change, biodiversity, and urbanization in policy and practice.

- A lack of evidence-based approaches to mapping multidimensional and interrelated vulnerabilities.
- Limited capacities and resources for conducting comprehensive assessments.
- The urban poor and residents of informal settlements being the most affected yet least engaged in decision-making processes.
- Insufficient tools for predicting future land-use changes and urban growth patterns.
- A lack of coordination and cooperation in transboundary and multidisciplinary planning.
- Minimal application of coherent, prioritized interventions and solutions.

These challenges highlight the need for a more integrated approach to vulnerability assessment and management. To address this, UN-Habitat's RISE UP programme has developed the Multilayered Vulnerability Assessment (MVA) tool, whose purpose is to help communities, cities, and local leaders to comprehensively map and assess multilayered vulnerabilities. The tool addresses the nexus between climate change hazards and risks, urbanization and spatial trends and characteristics, and biodiversity loss and land degradation to identify vulnerability hotspots arising from spatial overlaps and conflicts.

By deploying the MVA tool in communities, cities and urban areas, local and national leaders and policymakers in climate-vulnerable cities and communities can better plan and deliver inclusive, sustainable, and resilient urban development strategies for human and non-human inhabitants. This enables decision-makers to make informed choices about urban expansion and adapt to urgent climate-related challenges.

IMPLEMENTATION OF THE MULTILAYERED VULNERABILITY ASSESSMENT TOOL

This report is part of the "Accelerating the Implementation of the Paris Agreement by Building the Climate Resilience of the Urban Poor in Bolivia, Colombia, Ethiopia, Jordan, and Tunisia" RISE UP project in collaboration with the Spanish Agency for International Development Cooperation (AECID). It presents the vulnerability profiles of the selected project cities, detailing the outcomes of Stages 1 and 2 of the MVA, including preparation, and mapping and analysis, that will inform Stage 3: action planning.

The project engages communities in Cobija and Charagua in Bolivia, San Juan de Pasto in Colombia, Debre Birhan in Ethiopia, Sahab Municipality in Jordan, and Kerkennah in Tunisia. The selection of these locations was guided by several critical factors:

The MVA implementation in Bolivia, Colombia, Ethiopia, Jordan, and Tunisia lays the groundwork for targeted climate resilience interventions. With a focus on high-risk areas, strong community engagement, and collaboration with local governments, the project leverages local capacities for effective action.

General Context: Climate Change, Urbanization and Biodiversity.

The Mediterranean region as a whole—and Tunisia in particular, where the Kerkennah archipelago is located—is facing major economic, social, and environmental challenges driven by climate change, rapid urbanization, and biodiversity loss.

Climate change is affecting Tunisia in increasingly alarming ways. According to projections from the National Institute of Meteorology (INM), based on two emissions scenarios—the moderate RCP4.5 and the pessimistic RCP8.5—by the year 2100, the country is expected to experience a significant rise in temperatures, a decrease in precipitation, and rising sea levels (see Map 1).

For a semi-arid country like Tunisia, these developments intensify desertification and the depletion of water resources, placing agriculture and food security at serious risk. Furthermore, the growing frequency of extreme weather events—such as droughts and floods—is weakening infrastructure and natural ecosystems. The accelerated pace and severity of these events observed in recent years largely validate these projections.

Among the key factors that exacerbate these risks in Tunisia are:

1. Rapid and often uncontrolled urban expansion: Tunisia's high urbanization rate (72% in 2020 according to the OECD) and the fast-paced growth of coastal cities have led to unregulated urban sprawl. Informal housing, which made up over 40% of the national housing stock in 2014 (General Directorate of Housing), contributes to numerous environmental issues, including overstretched infrastructure, loss of natural spaces, and growing pressure on water resources. Major coastal cities such as Tunis, Sfax, and Sousse are especially vulnerable to climate change impacts—particularly sea level rise and coastal erosion.
2. Deforestation, overexploitation of natural resources, and pollution: According to the sixth national biodiversity report, Tunisia is undergoing an accelerated loss of biodiversity driven by multiple factors, including expanding urbanization, overuse of natural resources, climate change, and pollution. These pressures are impacting both terrestrial and marine ecosystems, threatening several endemic species and undermining the ecological services that are vital to agriculture and water resources.

   Despite ongoing conservation efforts and the designation of protected areas, the degradation of natural habitats and the decline of native flora and fauna continue.

Tunisia is thus at a critical juncture in its development, where environmental challenges play a decisive role in shaping its future. Sustainable land management, coupled with effective climate policies, is essential to address the intertwined challenges of climate change, urbanization, and biodiversity loss. The adoption of both adaptation and mitigation strategies—alongside more environmentally sustainable urban planning—represents a key pathway toward securing a viable future for generations to come. These strategies must be formulated and implemented across all territorial levels—national, regional, and local—and engage all sectors.

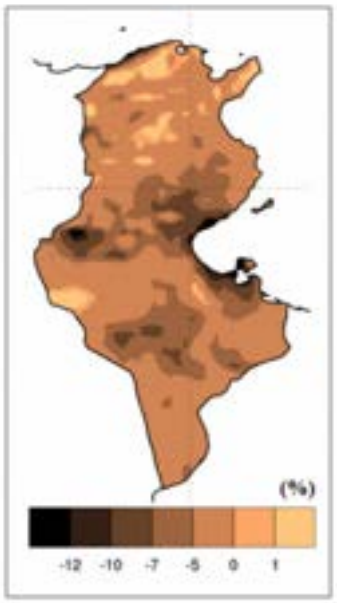
It is within this context that the present Multilayered Vulnerability Assessment (MVA)[1] of Kerkennah has been undertaken. Its objective is to assess the multiple vulnerabilities affecting this territory at the local level—an area particularly exposed to environmental, social, and economic risks. This document aims to identify key vulnerability factors, analyze local resilience capacities, and propose recommendations to strengthen adaptation and crisis response strategies. It serves as a decision-support tool for urban planning and risk management by providing reliable data and in-depth analyses.

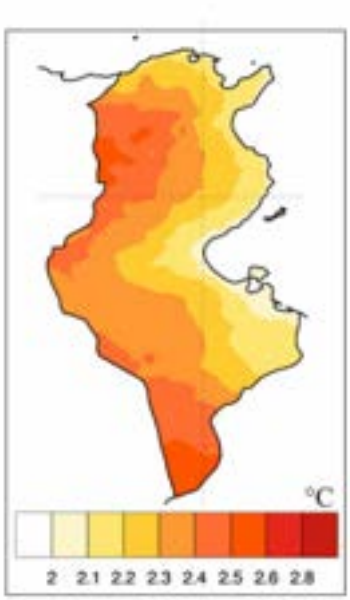
1 United Nations Human Settlements Programme (UN-Habitat). (2024). Multilayered Vulnerability Assessment Handbook: Resilience planning for urban, biodiversity, and climate action.

Daily precipitation

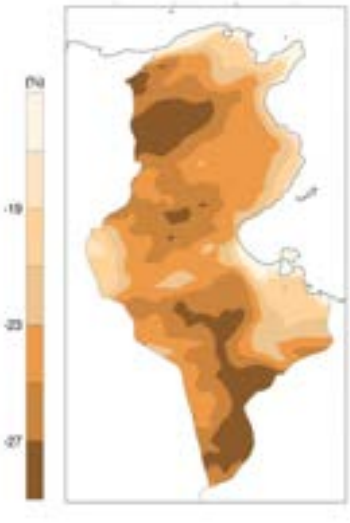
Average daily temperatures

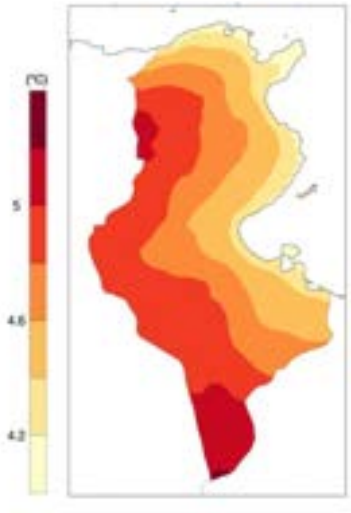
RPC 4.5





RPC 8.5





Map 1: Projected Precipitation and Temperature by 2100 under RCP 4.5 and RCP 8.5 Scenarios (Source: INM)

Specific Context of Kerkennah

LOCATION AND GEOGRAPHY

A flat, Semi-Arid, and Isolated Island Shaped by the Sea

The Kerkennah archipelago (Qarqna), the subject of this report, is located approximately 20 kilometers (12 miles) off the Tunisian coast near the city of Sfax, at the entrance of the Gulf of Gabès (southeastern Tunisia – 34°42'N, 11°10'E) (see Map 2). It comprises two main islands: Gharbia (Dzira or Mellita) to the southwest, covering 49 km², and Cherguia (also called Kerkena) to the northeast, covering 110 km². Cherguia is itself surrounded by around ten islets, including Charmandia, Sefnou, Roummadiya, Rakadiya, Lazdad, Gremdi, and Haj Hmida. The archipelago is flat, characterized by low steppe-like terrain stretching from southwest to northeast over roughly 30 kilometers. Due to its narrow width, no point on the islands is more than 5 km from the coastline, underscoring the centrality of the sea in both the natural landscape and the daily lives of the Kerkennians (Trousset, 2005).

The climate of the Kerkennah archipelago is classified as arid Mediterranean, characterized by hot, dry summers and mild, wet winters. Summer temperatures can reach up to 35°C, while winter temperatures typically range between 10°C and 15°C. Annual rainfall is low, generally not exceeding 200 mm, which limits the development of dense vegetation. The archipelago is also exposed to prevailing winds, particularly the sirocco—a hot, dry wind blowing from the Sahara—which further intensifies aridity. However, the proximity of the sea helps to moderate temperature extremes, resulting in a climate that is relatively milder than that of Tunisia's inland regions.

Much of the land in Kerkennah lies below 2 meters in elevation (see Map 3). These low-lying areas—often basins connected to the sea—host sparse, salt-tolerant vegetation and are largely made up of coastal sebkhas. Sebkhas are shallow depressions open to the sea that collect runoff, marine intrusions during high tides or storms, and groundwater that rises by capillarity. As this water evaporates, it leaves behind salt crusts that are reshaped by the wind. This process encourages the growth of halophilic (salt-loving) plants along the periphery, while the central areas remain largely sterile. The vegetated portions of the sebkhas, known as chotts, are closely associated with these ecosystems.

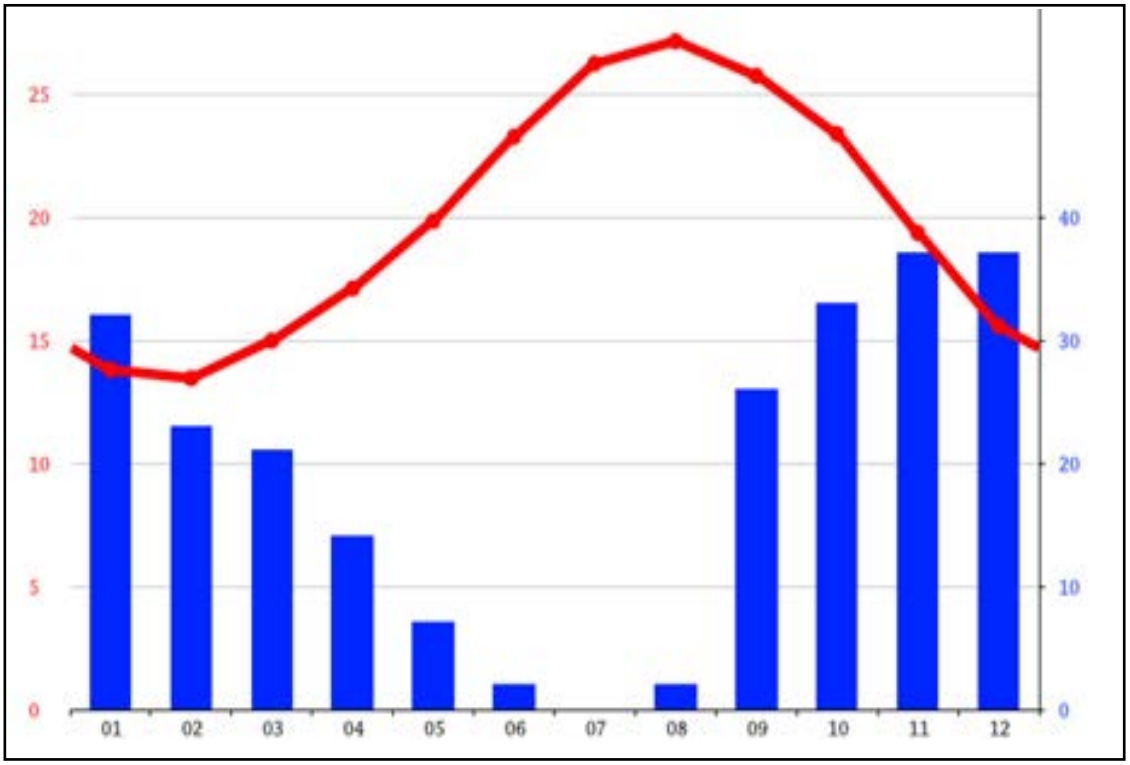


Fig. 1: Climatic Characteristics (Monthly Averages Recorded in Ouled Yaneg) of the Island of Kerkennah[2]

2 Source: climate-data.org data 1991 - 2021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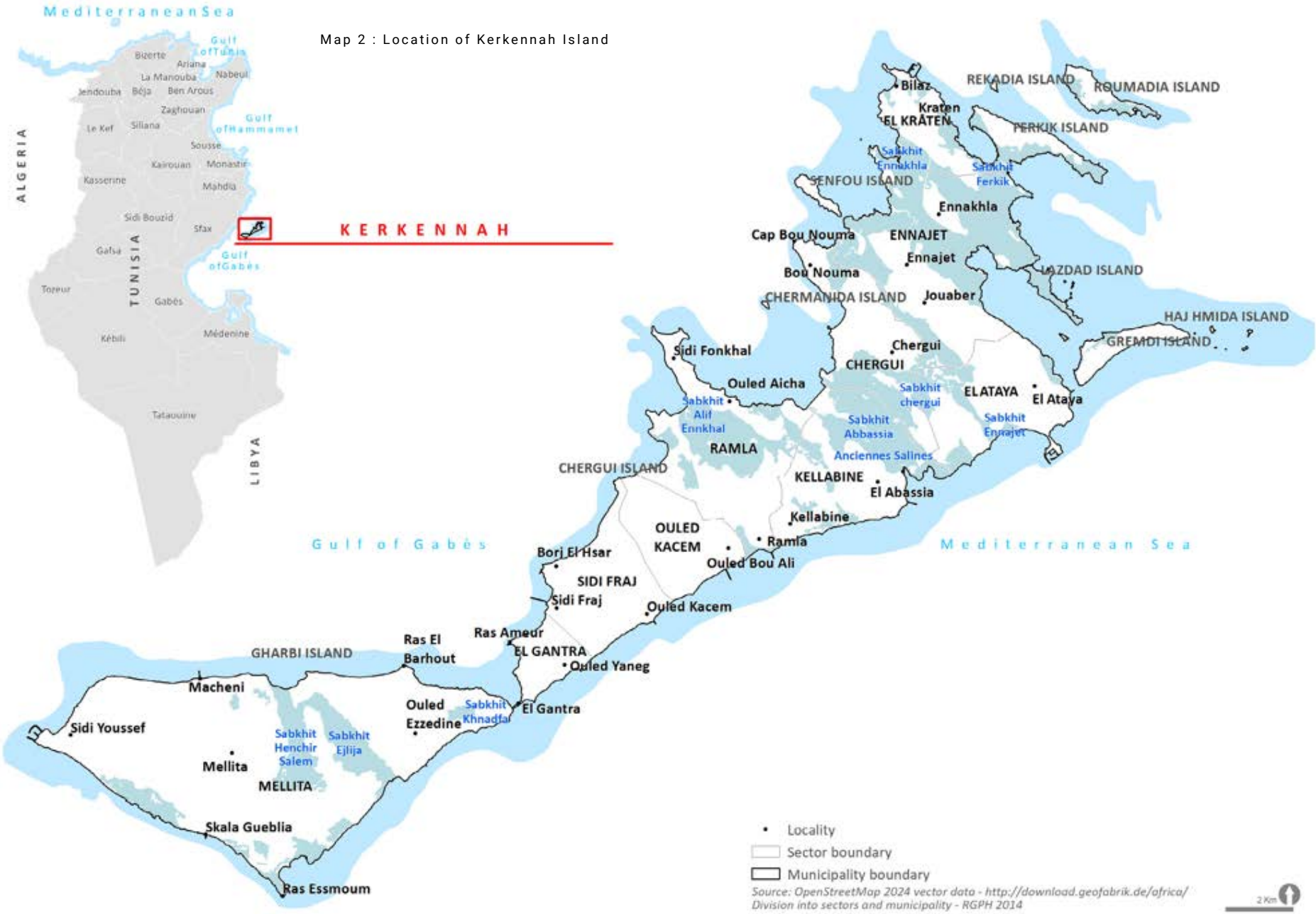
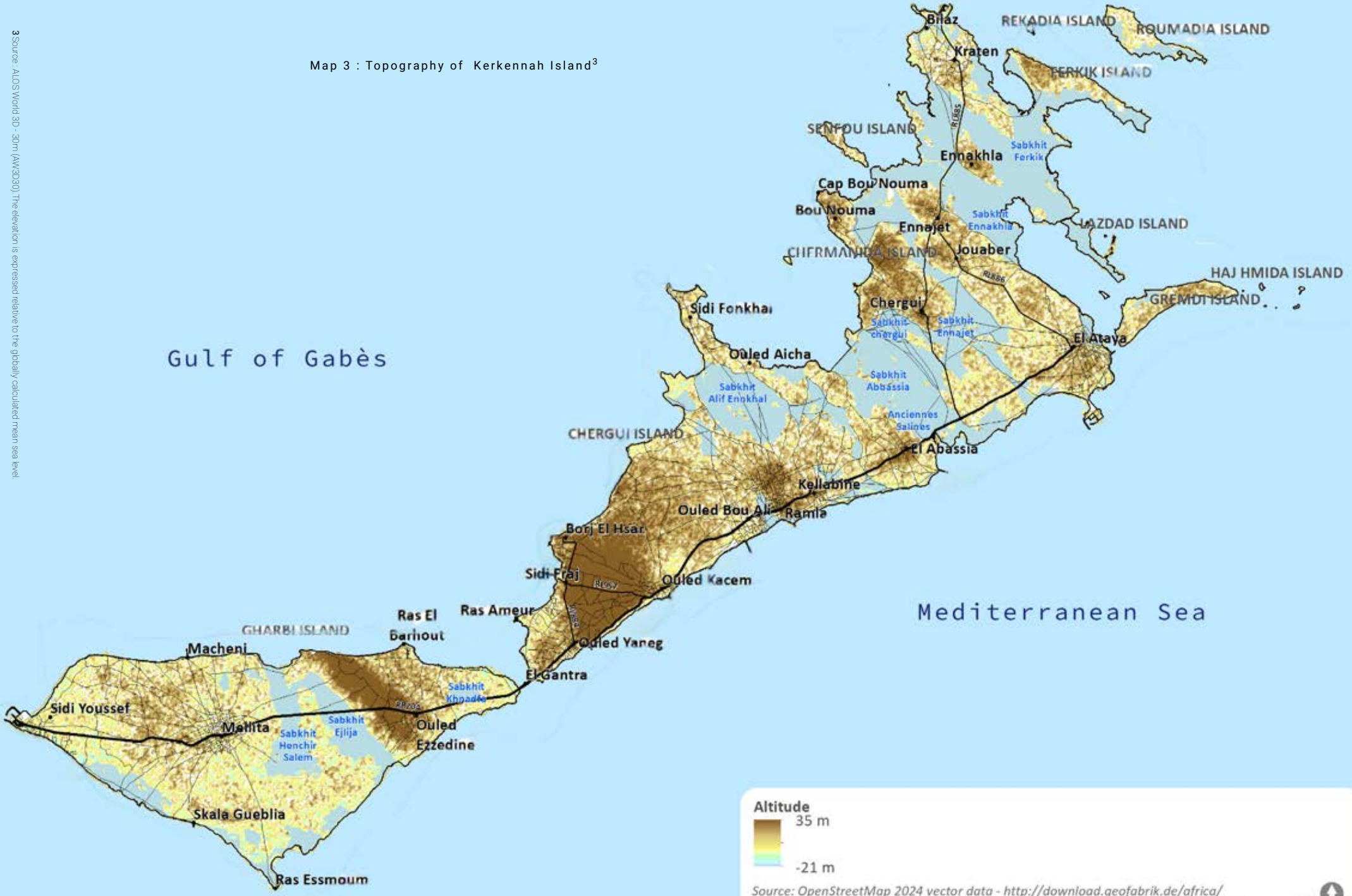
Map 2 : Location of Kerkennah Island



Map 3 : Topography of Kerkennah Island[3]



3 Source: ALOS World 3D - 30m (AW3D30) The elevation is expressed relative to the globally calculated mean sea level.

History of the Development and Growth of the Archipelago

A HISTORICALLY INHABITED TERRITORY ON THE MARGINS OF RECENT NATIONAL DEVELOPMENT

The two main islands of the archipelago are connected by a causeway built along the ancient Roman road known as El Kantra. This remnant, along with archaeological sites scattered along the northern coast, attests to the island's long history of settlement and the richness of its cultural and civilizational heritage. Since antiquity, the islands have been inhabited by the Phoenicians, who established strategic trading posts due to their advantageous maritime position. They later came under Carthaginian control before being incorporated into the Roman Empire, during which time they thrived through fishing and agriculture. In the Middle Ages, Kerkennah experienced a series of invasions—including Arab, Norman, and Ottoman—which shaped its cultural identity.

During the modern period, beginning with French colonization, the archipelago remained largely on the margins of the country's economic development, maintaining a traditional way of life centered on artisanal fishing and subsistence agriculture. Due to its relative isolation and unfavorable geographic conditions, Kerkennah did not benefit from the rapid growth of the city of Sfax—located just across the water on the mainland—which received significant investment in industry, commerce, services, and infrastructure, becoming Tunisia's second-largest economic hub. Nevertheless, Kerkennah remains a symbol of Tunisia's maritime heritage and draws attention for its unique biodiversity and ancestral fishing practices, such as charfia, which was inscribed on the UNESCO list of Intangible Cultural Heritage of Humanity in 2022.

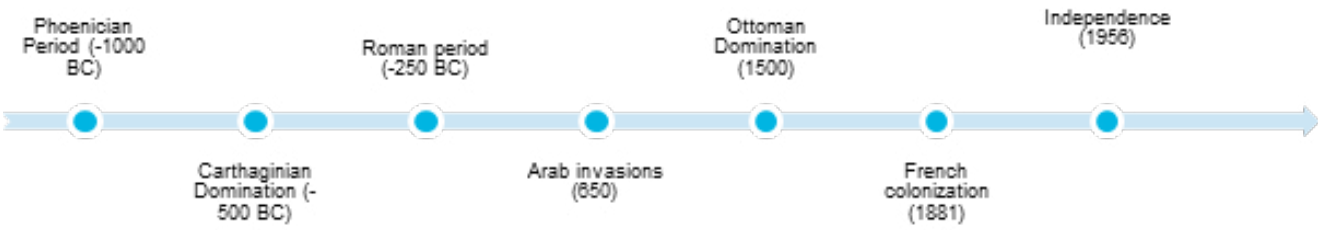


Fig. 2: Chronology of Human Settlement on Kerkennah Island

Fig. 3: Archaeological Site of Borj Lahsar (Wikimedia)

Demography

AN AGING POPULATION

According to the most recent population and housing census conducted in 2014, Kerkennah had 15,501 inhabitants. The latest official projections by the National Institute of Statistics (INS), as of January 1, 2022, estimate the population at 16,395—equating to a density of nearly 100 inhabitants per square kilometer.

The most densely populated areas are Mellita, Ramla, Kellabine, and Attaya. These are the archipelago's largest urban centers and the only ones showing slight population growth. The remaining sectors are sparsely populated and are experiencing either stagnation or demographic decline (see Map 4).

It is also worth noting that the population of all sectors increases significantly during the summer due to the return of emigrants and the arrival of seasonal visitors. In fact, according to the census, only 49.83% of dwellings are occupied year-round; the rest are secondary residences (37.33%), vacant (9.36%), or abandoned (1.86%).

The population of the archipelago is relatively old, with an inverted age pyramid. People aged over 40 represent more than 45% of the population, and those aged 60 and above account for 18.16%—compared to a national average of 11%. In contrast, individuals under 20 represent only 26% of the population, compared to 32% nationally.

The sex ratio in Kerkennah is nearly balanced, with an equal number of men and women. However, socio-economic indicators reveal significant gender disparities. Women are more affected than men by both illiteracy (25.77% compared to the national average of 10.36%) and unemployment (29.2% versus 5.56% nationally). These gaps are especially pronounced among older age groups. Among younger women aged 15 to 29, however, the illiteracy rate is notably lower—1.61% compared to 1.86% for young men.

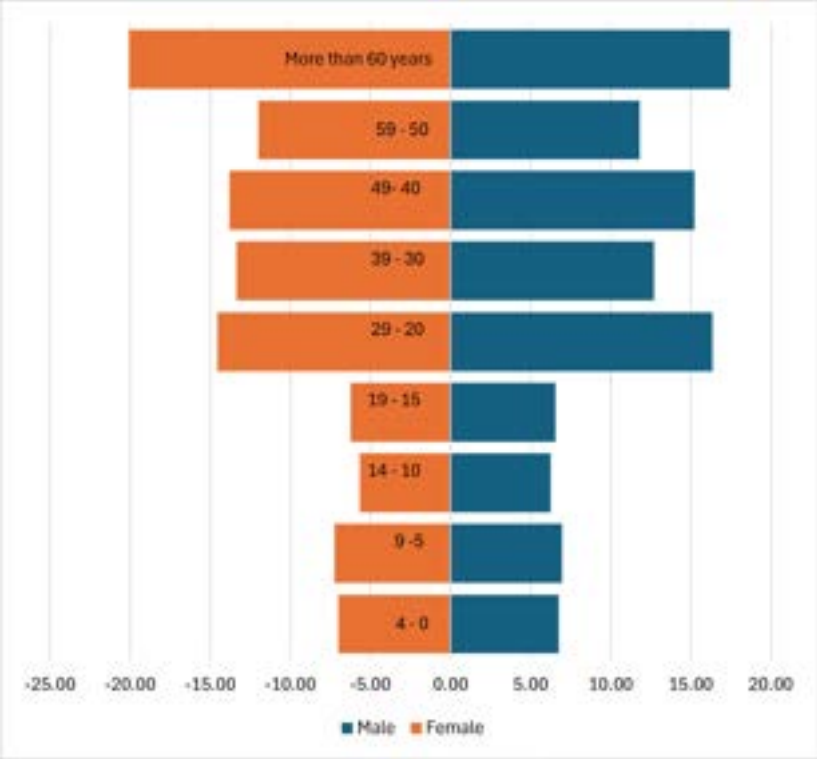
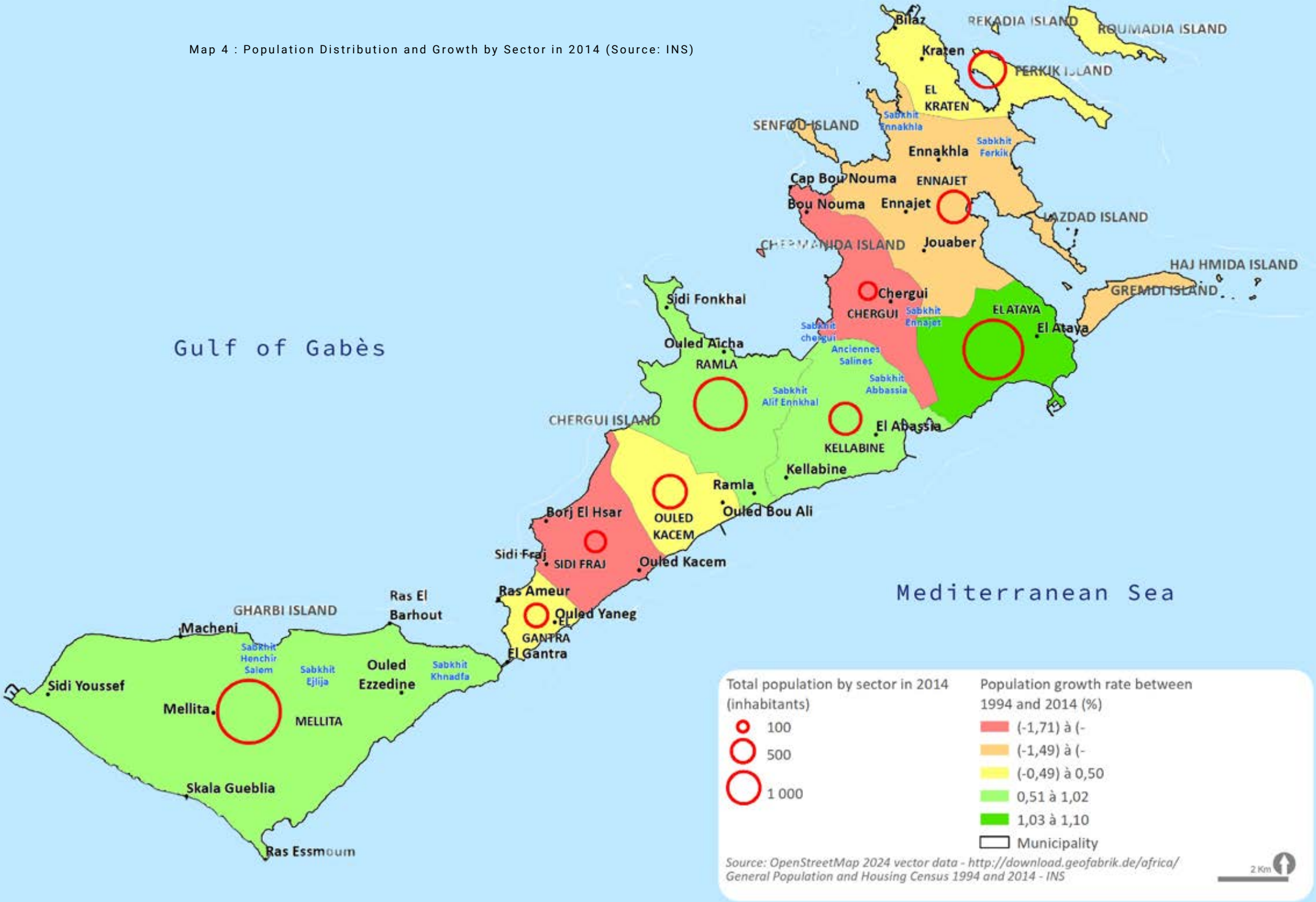


Fig. 4: Age Pyramid of Kerkennah Island in 2014 (Source: INS)

Map 4 : Population Distribution and Growth by Sector in 2014 (Source: INS)



Economic Sectors

A RURAL ECONOMY STARTING TO DIVERSIFY

Kerkennah's economy is primarily based on agriculture (which employs 41.78% of the workforce, mostly men) and public services, including administration (22.72%, primarily women).

Agriculture and fishing are practiced traditionally and on a small scale, providing for local subsistence with limited external dependency. The main catches include tuna, sardines, and octopus, while crops such as date palms, figs, grapes(Asli), olive trees, and cereals are cultivated for household consumption (see Map 5).

1. In recent years, two emerging sectors have begun to diversify the local economy—though not without potential risks: Hydrocarbons: Oil and gas reserves have been discovered both on land and offshore. Drilling operations and undersea pipelines have been installed in the Kerkennah Channel. While this activity has not directly created local employment, it has generated indirect jobs and some infrastructure investment by major companies. However, residents are concerned about the environmental risks, especially the possibility of oil spills or leaks that could severely damage Kerkennah's natural environment and threaten its fishing-based economy.
2. Tourism: Government initiatives and international support—such as USAID's VISIT Tunisia project in 2023—have promoted the archipelago as an ecotourism and cultural destination, including activities like snorkeling. Museums and cultural centers have also been developed to attract visitors. However, the tourism sector remains largely informal, dominated by secondary residences and occasional rentals, and is constrained by a weak local ecosystem (limited accommodations, few entertainment options, etc.).

In summary, Kerkennah's heavy dependence on fishing and agriculture, coupled with its semi-arid conditions and unique coastal morphology, make it particularly vulnerable to the effects of climate change. Although new sectors like oil and tourism offer economic potential, they must be integrated into a broader vision of sustainable territorial development to prevent additional fragility.

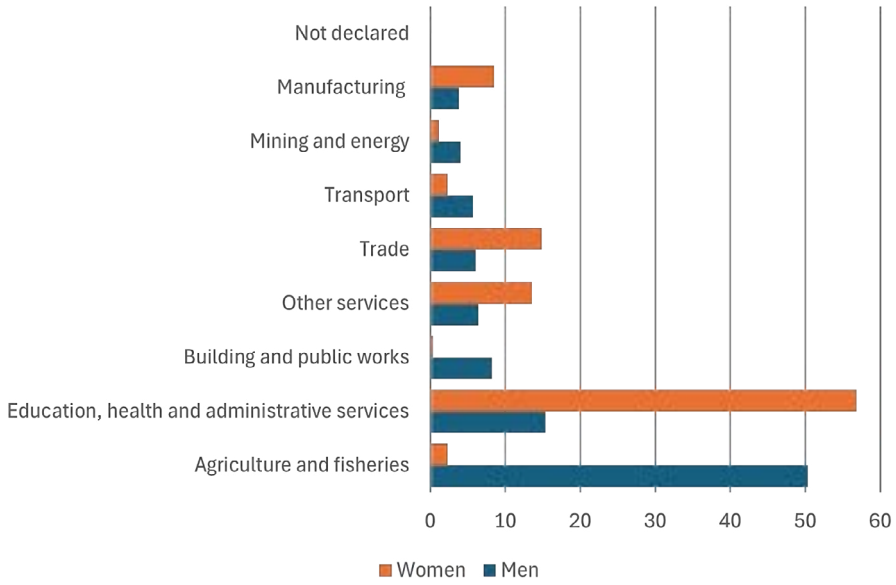
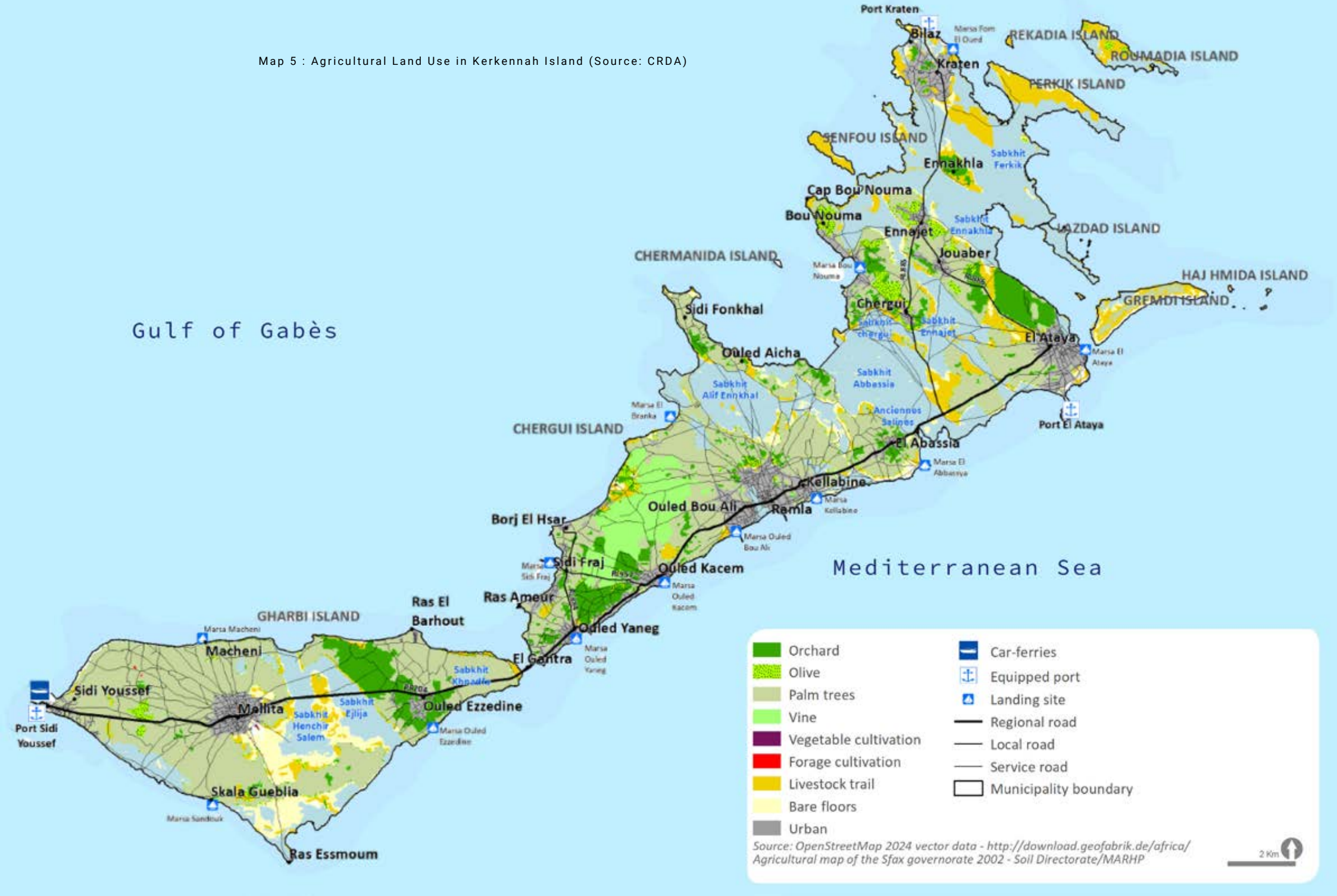


Fig. 5: Employment Distribution by Sector in 2014 (Source: INS)

Map 5 : Agricultural Land Use in Kerkennah Island (Source: CRDA)



Environment, Biodiversity and Climate

A UNIQUE ECOSYSTEM UNDER THREAT

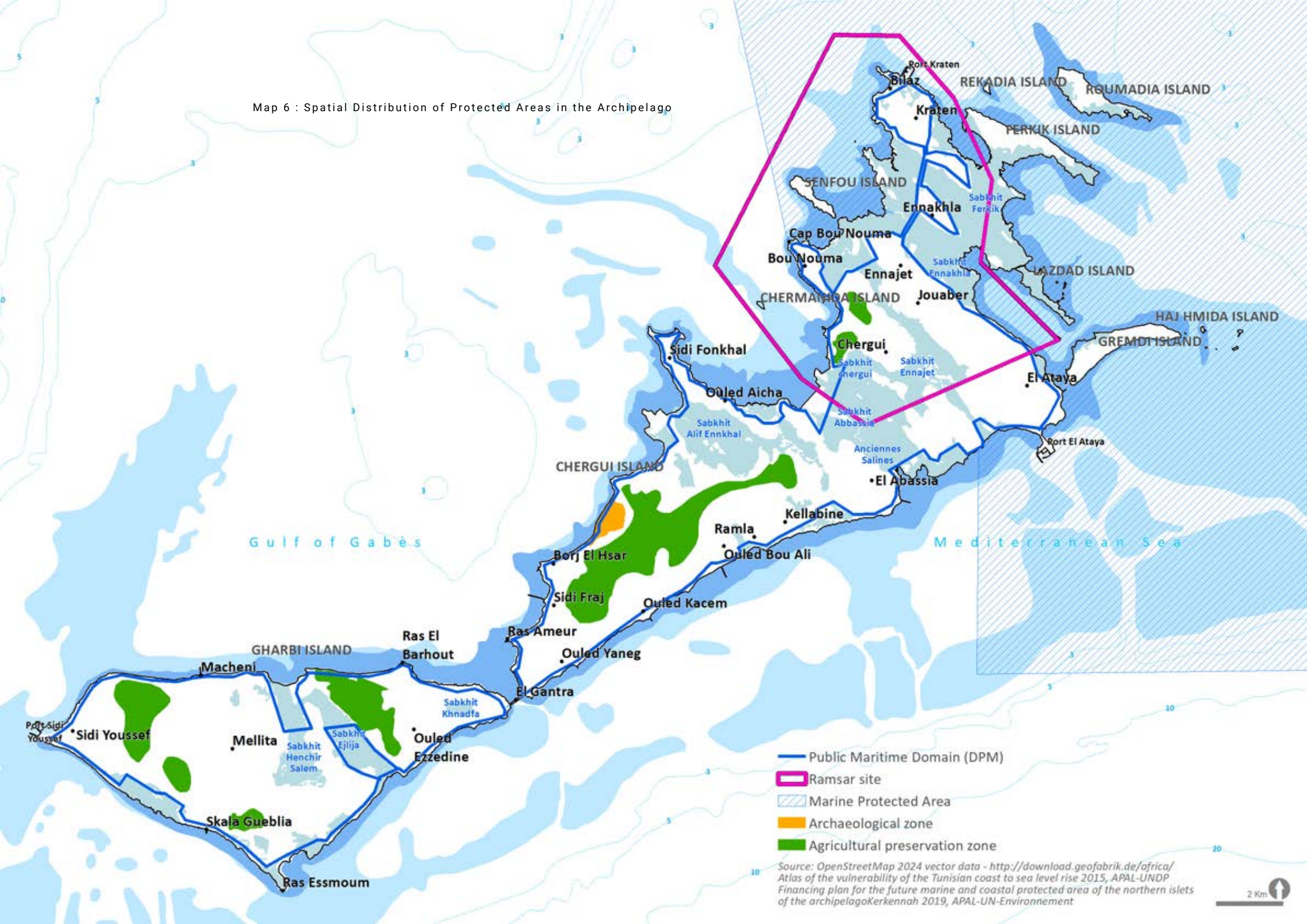
The Kerkennah Archipelago is characterized by remarkable biodiversity. Its marine and terrestrial landscapes offer a unique habitat to numerous marine and terrestrial species adapted to the specific conditions of this semi-arid insular environment.

At sea, the archipelago is surrounded by vast seagrass meadows of Posidonia oceanica and Cymodocea nodosa, which stabilize the seabed and provide shelter for many species. Among the most emblematic species of the island are fish such as sparids (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), dusky grouper (E*pinephelus marginatus*), and red mullet (*Mullus surmuletus*), as well as crustaceans and mollusks such as the common cuttlefish (*Sepia officinalis*), the common octopus (*Octopus vulgaris*), and the caramote prawn (*Melicertus kerathurus*), in addition to threatened or protected species such as the loggerhead sea turtle (*Caretta caretta*) and the bottlenose dolphin (*Tursiops truncatus*). Some of these species are essential to ecological balance, while others are central to the lifestyle of the inhabitants of Kerkennah, where artisanal fishing constitutes a major economic activity.

On land, the archipelago possesses an ecosystem shaped by a semi-arid climate and particular geological conditions. Its sandy soil and low elevation make the archipelago vulnerable to marine winds and salinity, which limit plant diversity. However, some plants have developed adaptation strategies to survive in this harsh environment. Among the dominant plant species found in the archipelago are esparto grass (*Lygeum spartum*), date palm (*Phoenix dactylifera*), white wormwood (*Artemisia herba-alba*), white bean-caper (*Zygophyllum album)*, cogon grass (*Imperata cylindrica*), and sea rush (*Juncus maritimus*). This terrestrial habitat, despite its unfavorable conditions, also shelters fauna adapted to local conditions. Reptiles such as the Montpellier snake (*Malpolon monspessulanus*) are present, as well as birds—Kerkennah being an Important Bird Area (IBA)—including the great cormorant (*Phalacrocorax carbo*), slender-billed gull (*Larus genei*), lesser black-backed gull (*Larus fuscus*), yellow-legged gull (*Larus michahellis*), Caspian tern (*Hydroprogne caspia*) , common tern (*Sterna hirundo*), common kestrel (*Falco tinnunculus*), cream-colored courser (*Cursorius cursor*), European bee-eater (*Merops apiaster*), and southern grey shrike (*Lanius meridionalis*). The archipelago also serves as a major stopover and nesting site for hundreds of thousands of migratory passerines in autumn and spring.

Despite its adaptability, Kerkennah's terrestrial biodiversity faces numerous challenges. Increasing urbanization, infrastructure development, and the overexploitation of resources threaten the natural habitats of many species. In response to these threats, local and international initiatives have been implemented to preserve this unique ecosystem. A large part of Chergui Island has been designated as a RAMSAR site since 2012, and in 2023, a vast marine area to the north of the archipelago was added to the list of future Marine and Coastal Protected Areas (MCPA) (see Map 6).

Map 6 : Spatial Distribution of Protected Areas in the Archipelago



Urbanization Trends

URBAN GROWTH OUTPACING POPULATION GROWTH

Human settlement in Kerkennah dates back to ancient times (see Historical Overview). The archipelago's urbanization has been shaped by its insular character, cultural heritage, and environmental constraints. Faced with poor climatic and soil conditions and limited arable land, local populations historically concentrated in urban centers to preserve the few cultivable areas. With the exception of Mellita, all major settlements are located along the coast, though set back slightly from the shoreline to avoid climate-related risks. Traditional architecture in these towns makes use of local materials—such as limestone and palm wood—and employs techniques adapted to the arid environment.

Although the island's harsh living conditions, relative isolation, and limited natural resources have helped maintain a stable population size, migration has also acted as a regulatory force. This trend continues today: the population has grown at a very modest rate of just 0.78% per year since 1994, compared to 1.06% for Tunisia as a whole and 1.2% for the Sfax governorate.

Paradoxically, satellite images and aerial photographs since 1940 show that urban expansion in Kerkennah has proceeded at a much faster pace than its demographic growth. In recent years, the rise of tourism, proliferation of secondary homes, and seasonal return of the diaspora have driven unregulated urban growth. Currently, fewer than half of all housing units are occupied year-round. Urban development has started to spread across the entire territory and along the coast. Previously untouched coastal areas, farmlands, and wetlands are now being urbanized and converted to other uses (see Map 7).

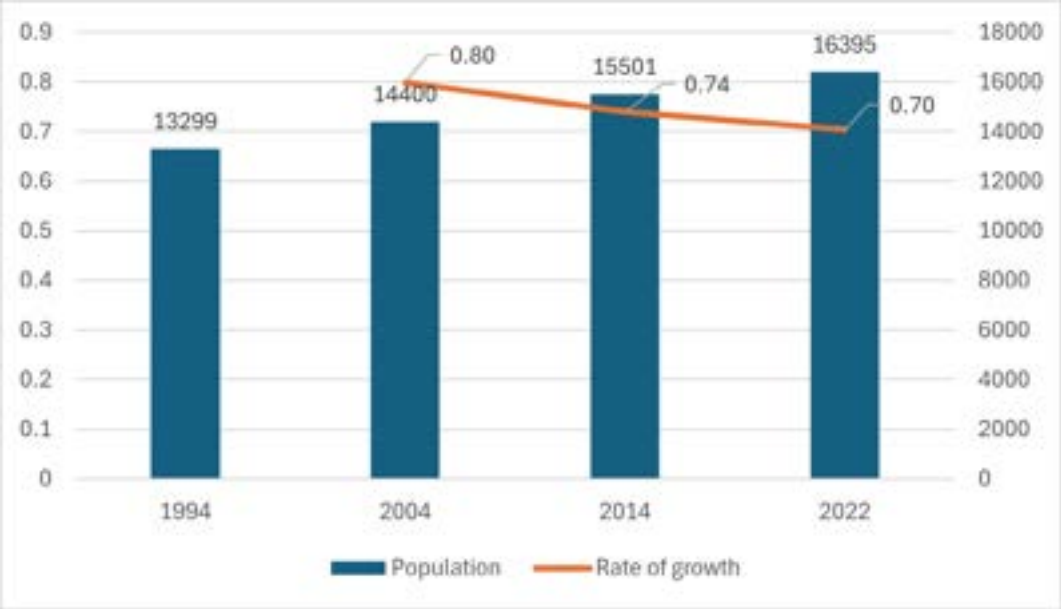
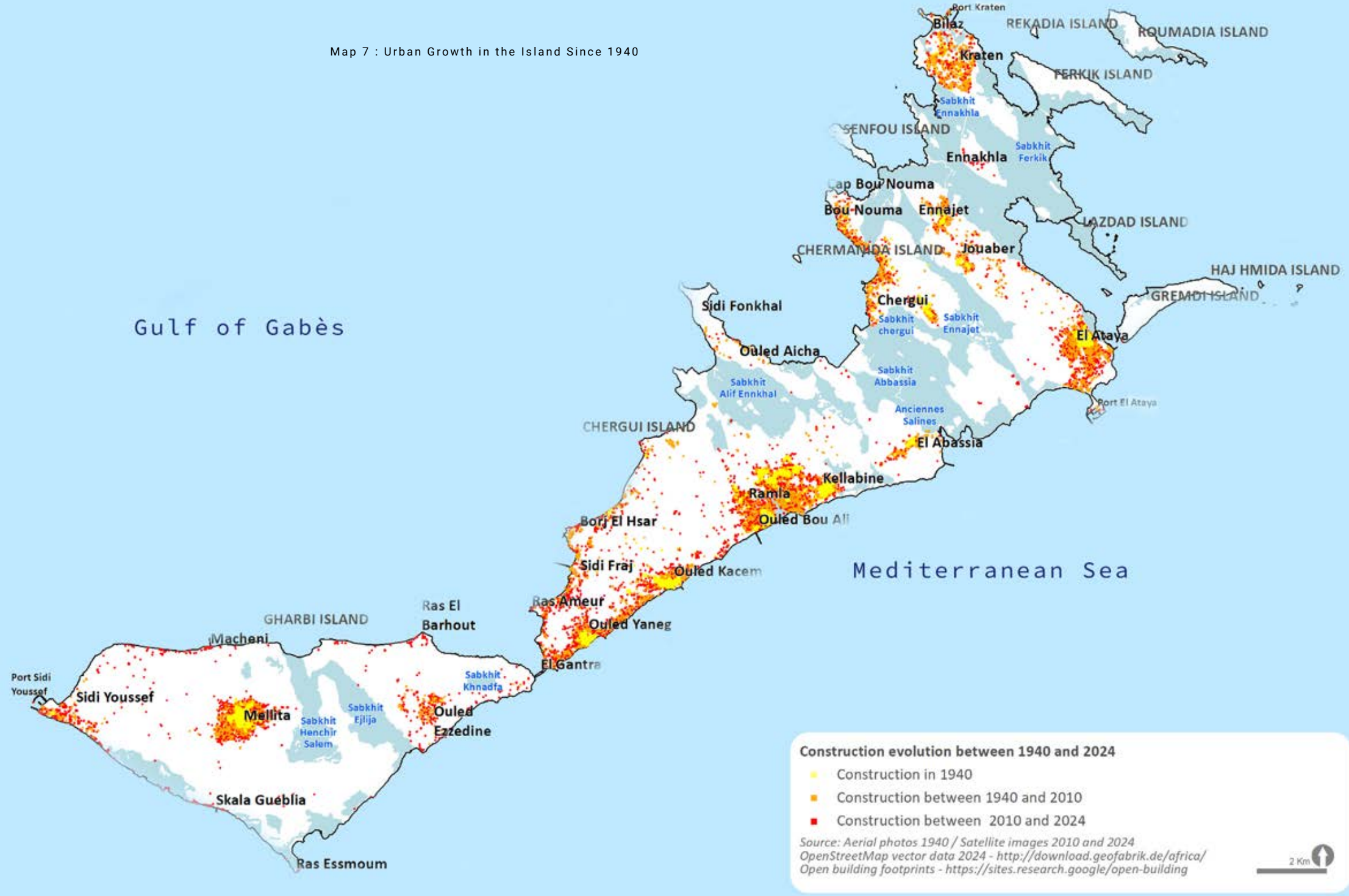


Fig. 6: Population Size and Growth of the Archipelago Since 1994

Map 7 : Urban Growth in the Island Since 1940



Social Infrastructure and Services

A GENERALIZED COVERAGE OF BASIC LOCAL SERVICES, BUT LIMITED ACCESS TO SPECIALIZED AND INTERMEDIATE SERVICES.

Access to essential urban services is nearly universal across the Kerkennah archipelago. According to the 2014 census, 97.62% of households are connected to the public drinking water supply and 98.41% to the public electricity grid. However, only 30.95% of dwellings—mostly in the municipal capital—are connected to a wastewater sanitation network.

The situation is more nuanced when it comes to access to public facilities. The spatial distribution of infrastructure and the configuration of the transportation network mean that some areas of the island are far from key services. While most residents can access basic facilities (primary schools, health posts, and kindergartens), access to intermediate services—such as youth centers, sports facilities, hospitals, middle schools, and high schools—is much more limited.

This disparity is linked to the island's layout, land use patterns, transport options, and the uneven distribution of public infrastructure. Basic services are relatively well distributed across the island's villages, but higher-level facilities are concentrated in the main urban centers, particularly in Ramla, the municipal capital (see Map 8). These services are accessible only via road and the local bus system, which connects most of the archipelago's key settlements (see Map 9)

It should be noted that despite relatively easy access to basic services, these—particularly health services—suffer from limited availability of care. Consultations with a general practitioner are provided only one day per week, with registration possible only in the morning before 10 a.m. Patients are then referred to the regional hospital, which suffers from a shortage of specialists, forcing most patients to travel back and forth between Sfax and Kerkennah.

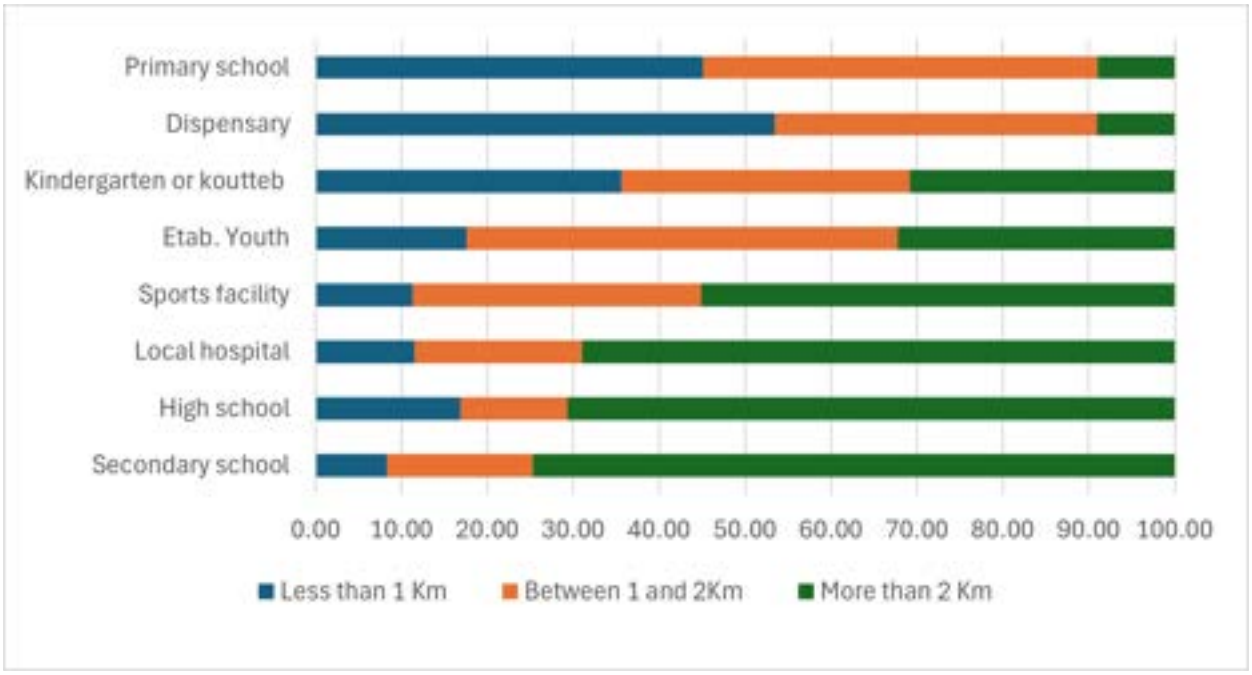
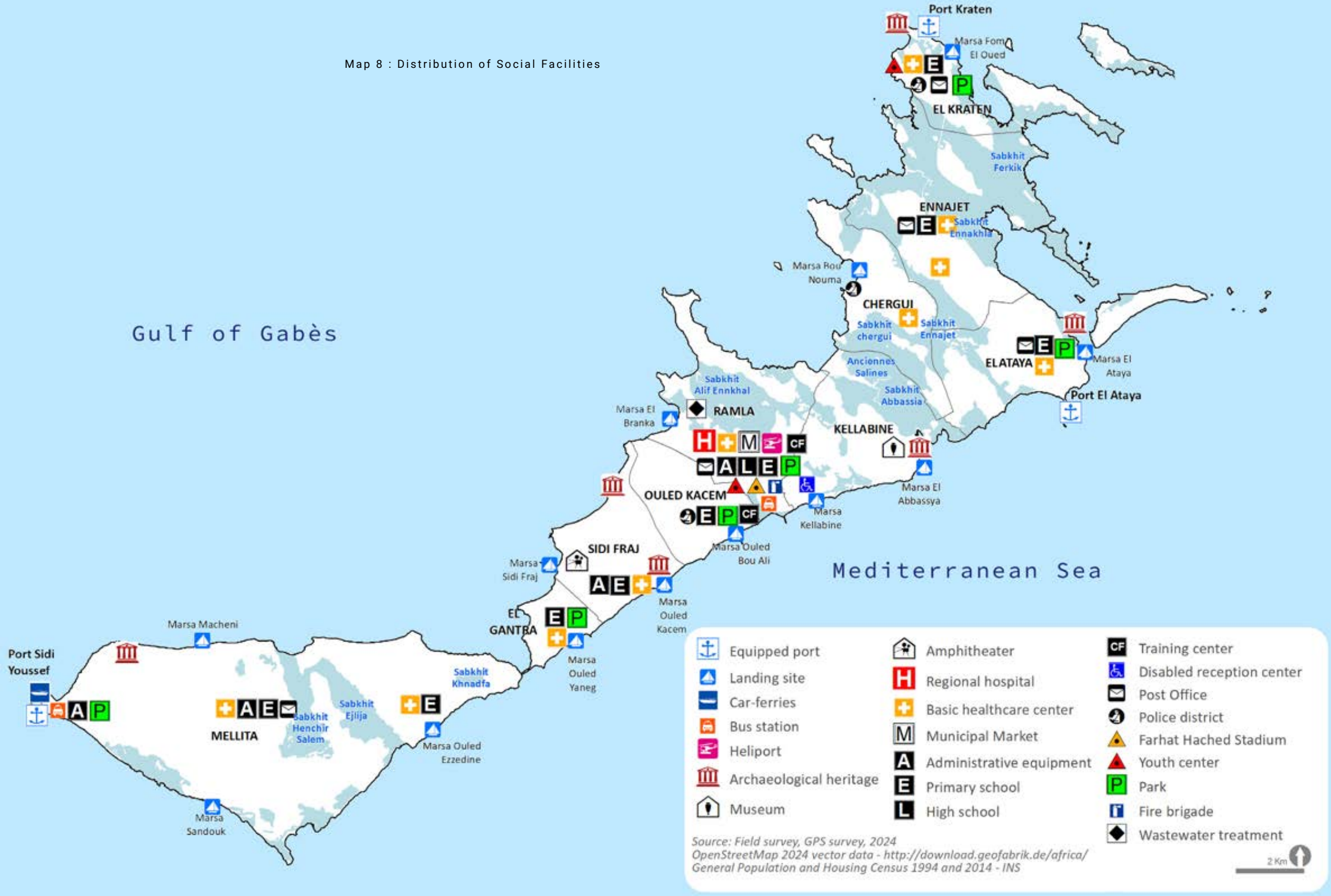


Fig. 7: Distribution of Housing by Distance to Social Facilities

Map 8 : Distribution of Social Facilities



Map 9 : Transportation Network

Institutional and Policy Frameworks

THE NEED FOR MULTI-STAKEHOLDER ACTION ON CLIMATE CHANGE MITIGATION AND ADAPTATION IN KERKENNAH

Administratively, the delegation of Kerkennah encompasses the entire archipelago and belongs to the governorate of Sfax. It is subdivided into ten sectors (imadats): El Ataya, El Ramla, Sidi Frej, Mellita, El Kallabine, Ennajet, El Chargui, El Kantra, El Kraten, and Ouled Kacem. The entire archipelago has constituted a single municipality since 1974[4].

Since the adoption of the Local Government Code in 2018, the municipality of Kerkennah has enjoyed financial and administrative autonomy and exercises a range of powers divided into three categories:

- Exclusive competencies, exercised independently without direct intervention from the state or other local authorities. These include the provision of basic services and facilities, as well as the development and implementation of municipal investment and infrastructure programs.
- Shared competencies, carried out jointly with the state, including local economic development and employment support, protection and promotion of local cultural heritage, investment facilitation, creation of economic activity zones, construction and maintenance of public infrastructure (such as stadiums, cultural centers, museums, parks, and swimming pools), coastal zone management, maintenance of sanitation and flood prevention infrastructure, urban and school transportation, and upkeep of primary schools and health centers.
- Transferred competencies, exercised by the state but eligible to be delegated to the municipality, provided the necessary resources and support are allocated. These may include responsibilities related to local development, infrastructure, or public service provision.

In practice, climate change mitigation and adaptation involve actions of varying scale and scope. While some fall within the competencies of the municipality, many are primarily implemented by the state and its decentralized agencies through national strategies, programs, and sectoral plans. Key stakeholders include the Ministry of Equipment, the Ministry of Environment, the Ministry of Energy, and the Ministry of Agriculture.

Climate change mitigation is addressed through various national initiatives, such as the Tunisian Solar Plan, the Renewable Energy Promotion Program, the National Energy Action Plan, the 30|30 Energy Efficiency Strategy, the National Waste Reduction and Recovery Strategy, the National Transport Master Plan 2040, the Urban Mobility Policy, the Green Economy Transition Strategy (2016–2025), and the National Energy Transition Program.

Adaptation strategies are more cross-cutting and embedded in sectoral frameworks for agriculture, tourism, industry, environment, health, and education, and are implemented through the National Economic and Social Development Plan. Given its limited resources, the municipality of Kerkennah will need to collaborate closely with the state, the private sector, and local, national, and international NGOs to implement the action plan arising from this assessment.

Thus, the municipality of Kerkennah, with limited resources, will undoubtedly need to involve the state, the private sector, and local, national, and international NGOs in the implementation of the action plan that will result from this document.

3 Décret n° 74-5 du 05 Janvier 1974, portant création d'une commune aux iles de Kerkennah

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02

METHODOLOGY

Approach and Methodology

The Multilayered Vulnerability Assessment (MVA) tool employs a three-stage methodology designed to help countries, cities, and communities effectively incorporate, adapt, and operationalize the assessment. This structured and phased approach facilitates improved resilience planning and decision-making. Each stage comprises specific steps and activities, outlined as follows:

STAGE 1: PREPARATION

This stage focuses on establishing the groundwork for the MVA and the framework for the assessment process. Key contributors are identified, and relationships necessary for completing the MVA and analysis are established. This initial phase is crucial for ensuring that the assessment is comprehensive, well-organized, and aligned with the goals and objectives of the organization or community involved. Stage 1 consists of three steps (e.g., Step 1.1: Set up delivery team and steering committee; Step 1.2: Conduct rapid diagnostic of the city or urban area) and eight activities.

STAGE 2: MAPPING AND ANALYSIS

This stage involves sourcing and applying data to provide a detailed analysis of vulnerability hotspots within urban areas, examining factors related to climate change, biodiversity, and urban dimensions. The maps produced in this stage are key outputs of the MVA, allowing for the overlaying of outputs to identify and analyze areas of conflicting vulnerabilities and vulnerability hotspots. Stage 2 is articulated in five steps (e.g., Step 2.2: Data acquisition and collection; Step 2.3: Mapping historic, current, and future vulnerabilities; Step 2.5: Interpretation and analysis of vulnerability hotspots) and encompasses 19 activities.

STAGE 3: INTERVENTION PLANNING

In this final stage, the findings from Stage 2 are transformed into bankable projects aimed at enhancing resilience to current and future climate, urban, and biodiversity shocks and stresses. Collaborating with a diverse range of stakeholders, this stage involves developing 10 to 12 resilience-building actions that are both financially and technically feasible, addressing the intersecting vulnerabilities identified in the MVA. Stage 3 comprises three steps (e.g., Step 3.1: Visioning and objective setting; Step 3.2: Develop resilience action plans) and includes 12 activities.

The MVA provides a clear, phased methodology that guides countries, cities, and communities through effective resilience planning. The tool's three-stage approach—preparation, mapping and analysis, and intervention planning — provides a clear framework for systematically identifying urban vulnerabilities and transforming insights into actionable, bankable projects. This method ensures that resilience-building actions are well-targeted, feasible, and aligned with local priorities, making it a critical tool for addressing the complex challenges posed by climate change, urbanization, and biodiversity loss.


1
Stage one
Preparation
Stage overview
Step 1.1
Set up delivery team and steering committee
Step 1.2
Conduct rapid diagnostic of the city or urban area
Step 1.3
Develop assessment plan
Checklist
Annexes
1. Stakeholder Tools
2. Suggested Project Workplan And Timelines
3. RACI matrix template
2
Stage two
Mapping and analysis
Stage overview
Assessment dimensions
Indicators
Biodiversity layers
Coastal datasets
Step 2.1
Mapping assessment preparation
Step 2.2
Data acquisition and collection
Step 2.3
Mapping historic and current future vulnerabilities
Step 2.4
Mapping multilayered vulnerability hotspots
Step 2.5
Developing the vulnerability profile
Checklist
Annexes
4A. Data Requirements Template – Summary
4B. Data Requirements Template – Literature And Data Review
5. Data Inventory Template
6. Data Collection Plan Template
7. Multilayered Vulnerability Profile Template
Data Collection And Analysis Technical Brief
3
Stage three
Intervention planning
Stage overview
Step 3.1
Prepare citywide resilience strategy
Step 3.2
Develop resilience action plans
Step 3.3
Prepare bankable projects
Step 3.4
Link projects to finance and implementation
Step 3.5
Disseminate, campaign and scale
Checklist

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03

URBAN DIMENSION

Urban dimension

In Kerkennah, urbanization has been a long-standing phenomenon. Faced with unfavorable climatic and soil conditions, and with limited arable land available, the island's population concentrated in urban centers in order to preserve its scarce and valuable agricultural land. However, in recent years, driven by the diversification and modernization of the local economy—along with the rise of tourism—urbanization has begun to spread across the territory, extending along the coastline and into agricultural areas, despite the wide array of regulations and planning instruments that govern urban development.

As in the rest of Tunisia, urbanization in Kerkennah is regulated by a robust legal framework, including:

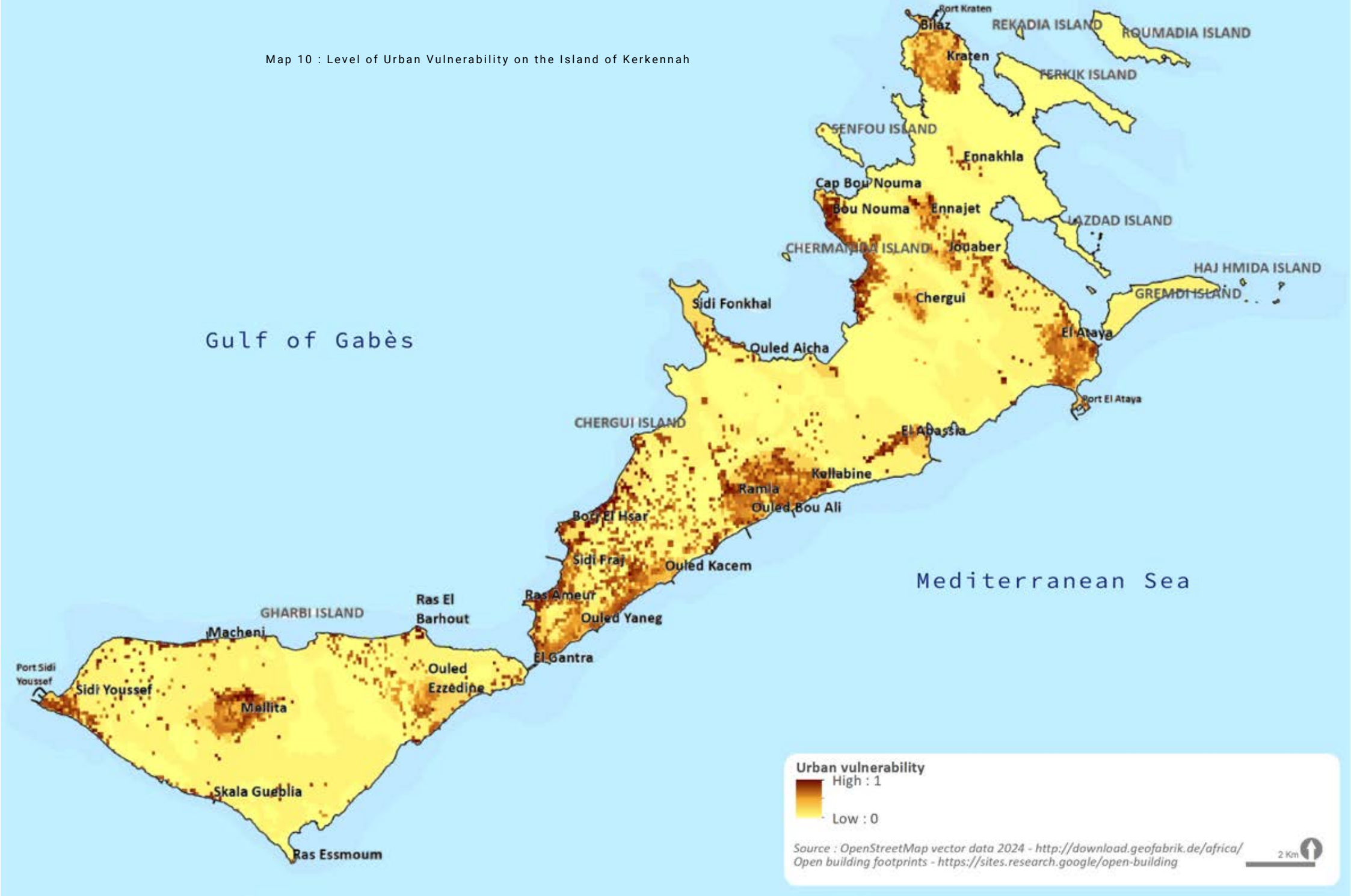
- The Land Use and Urban Planning Code (CATU)
- The Agricultural Land Protection Act
- The Law on the Maritime Public Domain
- The Water Code
- The Heritage Code

Although the island's main urban centers (Sidi Youssef, Mellita, Ouled Yaneg, Ouled Kacem, Ouled Bouali–Erramla–Kellabine, and El Attaya) are covered by urban development plans that define zones based on their designated primary use and regulate building densities within these zones—taking into account infrastructure capacity, existing or planned public facilities, soil quality, potential natural hazards, and environmental factors—the spread of informal housing has significantly increased across the island, encroaching on agricultural areas, the public maritime domain, archaeological sites, and ecologically sensitive zones.

To assess the urban dimension of vulnerability, five indicators were examined :

1. Access to Public Services: Access to basic urban services plays a key role in a community's capacity to prepare for, respond to, and recover from climate-related hazards, shocks, and stresses. Limited access to essential services—such as water and sanitation, telecommunications, energy, transportation, healthcare, education, social and cultural services, and emergency response—can increase vulnerability. This indicator was assessed in Kerkennah by analyzing access rates to urban services (water, electricity, and sanitation) and the accessibility of social services (education, health, administration, sports, culture, etc.).
2. Informal Settlements: The location, scale, demographic profile, physical conditions, and socio-economic dynamics of informal settlements can intensify vulnerability to the impacts of climate change. Residents of such settlements generally have limited access to services, resources, and infrastructure, and are often located in environmentally fragile areas. This indicator was evaluated in Kerkennah by examining the spatial distribution of buildings in relation to land use as defined in planning documents, to identify those constructed outside authorized zones.
3. Land Use: Different types of land use are associated with varying degrees of exposure to climate-related hazards, and land-use patterns often overlap with social vulnerabilities and fragile infrastructure systems. This indicator was assessed in Kerkennah by analyzing the island's land use and agricultural maps.
4. Population Density: High population density presents challenges such as greater exposure to extreme weather events, stress on infrastructure systems, limited green space, poor air quality, intensified heat stress, concentrations of vulnerable populations, and increased competition for essential services and resources. This indicator was evaluated in Kerkennah by analyzing building density and the distribution of the permanent population based on satellite imagery and population census data.
5. Urban Growth: Rapid and extensive urbanization can increase exposure to natural hazards, contribute to the fragmentation and loss of natural ecosystems and biodiversity, and weaken the capacity of infrastructure systems to support growing populations and withstand escalating climate risks. This indicator was assessed in Kerkennah through the analysis of a historica series of aerial photographs and satellite imagery.

Map 10 : Level of Urban Vulnerability on the Island of Kerkennah



Indicators

Indicator 1 : Access to public services

According to the 2014 General Population and Housing Census (RGPH), 97.62% of the island's households are connected to the public drinking water network, and 98.41% to the public electricity network. However, only 30.95% are connected to the public wastewater treatment network, which remains limited to the commune's main town. The majority of residents living in rural areas or small rural centers rely on septic tanks and soakaways.

Despite the low connection rate to the wastewater network, the island's population enjoys near-universal access to basic urban services, thanks to various sectoral policies that have extended electricity and drinking water networks throughout the national territory.

Access to public services, however, presents a more nuanced situation. The spatial distribution of public facilities and the configuration of the transport network mean that certain areas of the island remain underserved due to their remoteness.

To evaluate this indicator, three key criteria were used: the spatial distribution of public facilities, the spatial distribution of buildings, and the configuration of the transport network.

Thus, accessibility to three types of services was assessed for each building on the island:

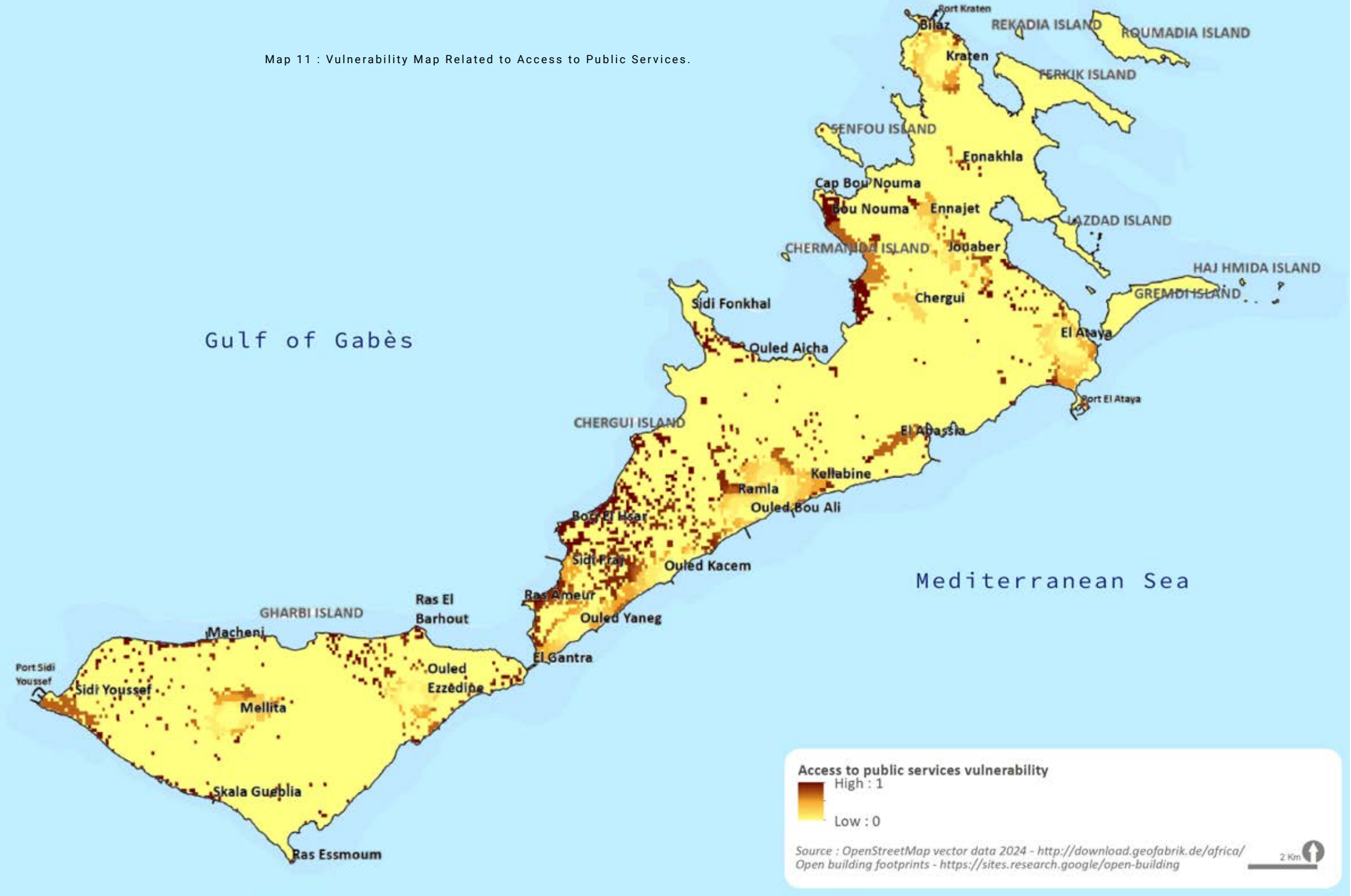
- Access to basic health services, with an accepted maximum walking distance of five minutes.
- Access to basic education services, with an accepted maximum walking distance of five minutes.
- Access to public transport stations, which provide motorized access to administrative services and less frequently available services (such as middle schools, high schools, hospitals, etc.), with an accepted maximum walking distance of five minutes.

Vulnerability in this dimension was calculated by combining the access time for each building to the three types of services, then refining the result using the population density indicator, which takes into account the nature of each building's occupancy (whether by year-round or seasonal residents; see the population density indicator).

The level of vulnerability is defined as the inverse of accessibility: the more difficulty a population has in accessing basic services, the more vulnerable it is.

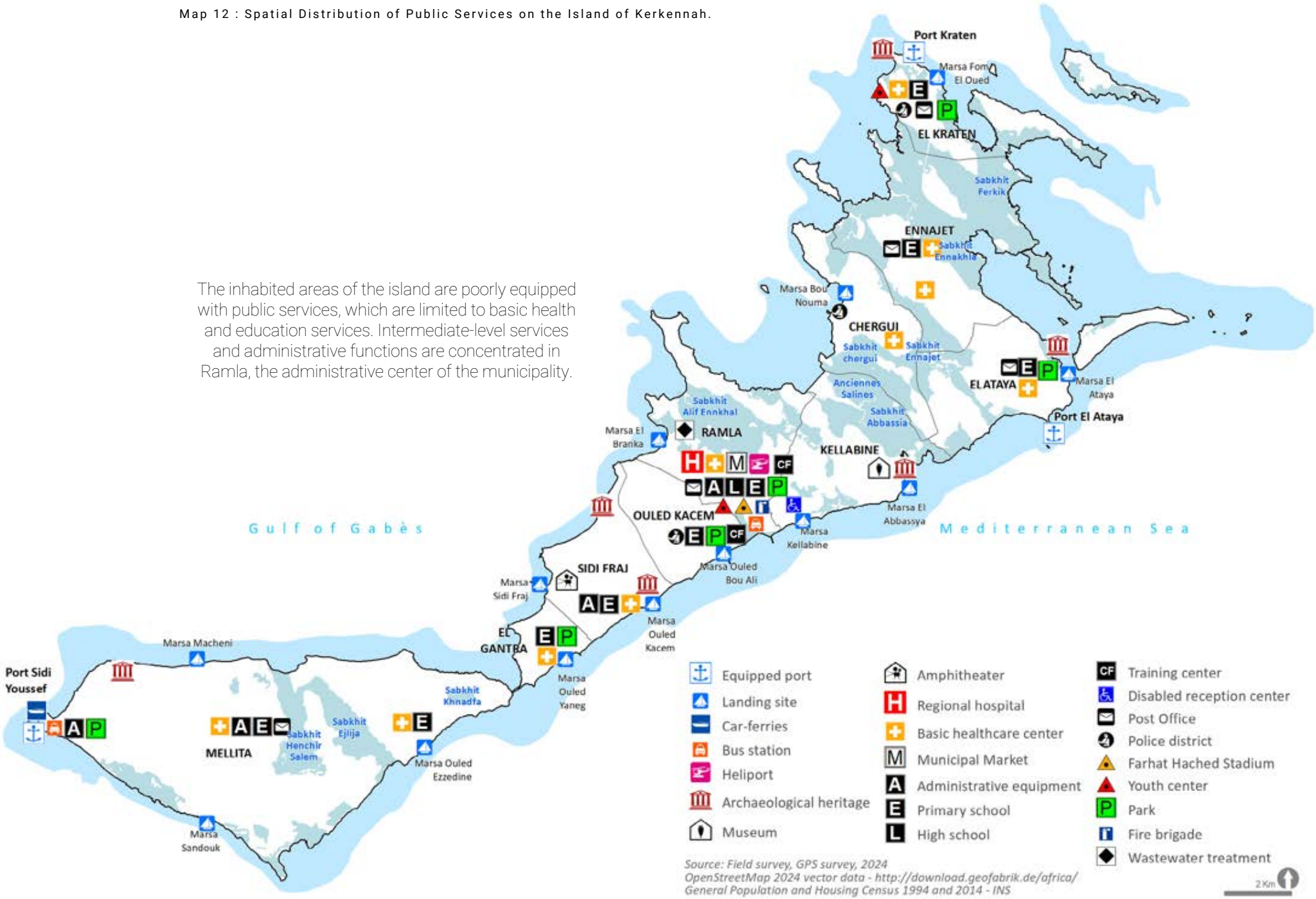
Thus, the residents who face the greatest difficulties in accessing public services are those living on the outskirts of the island's main urban centers (the Ouled Bou Ali–Remla–Kellabine conurbation, the town of Mellita, and the town of Attaya), those in small, relatively isolated centers with limited services (Chergui, Ennajet, and Jouabe), and those scattered across agricultural areas in the southwest of Chergui Island.

Map 11 : Vulnerability Map Related to Access to Public Services.



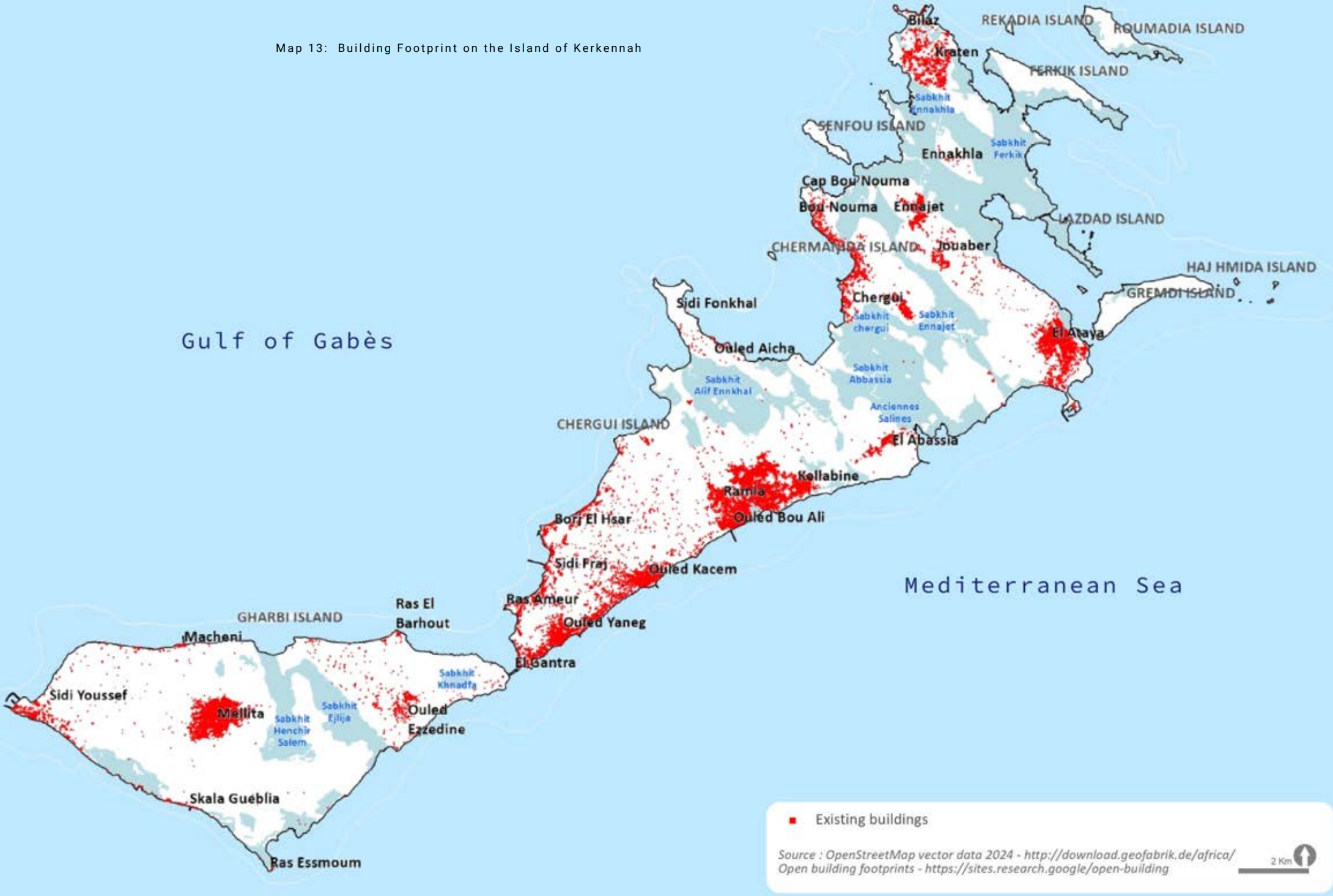
Map 12 : Spatial Distribution of Public Services on the Island of Kerkennah.

The inhabited areas of the island are poorly equipped with public services, which are limited to basic health and education services. Intermediate-level services and administrative functions are concentrated in Ramla, the administrative center of the municipality.



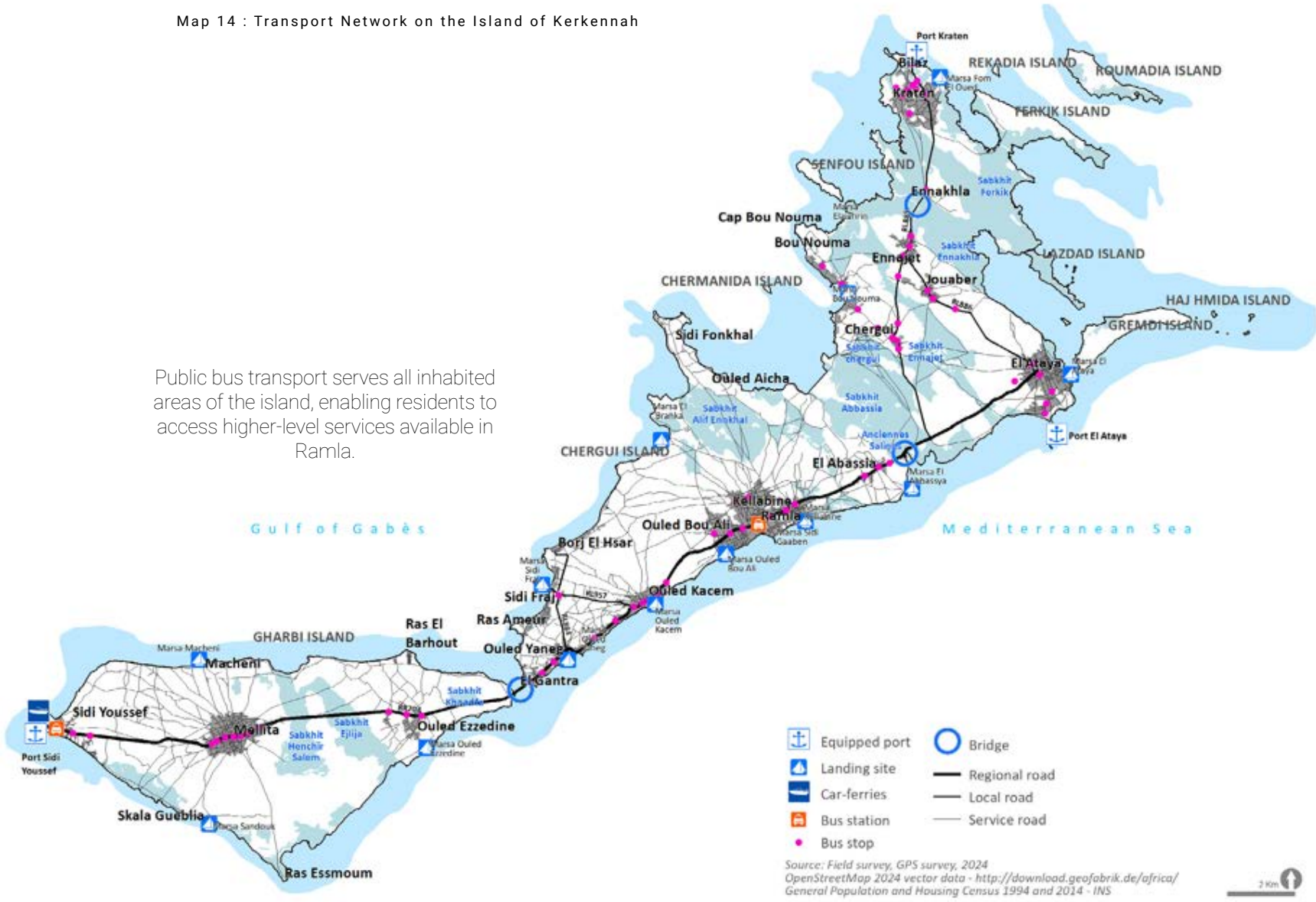
Source: Field survey, GPS survey, 2024
OpenStreetMap 2024 vector data - http://download.geofabrik.de/africa/
General Population and Housing Census 1994 and 2014 - INS

Map 13: Building Footprint on the Island of Kerkennah



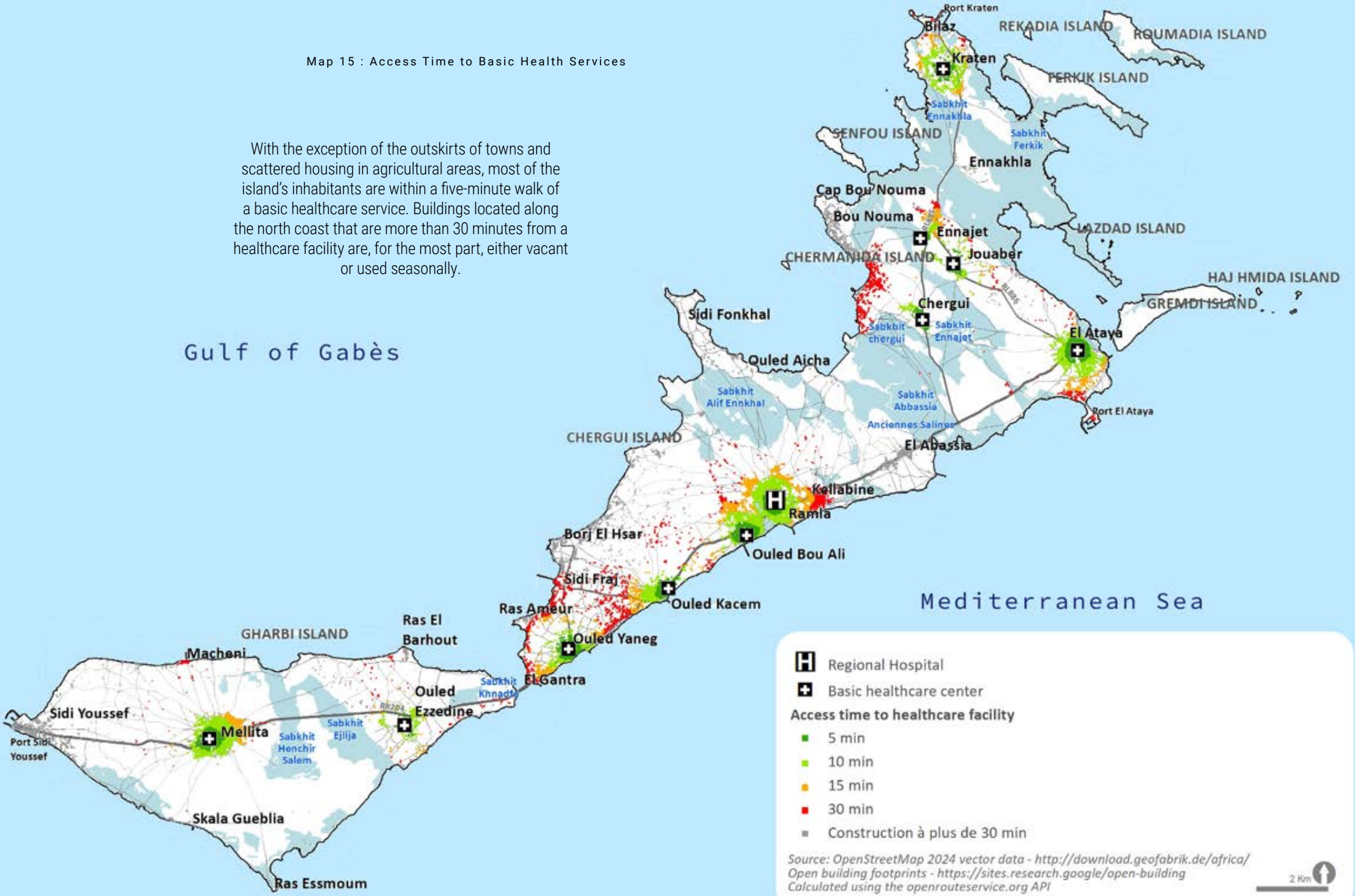
Map 14 : Transport Network on the Island of Kerkennah

Public bus transport serves all inhabited areas of the island, enabling residents to access higher-level services available in Ramla.



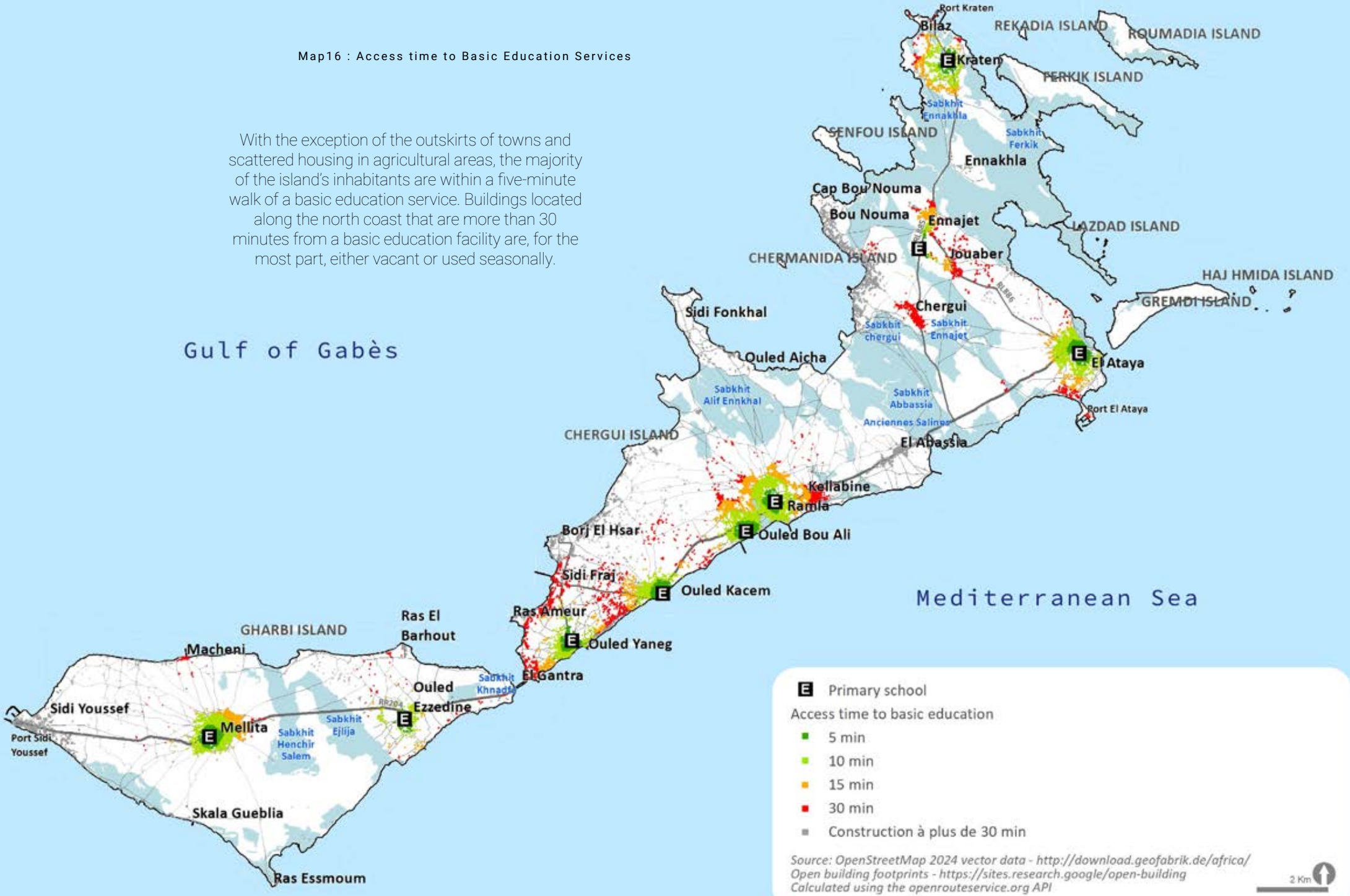
Map 15 : Access Time to Basic Health Services

With the exception of the outskirts of towns and scattered housing in agricultural areas, most of the island's inhabitants are within a five-minute walk of a basic healthcare service. Buildings located along the north coast that are more than 30 minutes from a healthcare facility are, for the most part, either vacant or used seasonally.



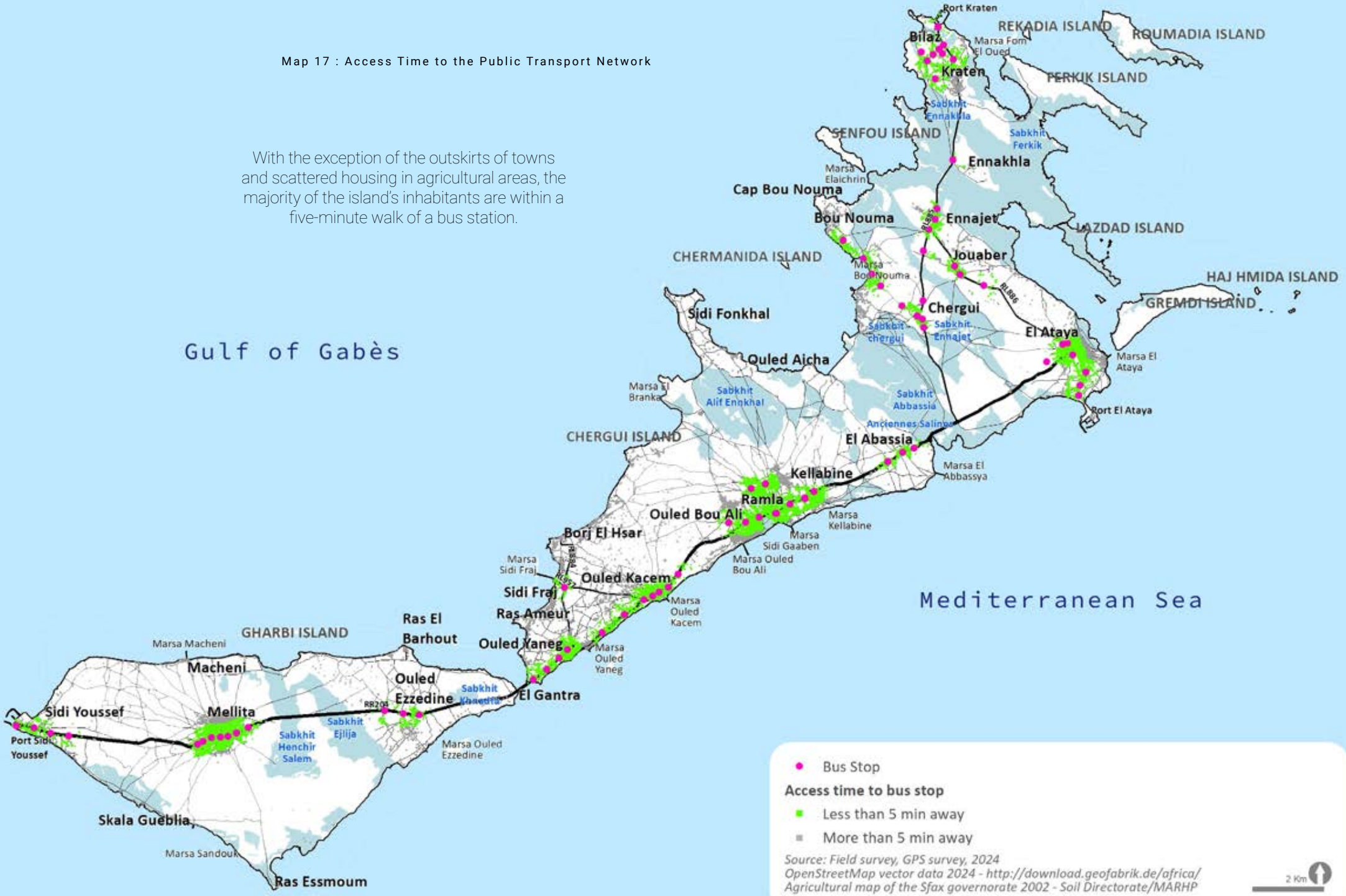
Map16 : Access time to Basic Education Services

With the exception of the outskirts of towns and scattered housing in agricultural areas, the majority of the island's inhabitants are within a five-minute walk of a basic education service. Buildings located along the north coast that are more than 30 minutes from a basic education facility are, for the most part, either vacant or used seasonally.

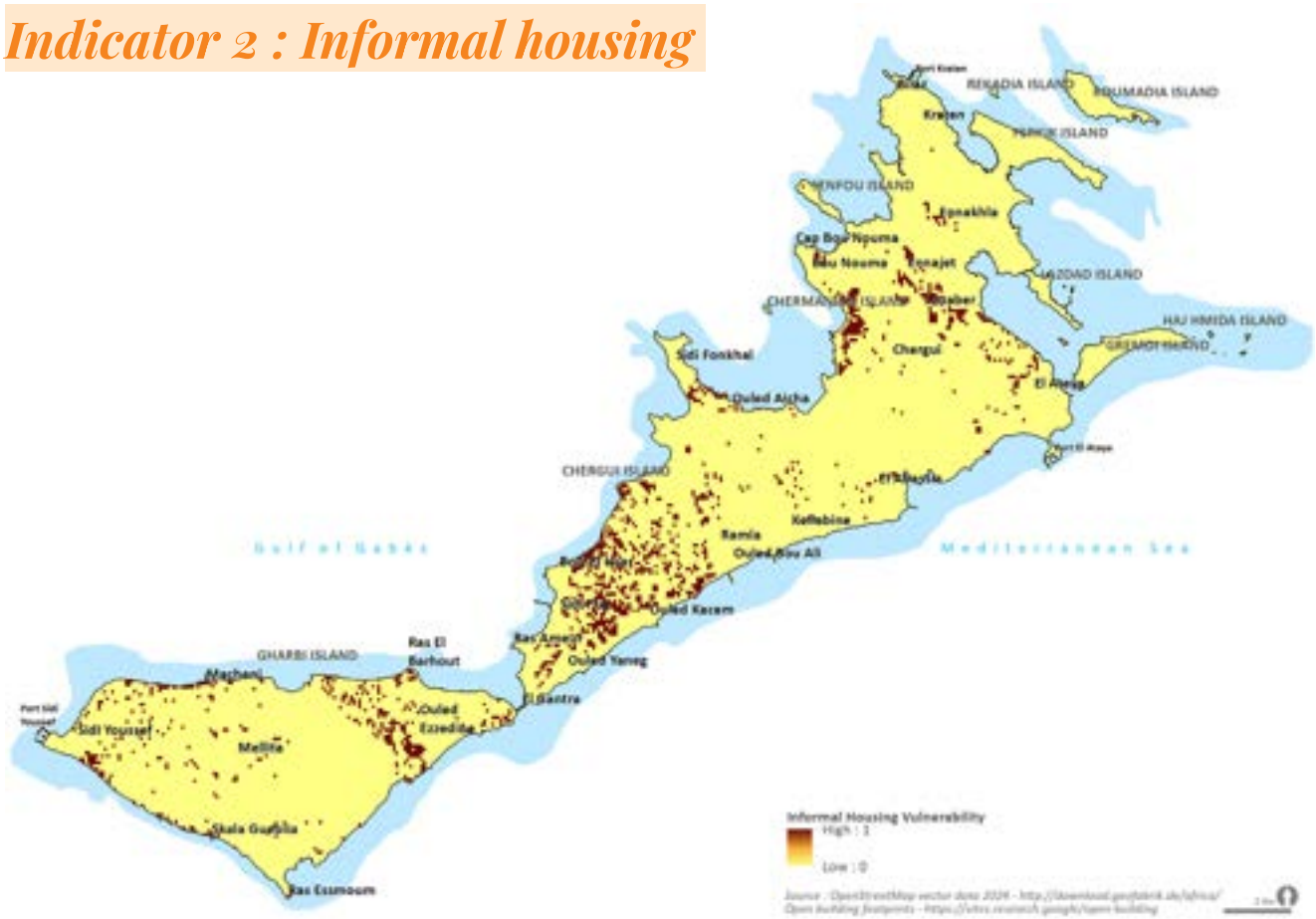


Map 17 : Access Time to the Public Transport Network

With the exception of the outskirts of towns and scattered housing in agricultural areas, the majority of the island's inhabitants are within a five-minute walk of a bus station.



Indicator 2 : Informal housing



Map 18 : Level of vulnerability relative to housing informality

In Kerkennah, rudimentary housing is very rare (0.23% of buildings according to the 2014 RGPH). Nearly all buildings are solidly constructed with durable materials, and the vast majority are equipped with a bathroom or shower (97.72%), a kitchen (98.39%), and proper toilets (99.14%). Under these conditions, in Kerkennah—as elsewhere in Tunisia—informal housing does not refer to the physical characteristics of the dwelling, but rather to its administrative status: whether or not a building permit exists, and the degree of conformity between the approved plans and the completed construction.

This type of housing is considered vulnerable because it is built on undeveloped, unserviced land and typically faces difficulty accessing public services, which are generally provided in areas designated for planned urbanization.

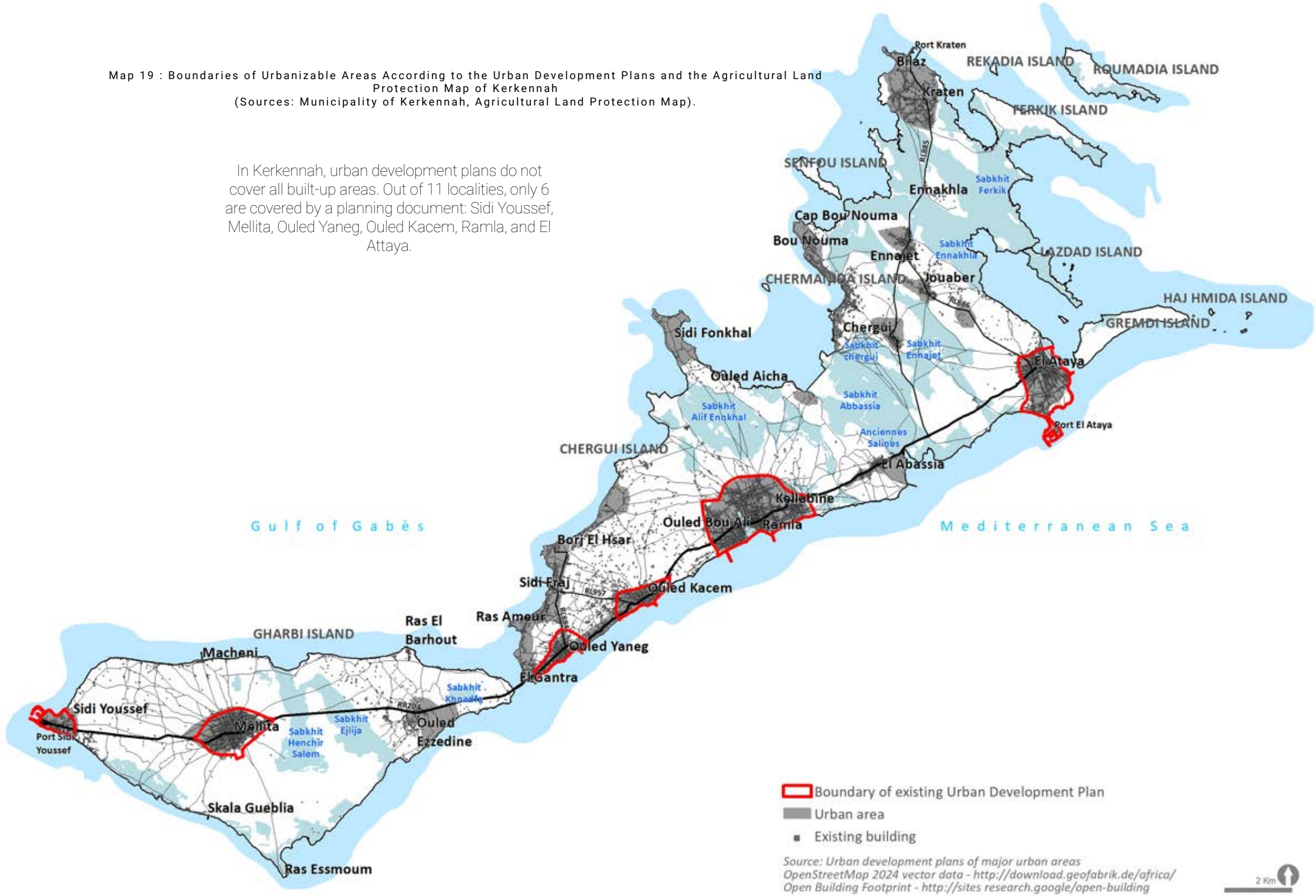
However, assessing this indicator is limited by the lack of spatial data that would make it possible to verify the regulatory status of each building in relation to current urban planning laws. To evaluate the degree of vulnerability associated with this indicator, each dwelling's location is analyzed in relation to official planning documents. Indeed, any building constructed outside the zones authorized by planning documents or the agricultural land protection map is considered informal. Consequently, it is deemed to be located in an area unsuitable for urbanization due to its physical, ecological, or agricultural characteristics, and is unlikely to benefit from public service and infrastructure investments.

Specifically, the construction footprint map (Map 4, based on Google's building footprint data) was overlaid with the map delineating urbanizable zones (Map 9, drawn from the island's Urban Development Plans and the agricultural land protection map). Buildings located outside the urbanizable perimeters are considered vulnerable.

Thus, informal housing on the island of Kerkennah is located primarily in the agricultural zone in the southwest of Chergui Island, within the Kantara–Ouled Bou Ali–Borj El Hsar triangle, and along the north coast of the island around the bay north of Sidi Founkhal.

Map 19 : Boundaries of Urbanizable Areas According to the Urban Development Plans and the Agricultural Land Protection Map of Kerkennah
(Sources: Municipality of Kerkennah, Agricultural Land Protection Map).

In Kerkennah, urban development plans do not cover all built-up areas. Out of 11 localities, only 6 are covered by a planning document: Sidi Youssef, Mellita, Ouled Yaneg, Ouled Kacem, Ramla, and El Attaya.



Indicator 3 : Land use

The territory of the island of Kerkennah is distinguished by the richness of its landscapes, primarily due to the diversity of land use, which ranges from urban areas to agricultural zones (orchards, olive groves, palm groves, grazing lands), as well as humid and natural environments (sebkhas, intertidal zones, etc.).

The degree of vulnerability is assessed here based on two factors:

1. The sensitivity of each type of land use to climate change.
2. The economic, cultural, and heritage value of each type of land use.

For the first factor, satellite-observed land cover was used (global land cover based on data from the European Space Agency's Sentinel-1 and Sentinel-2 satellites). For the second, the agricultural land protection map (CRDA) was used. Indeed, we consider that the more strongly a piece of land is protected, the higher its agricultural value.

Since vulnerability related to land use is closely tied to local practices, the economy, and historical context, its assessment was based on the judgment of experts and stakeholders consulted during public meetings. After discussion, they reached a consensus on the vulnerability level of each type of land use. Accordingly, the areas were classified, in descending order of vulnerability, as follows:

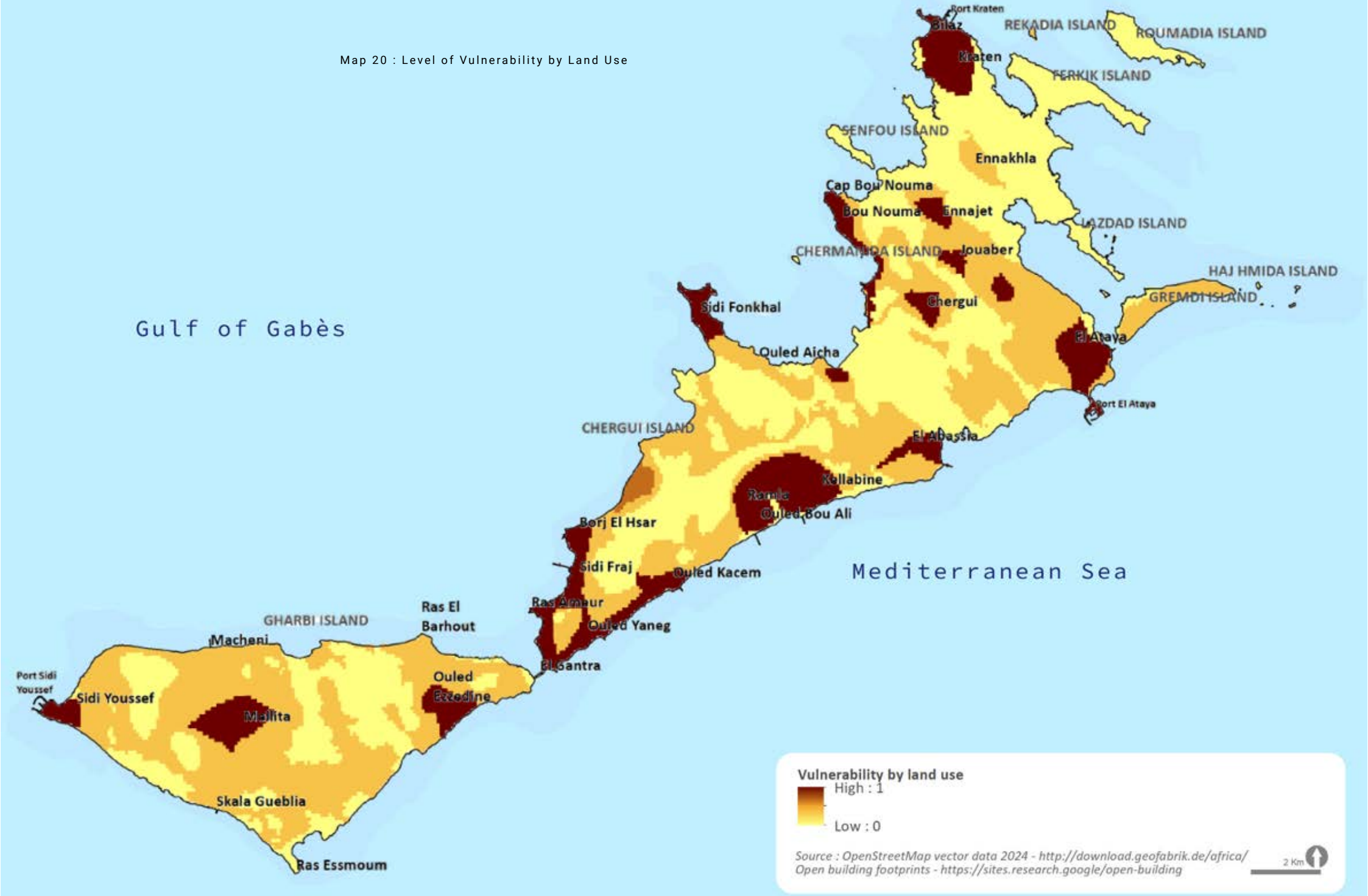
1. Urban areas, tourist areas, and archaeological zones
2. Unprotected agricultural land (other agricultural areas)
3. Safeguard zones (protected agricultural areas)
4. Sebkhas

According to the stakeholders consulted:

- Most activities, public services, and the population are concentrated in urban areas, which generate the majority of the island's income. These areas received the highest vulnerability score.
- Unprotected agricultural areas host a large share of family gardens but suffer from weak protection measures. They are also affected by unfavorable conditions (soil and water) and are highly vulnerable to climate change.
- Protected agricultural areas are considered less vulnerable than the previous ones, as they benefit from more favorable conditions and strict protection measures.
- Finally, the sebkhas currently generate no income for the island's population (apart from salt extraction) and are uninhabited.

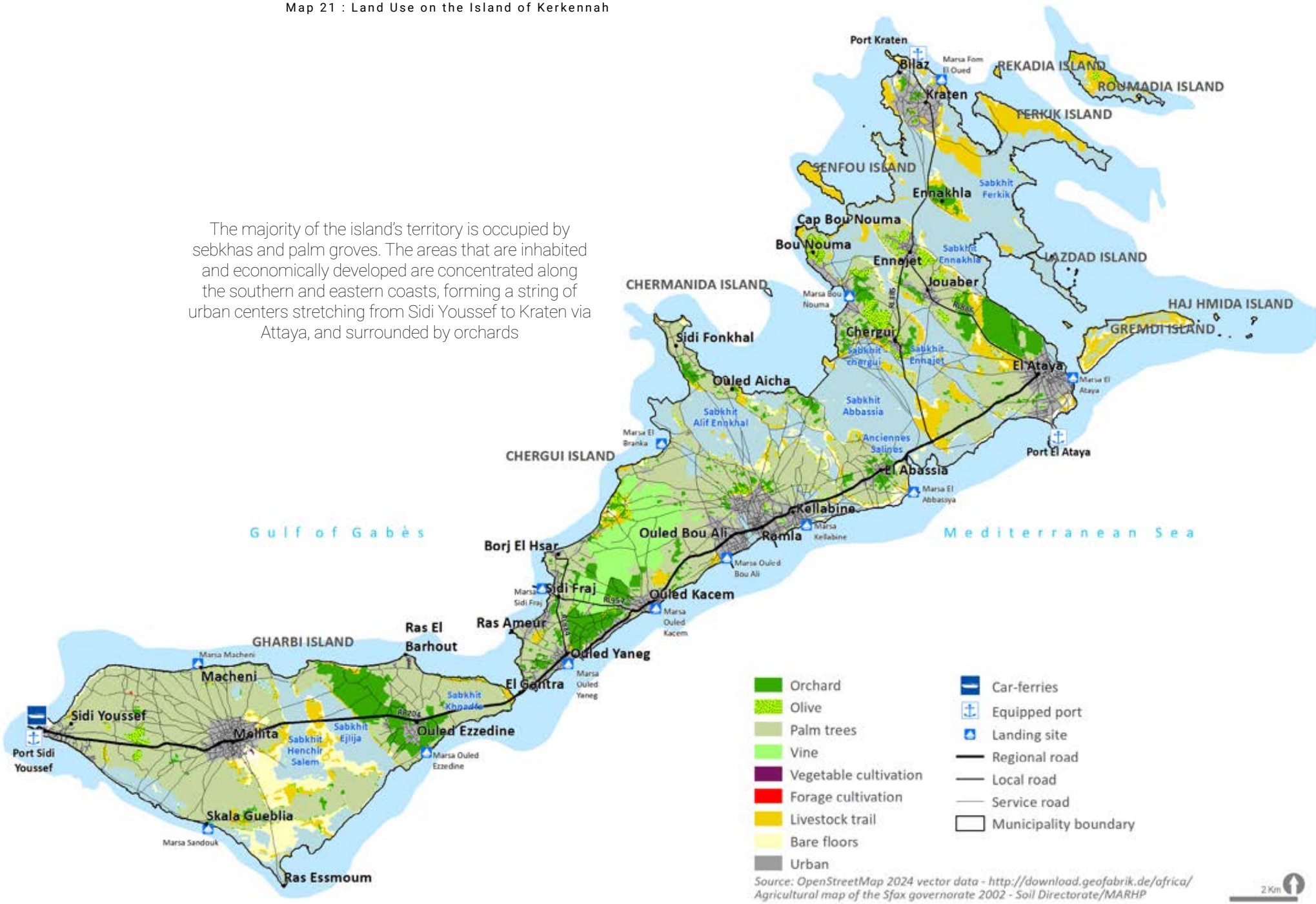
Thus, in terms of land use—and therefore of the economic, social, and cultural value of the island's territories—the most vulnerable areas are located, from north to south, in Kraten, Ennajet, Louaber, Chergui, Bou Nouma, Attaya, Abbassia, Sidi Founkhal, Ramla (and surrounding areas), Ouled Kacem, Ouled Yaneg, Gantra, Ras Ameur, Sidi Fraj, Borj El Hsar, Ouled Ezzedine, Mellita, and Sidi Youssef.

Map 20 : Level of Vulnerability by Land Use



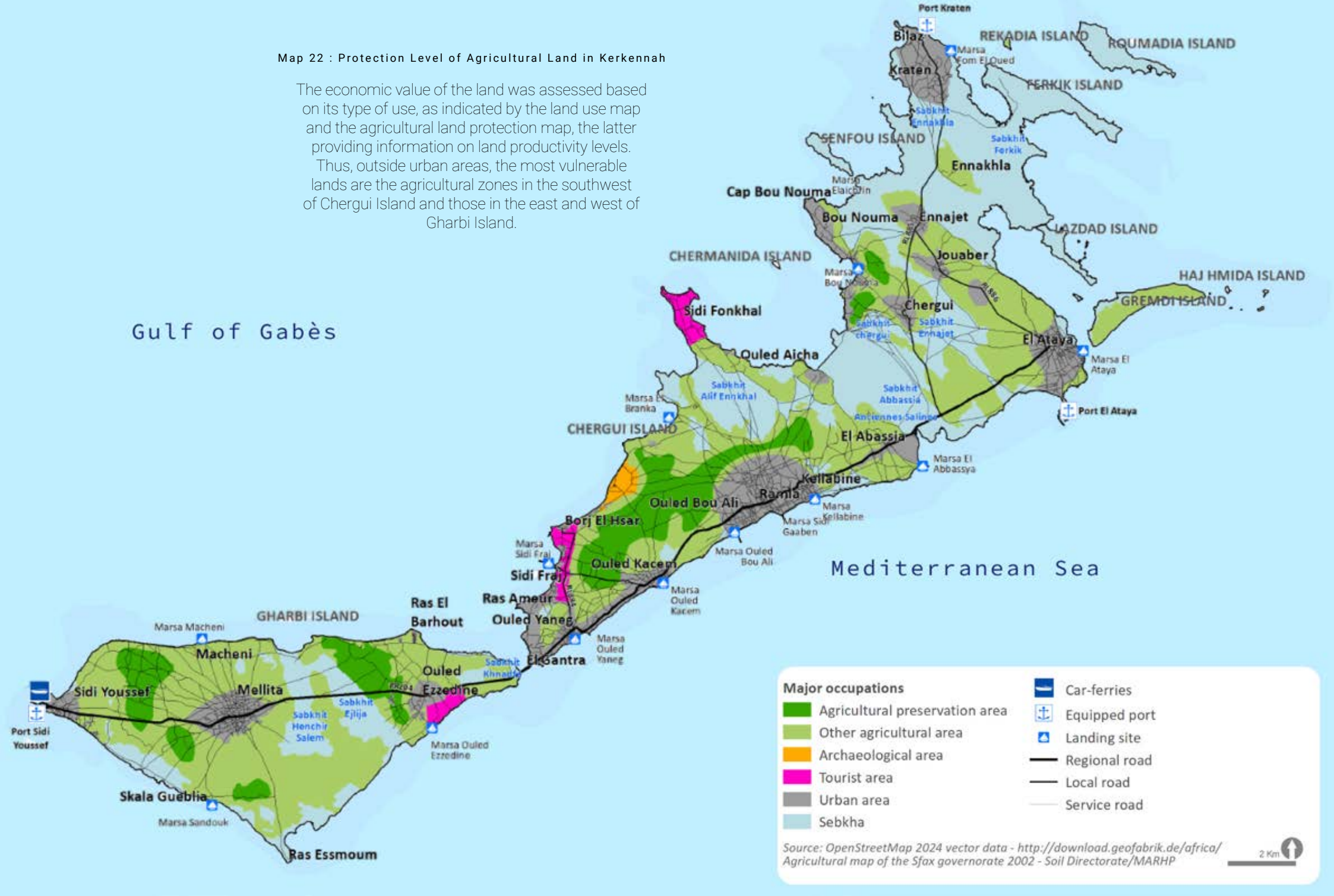
Map 21 : Land Use on the Island of Kerkennah

The majority of the island's territory is occupied by sebkhas and palm groves. The areas that are inhabited and economically developed are concentrated along the southern and eastern coasts, forming a string of urban centers stretching from Sidi Youssef to Kraten via Attaya, and surrounded by orchards

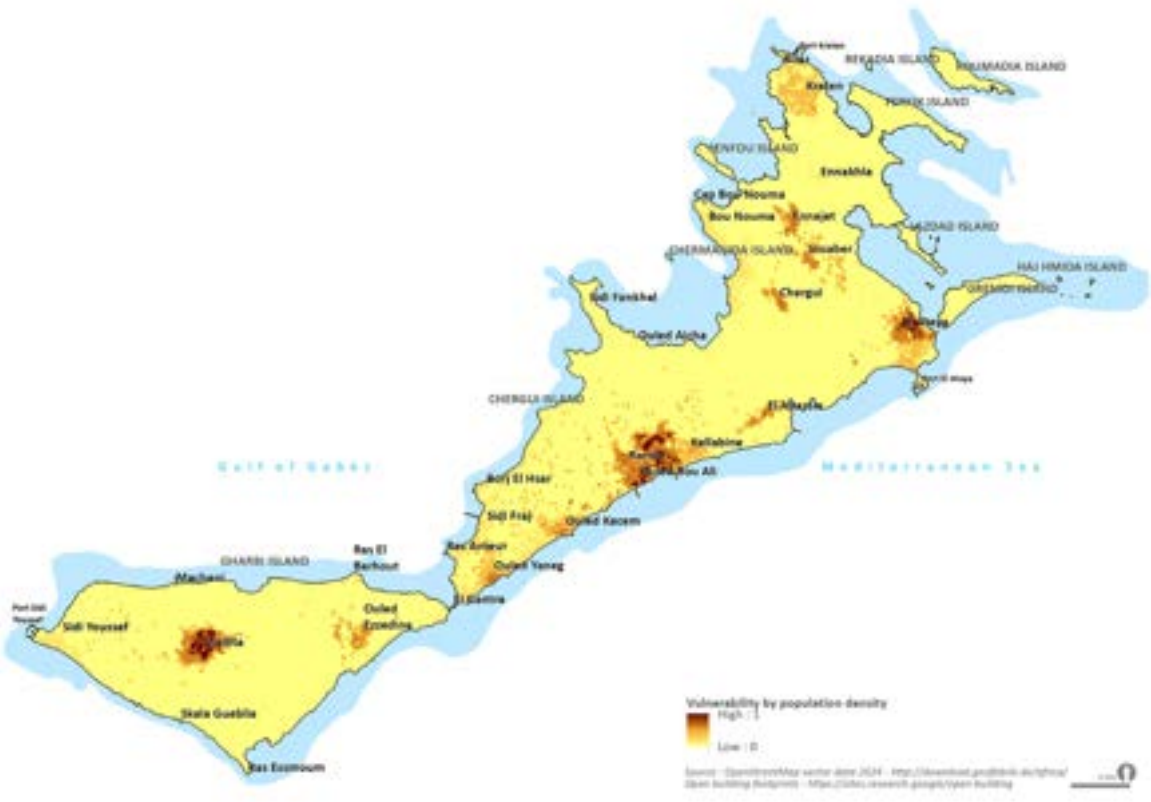


Map 22 : Protection Level of Agricultural Land in Kerkennah

The economic value of the land was assessed based on its type of use, as indicated by the land use map and the agricultural land protection map, the latter providing information on land productivity levels. Thus, outside urban areas, the most vulnerable lands are the agricultural zones in the southwest of Chergui Island and those in the east and west of Gharbi Island.



Indicator 4 : Population density



Map 23 : Level of Vulnerability by Population Density.

The island of Kerkennah is generally characterized by very low building density. Housing is predominantly low-rise and consists almost entirely of single-family dwellings. The spatial distribution is marked by a concentration of buildings in historic urban centers arranged in a chain along the main road and the southern coast, as well as in the new seaside tourist developments on the northern coast.

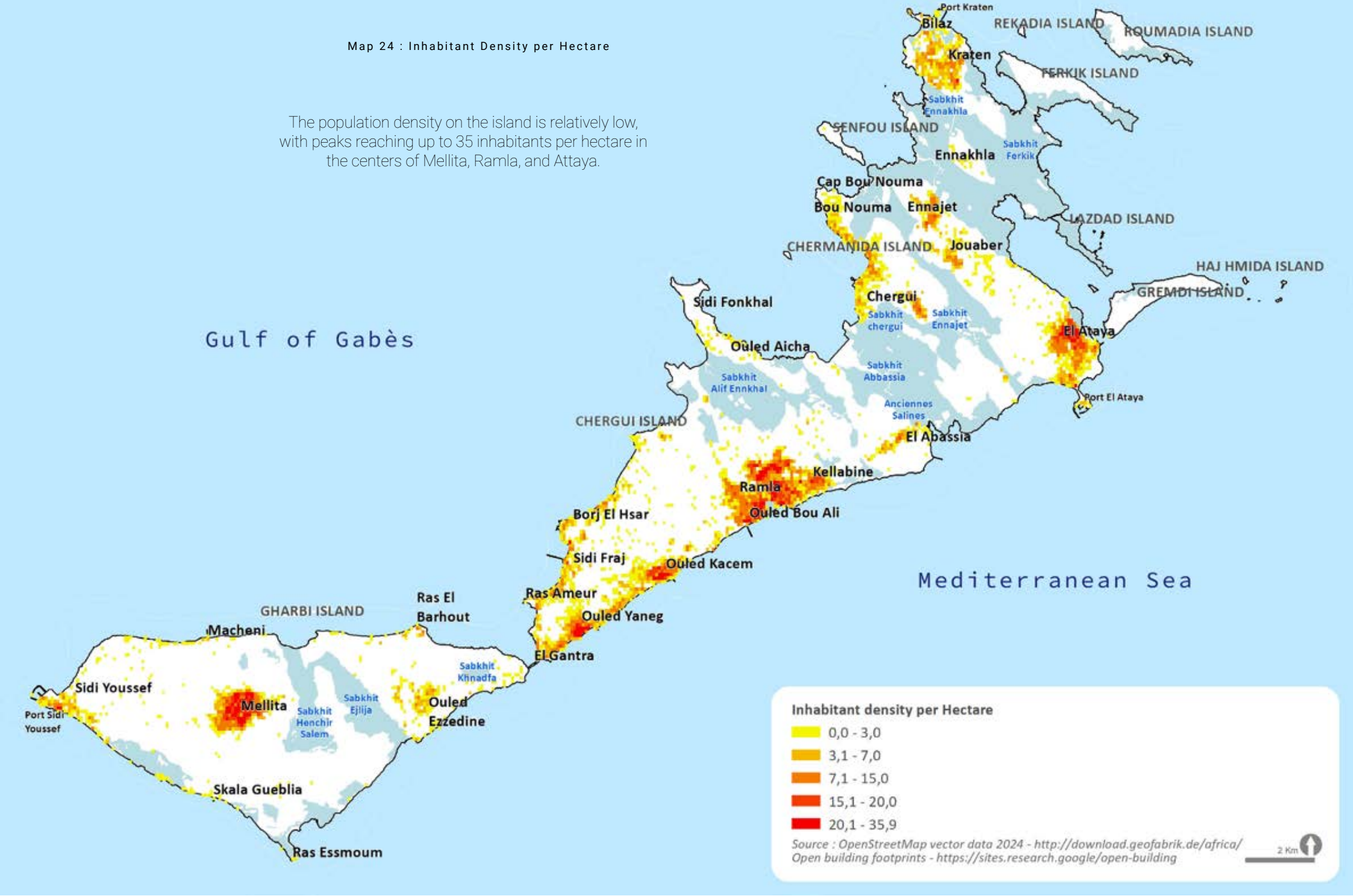
However, this distribution of buildings does not reflect the distribution of the population. According to the 2014 General Population and Housing Census (RGPH), only 49.83% of buildings are occupied; the remainder are either vacant, abandoned, used as secondary residences, or owned by emigrant families.

To assess population density, the building density map was adjusted using a specific occupancy rate for each area, as determined in consultation with municipal authorities. For instance, despite a high density of buildings, the northern coastline has a low population density.

Thus, the highest population densities on the island are found in the center of Mellita, in the center of the Ouled Bou Ali–Ramla–Kellabine conurbation, and in the center of Attaya..

Map 24 : Inhabitant Density per Hectare

The population density on the island is relatively low, with peaks reaching up to 35 inhabitants per hectare in the centers of Mellita, Ramla, and Attaya.



Indicator 5 : Urban growth

Map 25 : Level of Vulnerability by Urban Growth

In Kerkennah, urban growth in recent years has occurred through three main forms:

1. Densification of the central fabric of urban areas
2. Fragmentation of agricultural land (outside Urban Development Plans)
3. Progressive occupation of the coastline

Urban growth has accelerated in recent years due to the island's tourist appeal, which has encouraged the emergence of second homes and seasonal rental housing, primarily concentrated along the coastal fringe.

Growth linked to (relatively low) population increase has mainly involved the occupation of urban infill areas (densification) and the immediate outskirts of urban centers.

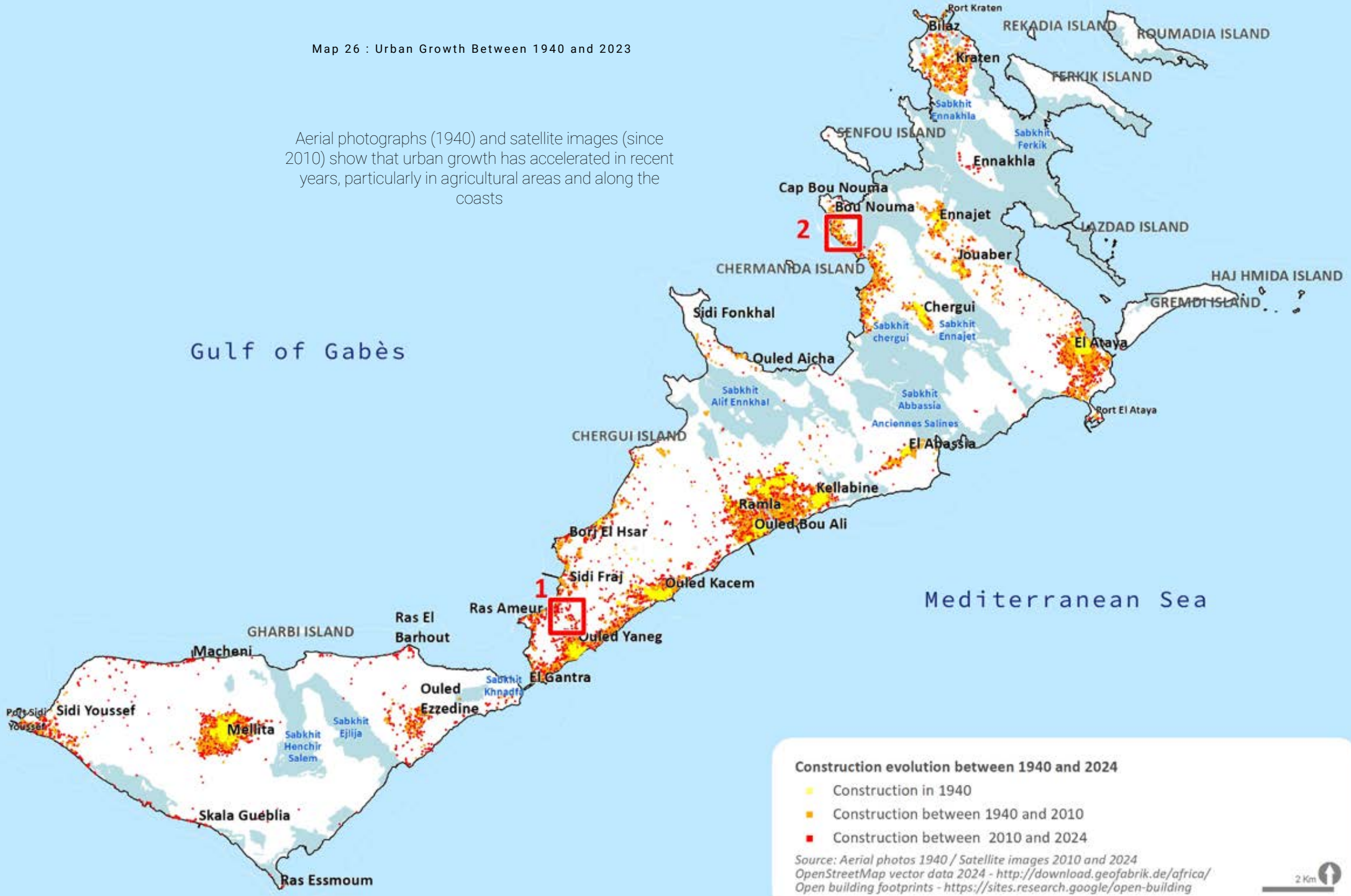
To assess the intensity of urban growth, satellite images from 2013 and 2023 were compared to determine the number of new buildings constructed in each area. The areas that have experienced the fastest urban expansion are considered the most vulnerable.

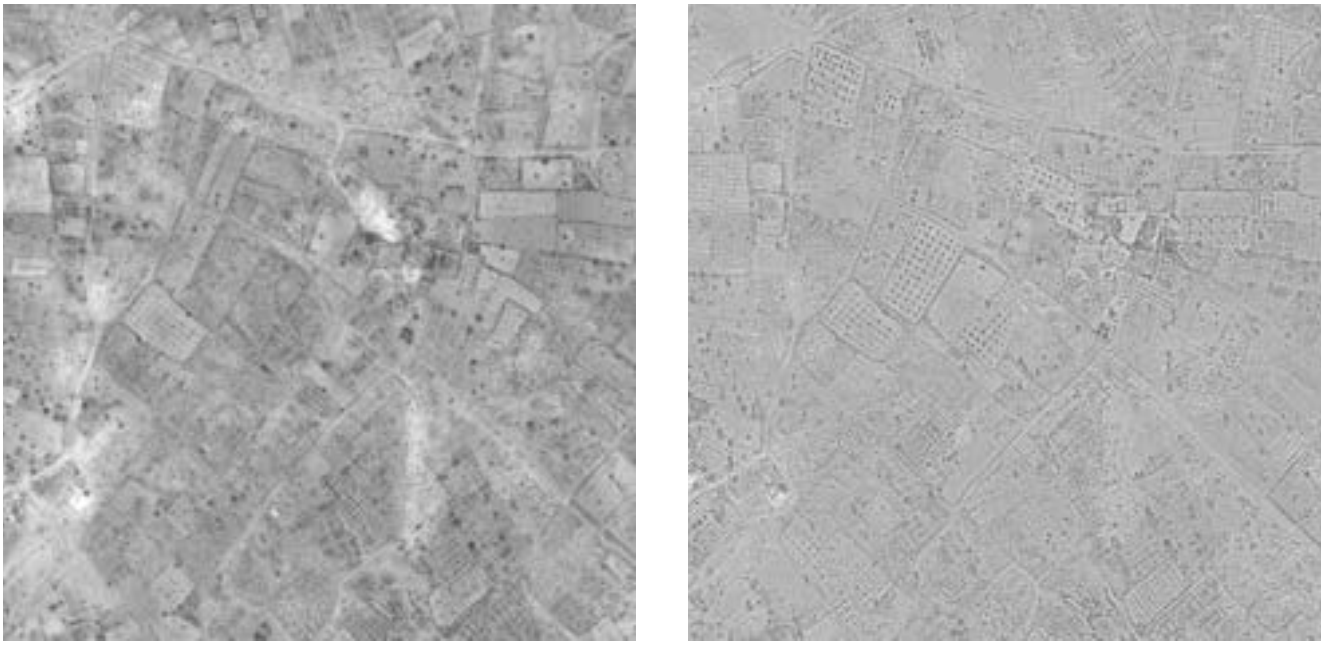
Thus, aside from the peripheral growth of the island's main centers (Mellita, Ramla, and Attaya), the most significant expansion has been observed along the southern coasts of Chergui Island: the Gantra–Ouled Kacem axis and the Gantra–Borj Hsar axis, as well as along the coastline south of Cape Bou Nouma.

In addition, the agricultural lands of Chergui Island and the orchards of Kraten have experienced relatively significant fragmentation.

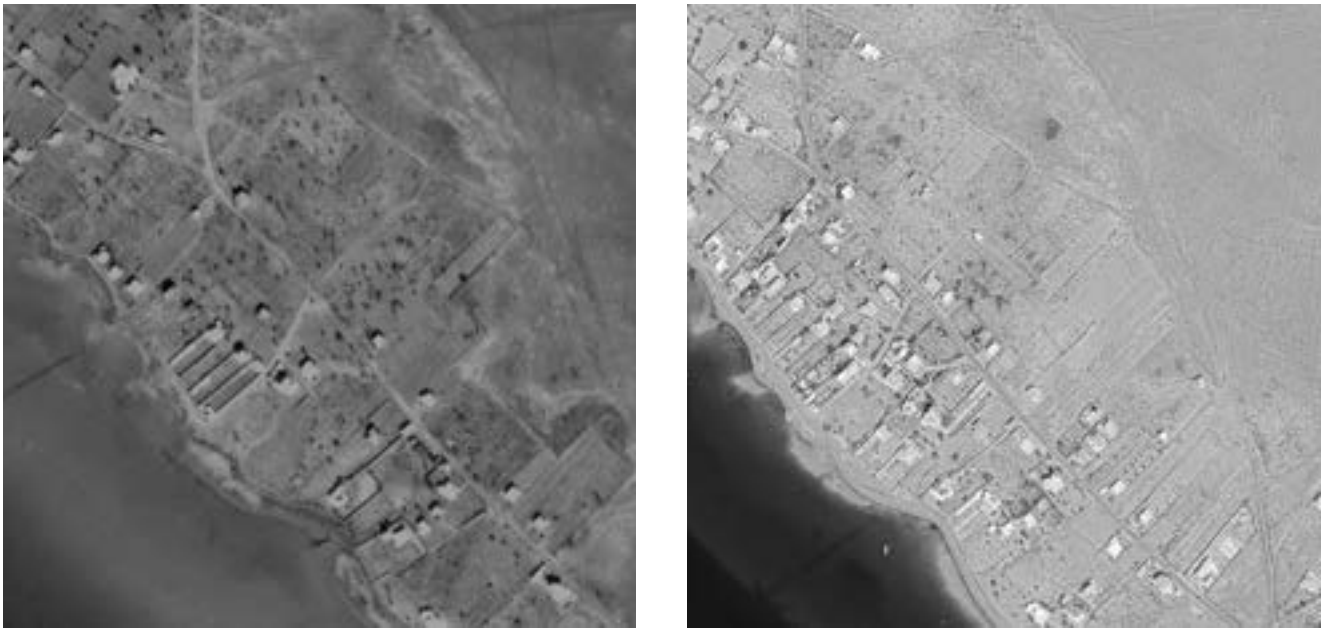
Map 26 : Urban Growth Between 1940 and 2023

Aerial photographs (1940) and satellite images (since 2010) show that urban growth has accelerated in recent years, particularly in agricultural areas and along the coasts



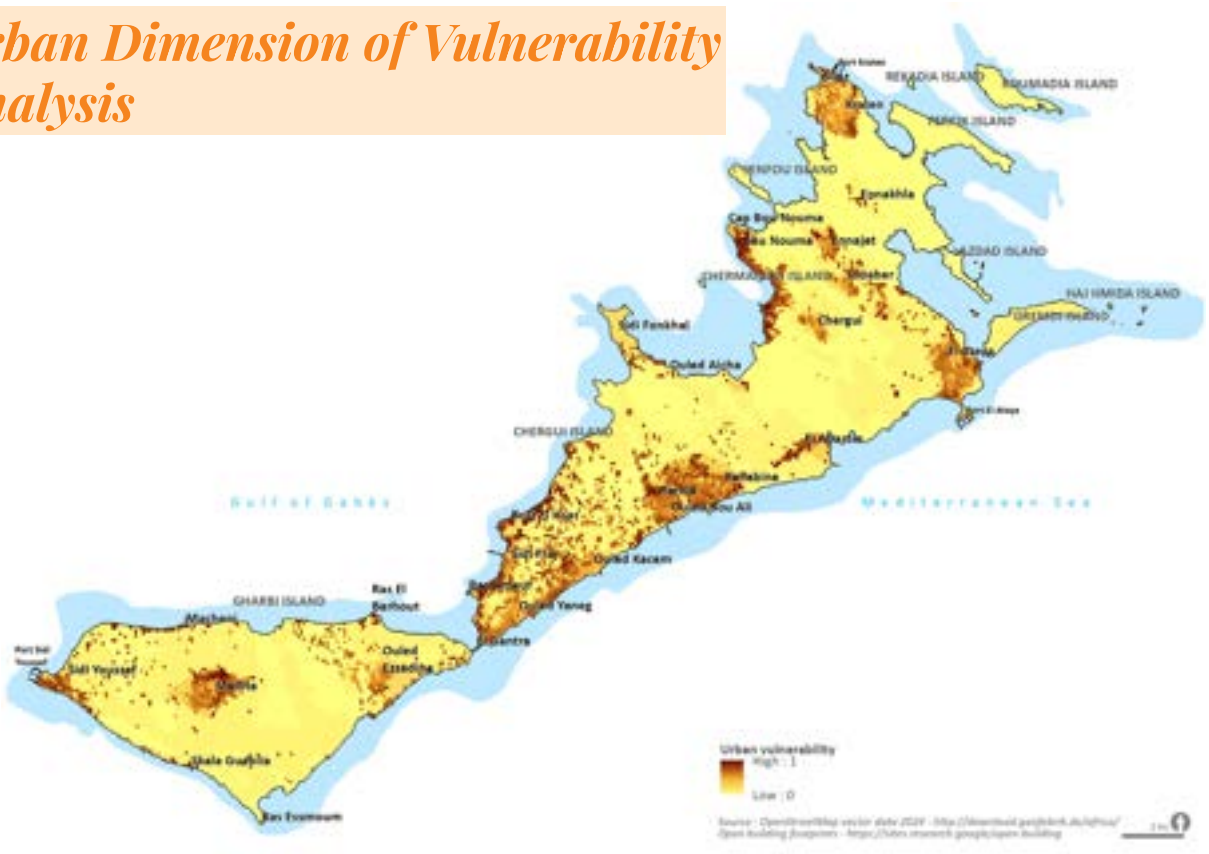


Map 27 : Agricultural Land Fragmentation Between 2013 (Left) and 2023 (Right) (Box 1)



Map 28 : Coastal Urban Expansion Between 2003 (Left) and 2023 (Right) (Box 2)

Urban Dimension of Vulnerability Analysis



Map 29 : Level of Urban Vulnerability on the Island of Kerkennah in September 2024

The analysis of the urban dimension of vulnerability in Kerkennah Island was based on the evaluation of five indicators. Each indicator was assigned a weighting coefficient used to calculate the final vulnerability score:

1. Access to Public Services: 3
2. Informal Housing: 1
3. Land Use: 2
4. Population Density: 1
5. Urban Growth: 2

These coefficients were defined during a consultation workshop with local stakeholders held locally in September 2024. They reflect local concerns related to the urban dimension of vulnerability. These coefficients reduce the weight of the population density and informal housing indicators in the final score. Indeed, across the entire island, population density is very low, and even the most populated areas have densities with no significant impact on vulnerability. Likewise, informal housing on the island is structurally sound, built with durable materials, and connected to drinking water and electricity networks.

It turns out that the most vulnerable areas of the island, from an urban standpoint, are located:

- On the immediate outskirts of the historic urban centers along the southern coast, and in the new extensions along the northern coast, particularly in the areas stretching from Cape Bounouma to Sidi Founkhal and from Borj El Hsar to Ras Ameur. These areas are undergoing rapid urban expansion, characterized by high building densities and relatively limited access to public services.
- In the agricultural areas located within the Ramla–Sidi Founkhal–El Gantra triangle, a rapid change in land use and accelerated scattered development are underway. Family vegetable gardens face a high risk of disappearing, and scattered informal housing struggles to access public services.
- Overall, urban vulnerability in Kerkennah is primarily the result of uncontrolled urban growth along the coasts, on the outskirts of historic urban centers, and at the expense of agricultural land—leading to greater distance from public services and a lack of urban amenities.

Future urban vulnerabilities

The urban growth trends observed in recent years are expected to continue and become more pronounced, particularly in the following areas:

1. Around historic town centers, where informal housing is proliferating. This trend, though driven by relatively low local population growth, is exacerbated by the scarcity of urbanizable land accessible to the most disadvantaged households. The lack of urban planning documents in these areas limits the ability to provide basic services, further increasing the vulnerability of these populations.
2. Along the coasts, the most environmentally and climatically fragile areas, where urban expansion is fueled by tourism, leading to the development of second homes and rental properties.
3. In agricultural areas, which will increasingly lose their economic function due to the combined effects of climate change (declining yields from rain-fed agriculture) and shifting lifestyles (population urbanization and the growing dominance of the service sector).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04

CLIMATE CHANGE DIMENSION

Climate change dimension

Kerkennah Island, located off the eastern coast of Tunisia, is vulnerable to climate change due to its low-lying topography and dependence on coastal ecosystems. The island faces significant challenges, including sea level rise, increasing salinization, and changes in temperature and precipitation patterns.

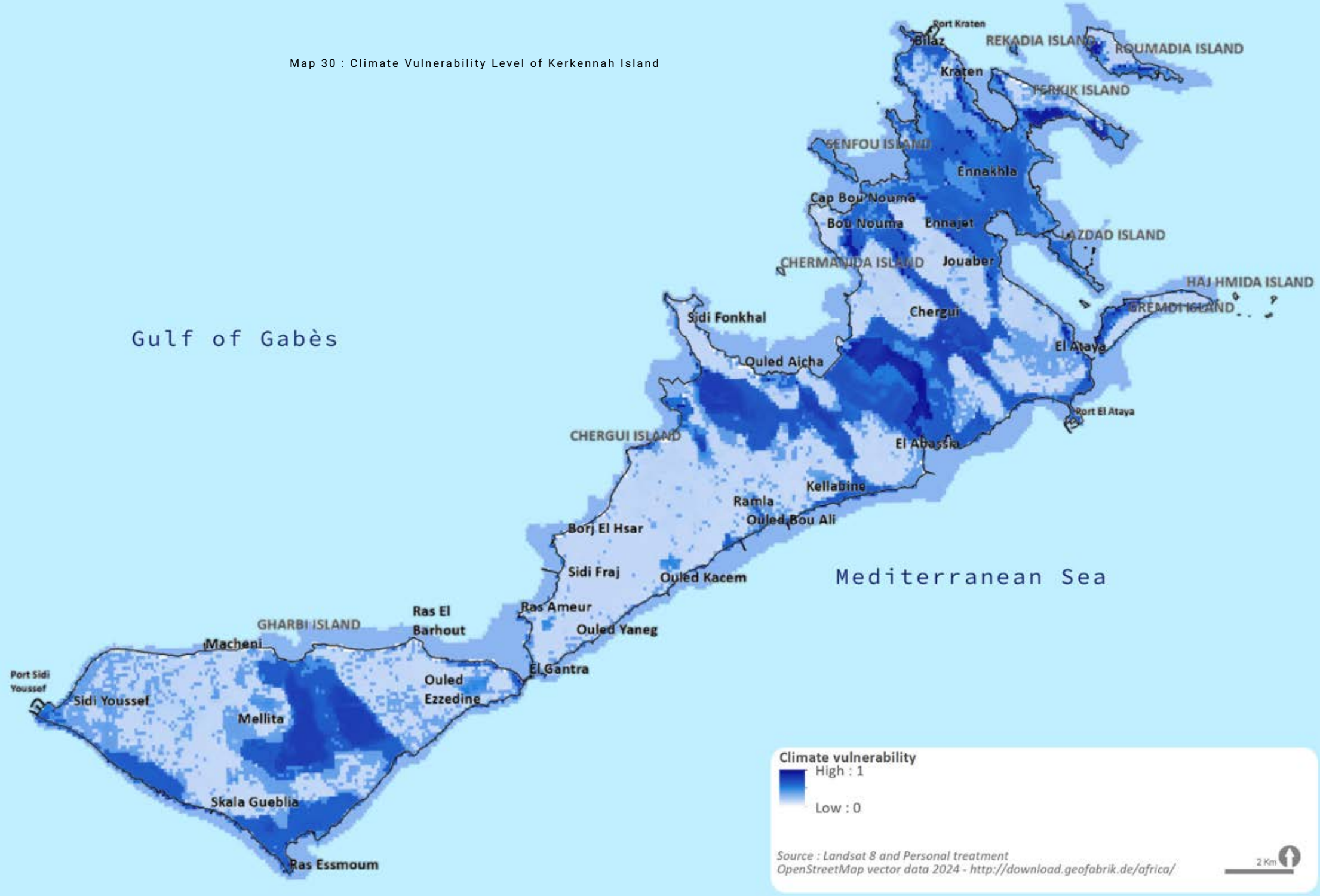
These environmental changes jeopardize not only the natural landscape but also the livelihoods of local communities who depend on agriculture, fishing, and tourism.

To assess the urban dimension of vulnerability, five key indicators were examined:

1. Temperature trends: Rising temperatures can affect precipitation patterns and evaporation rates, impacting the availability and quality of water resources. These changes can increase the frequency of heat waves, endangering human health, well-being, and productivity. Additionally, they disrupt ecosystems, alter biodiversity patterns, and cause heat stress, as well as damage to critical infrastructure. Given the lack of spatially distributed meteorological measurements in the public data of the National Institute of Meteorology , this indicator was studied in Kerkennah by extrapolating it from the observed changes[4] in average ground temperatures over the last decade, focusing on the hottest month of the year.
2. Sea level rise: Rising sea levels present significant risks to coastal communities, including increased coastal flooding, erosion, fragmentation and degradation of coastal habitats, and damage to coastal infrastructure and services. This also results in decreased water quality and availability. This indicator was studied in Kerkennah using simulations conducted by the Coastal Protection and Development Agency (APAL), specifically for Kerkennah, in line with IPCC scenarios.
3. Pluvial flooding: Floo ding, with the potential to cause loss of life, injury, and property damage, disrupts infrastructure systems, urban services, and economies, displaces populations, and damages agricultural land. Floods pose significant hazards to communities in at-risk areas. This indicator was assessed in Kerkennah using topographic, meteorological, and land-use data.
4. Drought risk: Droughts present a major threat due to their significant and cumulative impacts. Water scarcity caused by droughts affects not only the availability of drinking water but also public health, agriculture, food security, ecosystems, economic activities, and resilience. This indicator was studied in Kerkennah using open data from the Normalized Difference Water Index (NDWI) available over the last decade.
5. Coastal erosion risk: Coastal erosion threatens critical infrastructure such as roads, bridges, ports, utilities, housing, and buildings located in coastal areas. It also has significant environmental consequences, including habitat loss, shoreline retreat, and sedimentation of water bodies. This indicator was studied in Kerkennah using satellite imagery from the last ten years to track changes in the coastline

4 Kerkennah Island has no synoptic meteorological stations

Map 30 : Climate Vulnerability Level of Kerkennah Island



Indicators

Indicator 1 : Temperature trends

Climate data for Kerkennah Island from 2014 to 2024 reveal a significant increase in average monthly temperatures. In 2014, average temperatures ranged from 21°C in January to 30°C in July. By 2023, temperatures had increased significantly, with averages ranging from 24°C in January to 37°C in July. This trend highlights a clear warming trajectory, particularly during the summer months. To estimate air temperature from land surface temperature (LST), the following empirical relationship can be applied:

$T_{c°(air)} = a \times LST + b$

Or :

$T_{c°(air)}$ is the estimated air temperature,
LST is the land surface temperature,
a and b are regression coefficients.

For the island of Kerkennah, the specific equation used is as follows: $T_{c°(air)} = 0.7 \times LST + 3$

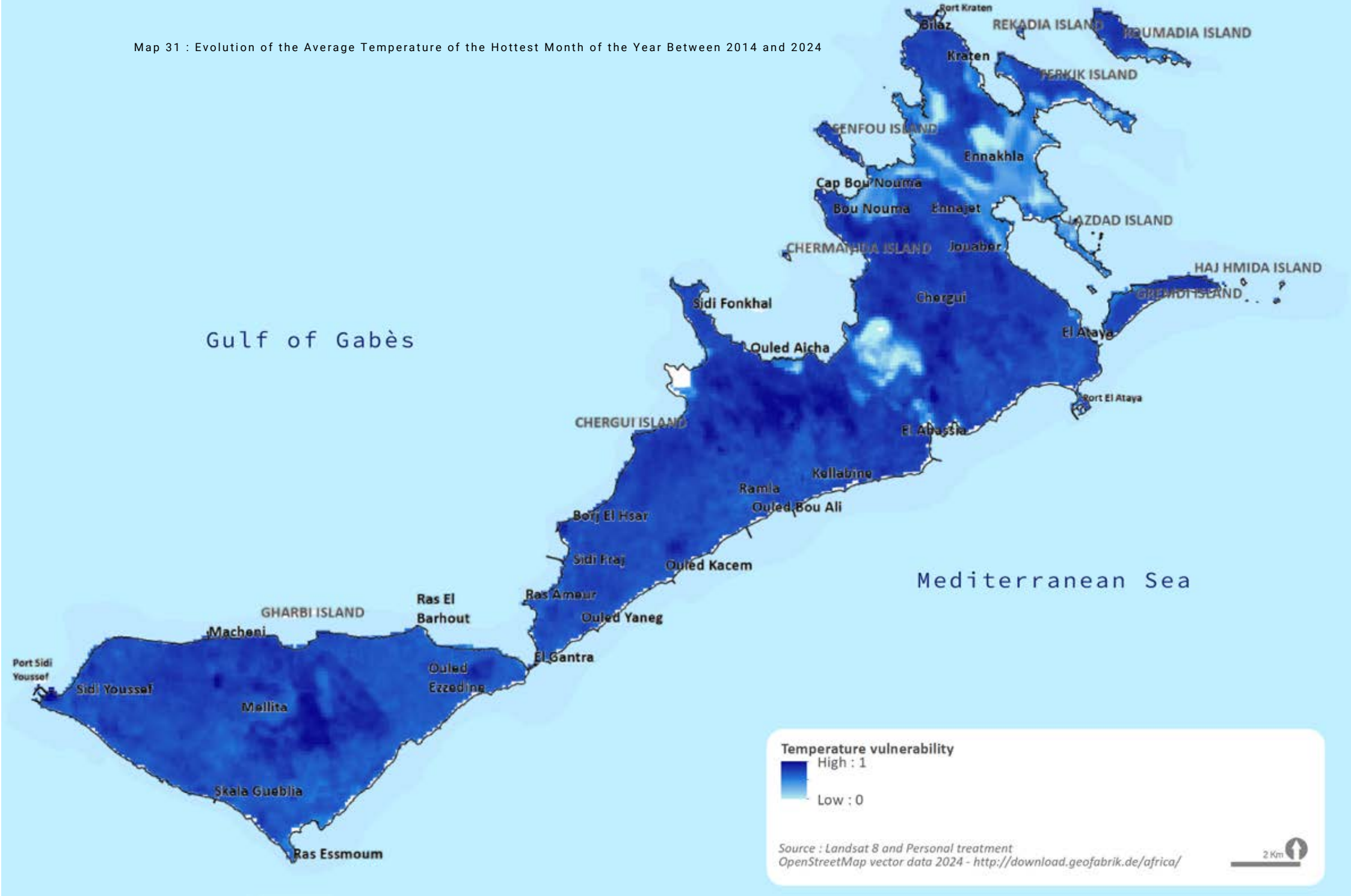
Why use a coefficient of 0.7 and an intercept of 3?

1. Coefficient 0.7: This coefficient reflects the correlation between LST and air temperature in similar regions. Studies suggest that because land surfaces warm more quickly than the air, LST tends to be slightly higher than air temperature. A coefficient of 0.7 implies that the air temperature is roughly 70% of the LST in semi-arid or coastal climates.
2. Intercept 3: This constant adjusts the estimated air temperature to account for regional factors such as humidity, altitude, and local microclimates. It lowers the estimated air temperature, since LST is often higher—especially in coastal areas where heat accumulates on the ground during the day.

Relevance to Kerkennah:

Kerkennah Island has a coastal Mediterranean climate influenced by the sea. During the day, LST can be significantly higher than air temperature because direct sunlight heats land surfaces, while sea breezes keep the air cooler. The 0.7 coefficient accounts for this difference, while the +3 constant empirically adjusts the estimate to align more closely with actual observations in similar environments.

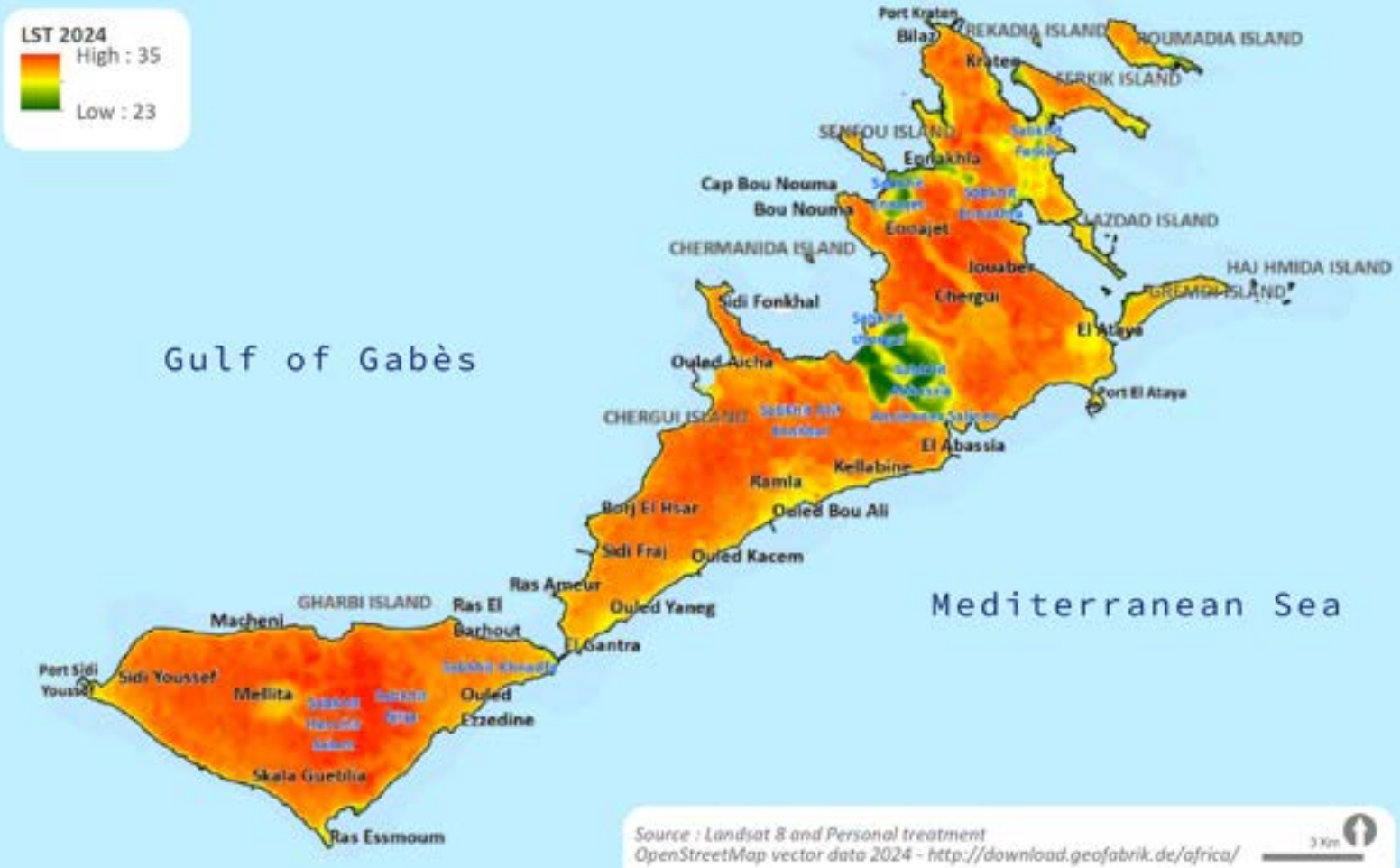
Map 31 : Evolution of the Average Temperature of the Hottest Month of the Year Between 2014 and 2024



Data acquisition:

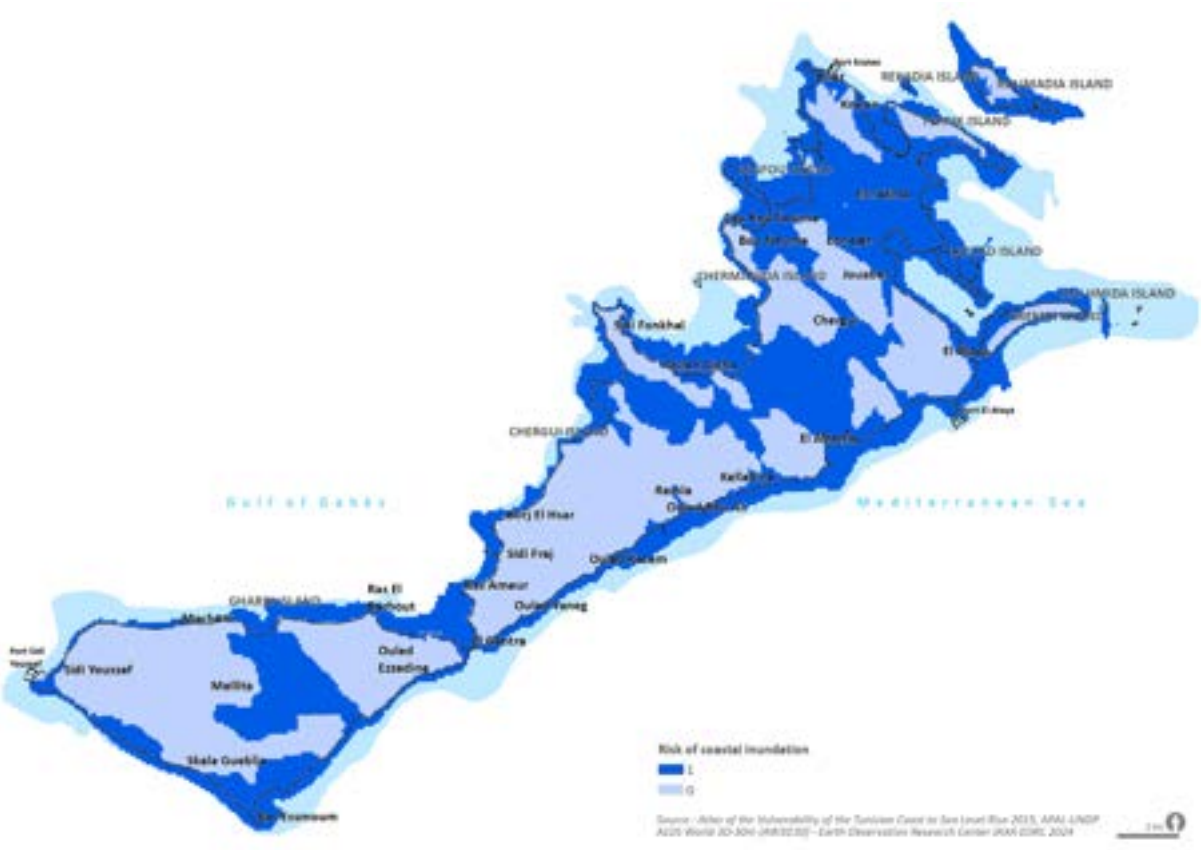
In the absence of direct temperature measurements for Kerkennah Island, and without publicly available data such as Copernicus ERA5 or NASA's GPM, satellite imagery was used to collect land surface temperature data. This data was then processed using the empirical relationship described above to estimate air temperatures. This approach made it possible to assess the increase in average July temperatures between 2004 and 2024. As a result, the areas with the greatest increases could be identified.

It appears that the areas of the island that have experienced the greatest temperature variations are those located inland, particularly in the area of Gharbi Island (around Mellita) and Chergui Island north of Ramla. These areas correspond to the large sebkhas of the island, which are likely to dry out further in the coming years and experience increased salinity levels. This will have a significant impact on the local ecosystem, particularly the wetlands and agricultural areas bordering them (Ramla Lakdima and Mellita).



Source : Landsat 8 and Personal treatment
OpenStreetMap vector data 2024 - http://download.geofabrik.de/africa/

Indicator 2 : Sea level rise



Map 32: Level of Risk of Coastal Inundation in Kerkennah[5]

Kerkennah Island, characterized by its low-lying topography, is particularly vulnerable to the effects of sea level rise, a phenomenon driven by climate change, melting ice caps, and the thermal expansion of seawater. Even a minor rise in sea level can have significant impacts on the island. Coastal erosion already presents an immediate threat to infrastructure, agriculture, and natural habitats. Additionally, saltwater intrusion into freshwater resources poses a further risk to agricultural viability and drinking water supplies, further disrupting local ecosystems and threatening biodiversity.

Addressing these challenges requires a multifaceted approach. Strengthening coastal defenses and improving drainage systems are essential steps to mitigate the impacts of rising sea levels. Furthermore, promoting sustainable agricultural practices and preserving natural habitats will enhance resilience to climate-related threats. Engaging local communities in conservation and adaptation efforts is crucial for fostering long-term resilience to climate change.

Recent meetings with the Steering Committee have underscored the urgency of addressing sea-level rise, highlighting the significant environmental challenges facing the Kerkennah archipelago. Indeed, local stakeholders have expressed genuine concern about the sea-level projections established by the relevant authorities and are deeply worried about the impact this rise could have on their way of life, the local economy, and the environment.

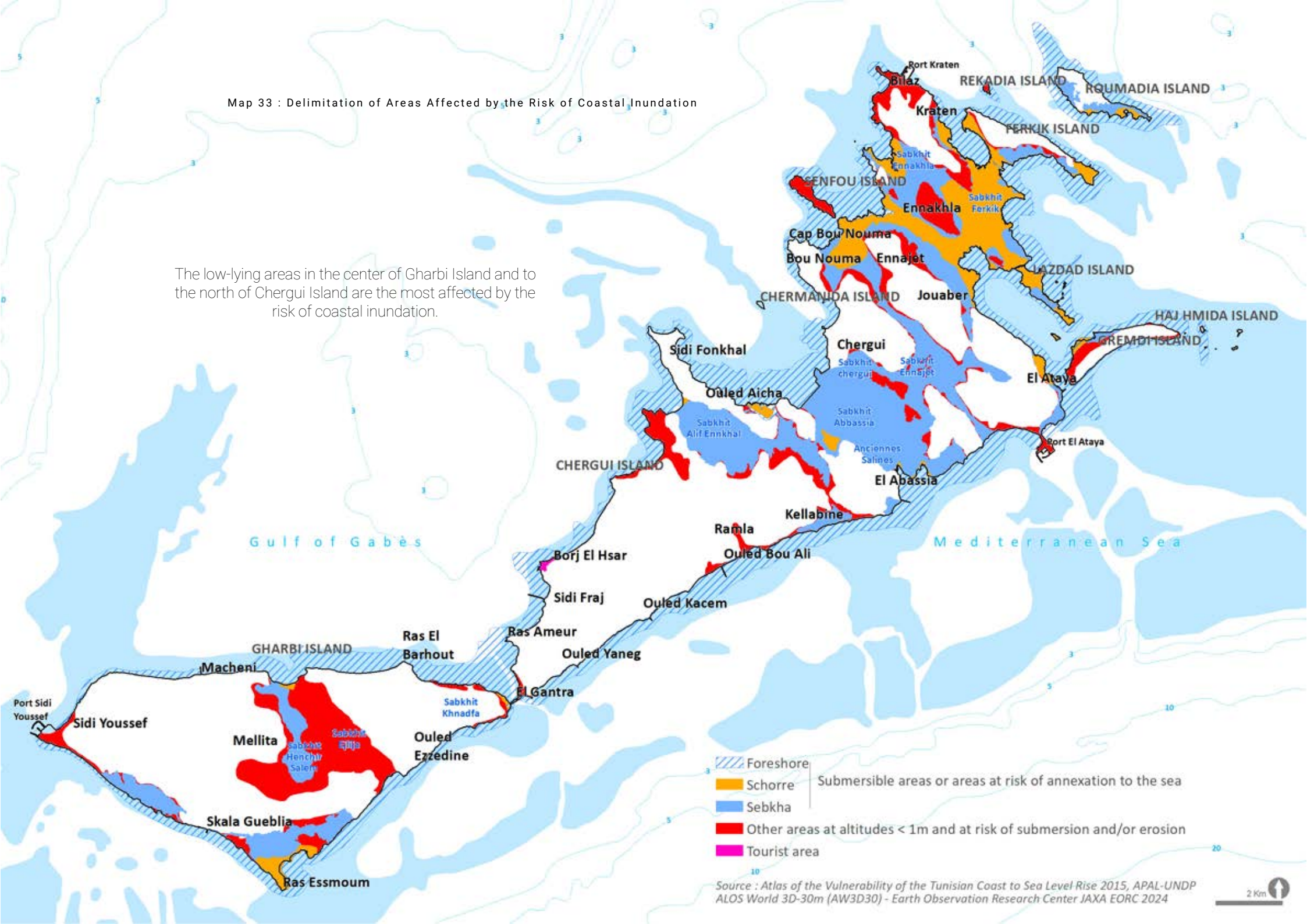
The data on the delimitation of areas at risk of coastal inundation are based on the work of the Coastal Protection and Development Agency (APAL[6]), which considered a maximum risk scenario of a 50 cm rise in sea level by 2100, affecting land located less than 1 meter above the current sea level.
It appears that all the coastal marches and sebkhas of the island are at significant risk of inundation, and the low-lying areas surrounding them (with altitudes less than 1 meter) are also at risk of inundation and/or erosion. This primarily concerns the central areas of Gharbi Island and the northern part of Chergui Island.

5 The areas indicated with a score of 1 are those affected by sea level rise. The areas with a score of 0 are not affected by sea level rise.

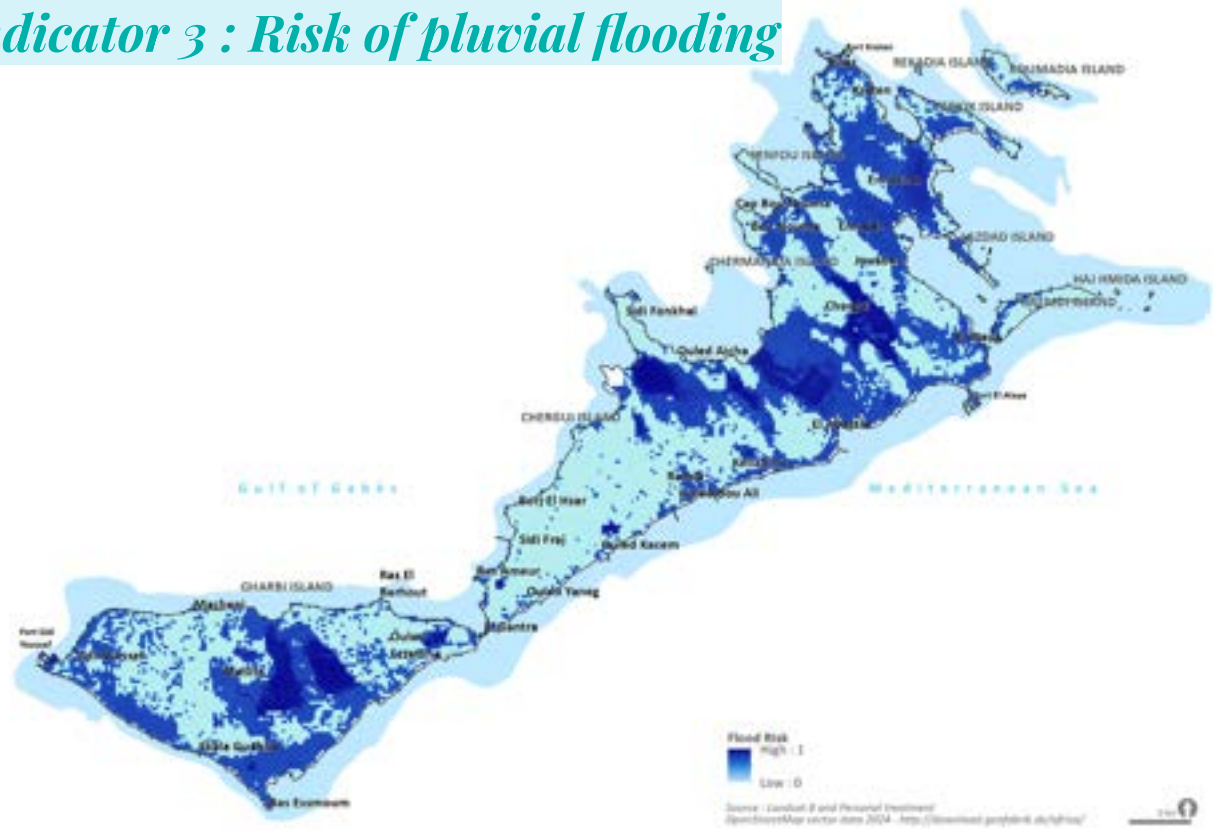
6 Atlas de la vulnérabilité du littoral tunisien à l'élévation du niveau marin, APAL, 2015.

Map 33 : Delimitation of Areas Affected by the Risk of Coastal Inundation

The low-lying areas in the center of Gharbi Island and to the north of Chergui Island are the most affected by the risk of coastal inundation.



Indicator 3 : Risk of pluvial flooding



Map 34 : Flood risk level on Kerkennah Island

Kerkennah Island experienced three days of extreme rainfall in December 2013[7], during which a Landsat 8 satellite image captured the flooded areas. Using processing techniques with Landsat 8 data, it was determined that 2,500 hectares were flooded, including the entire wetland area and some cultivated clay-loam fields. Water remained stagnant in the wetland for over four months.

Towns such as Mellita, Ramla, Kraten, Ataya, and Sidi Fraj were significantly affected by the 2013 floods.

This extreme event provides insight into land areas that could be overtaken by wetlands in the coming years. These areas are characterized by elevations close to sea level and saline soils. This observation must be considered when developing vulnerability scenarios in the event of sea level rise or extreme weather events.

The Kerkennah flood risk map was developed by combining historical rainfall data from the National Institute of Meteorology (INM) with data on altitude, hydrographic networks, and land use.

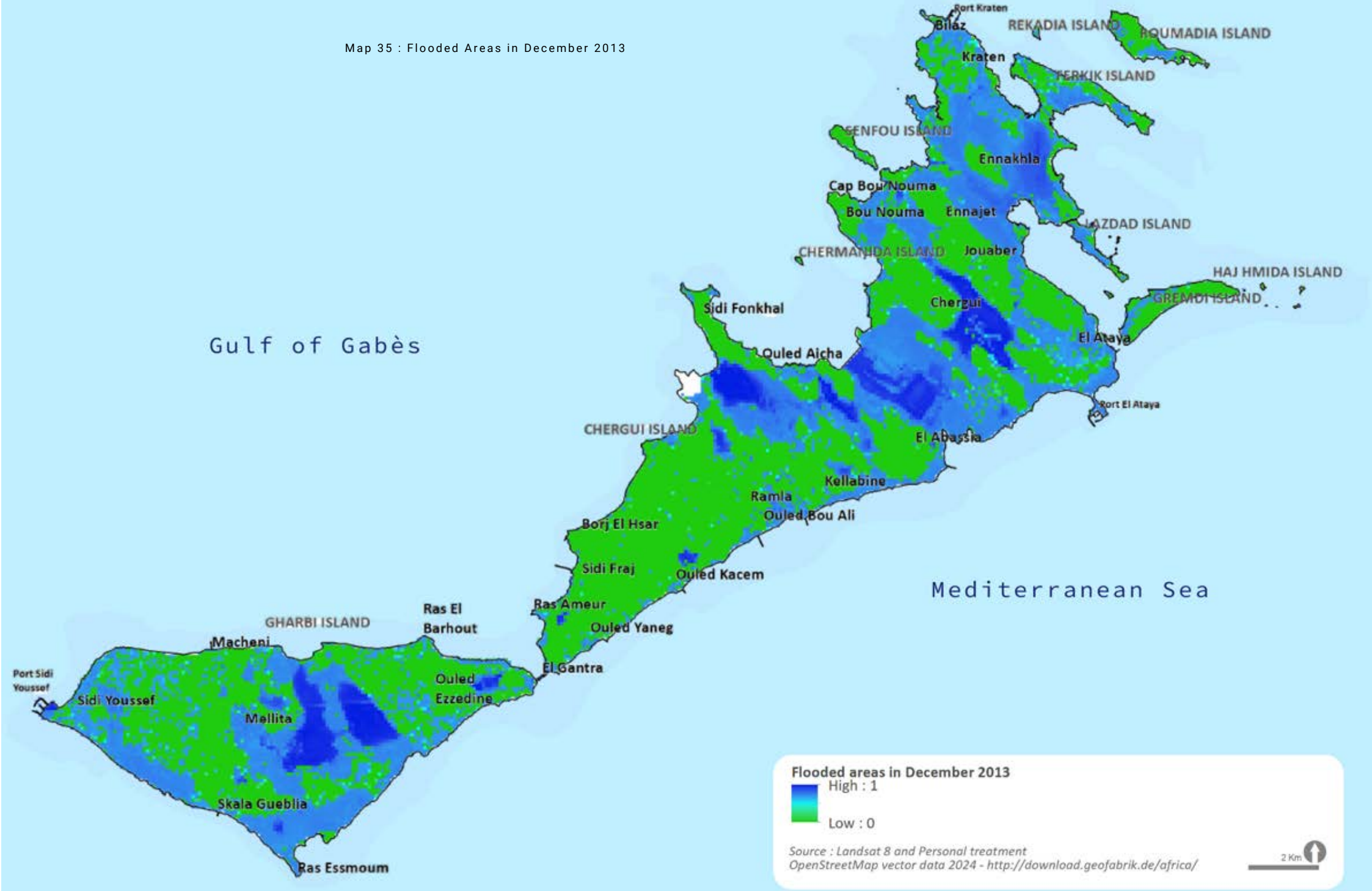
Historical data enabled the determination of flow characteristics for ten-year, twenty-year, fifty-year, and hundred-year rainfall events, thus allowing for the calculation of the maximum water level for each rainfall frequency. Due to the island's relatively flat nature, water is evacuated slowly and tends to accumulate in low-lying areas.

The areas most affected by the risk of flooding are as follows:

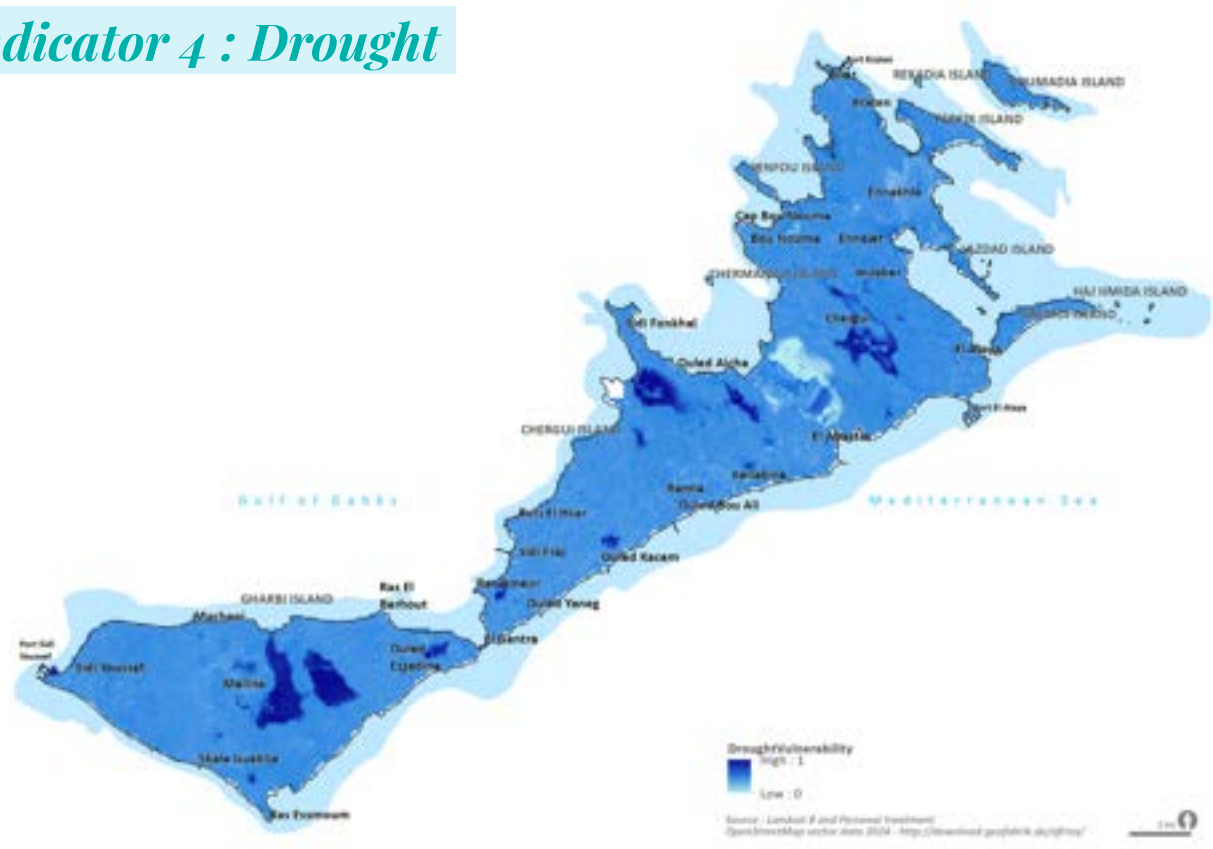
1. All the low-lying, flat areas formed by the sebkhas (Ferkik, Ennakhla, Ennajet, Chergui, Abbassia, Alif Ennakhal, Ejlija, and Henchir Salem). These unoccupied areas naturally serve as absorption spaces for the runoff from small rivers flowing into them. Their non-detrimental floodability is not problematic; however, the recent disruption of their hydrological functions—especially due to road infrastructure and the expansion of salt marshes—means this buffering role is no longer fully effective, which poses a risk to the occupied areas downstream.
2. The lower periphery of all coastal towns (Kraten, Ennajet, El Attaya, El Abbassia, Ramla, Ouled Kacem, and Ouled Yaneg). These low-lying areas are under increasing land pressure, with accelerating urban expansion and the establishment of public facilities on at-risk land.

7 Dahech S et al , L'archipel de Kerkennah (Tunisie) face au risque d'inondation : approche par l'aléa et les vulnérabilités. In actes CNFG March 2015.

Map 35 : Flooded Areas in December 2013



Indicator 4 : Drought



Map 36 : Drought risk level

In assessing drought conditions on Kerkennah Island, a comparative analysis using the Normalized Difference Water Index (NDWI) for the years 2014 and 2024 reveals significant changes in the health of wetlands.

NDWI data indicate that while the condition of wetlands in 2014 was relatively stable, between 2014 and 2024, several wetlands experienced significant water stress.

This change highlights a concerning trend of decreasing water availability in these ecosystems, likely influenced by climate change, including increased evaporation rates and altered local precipitation patterns.

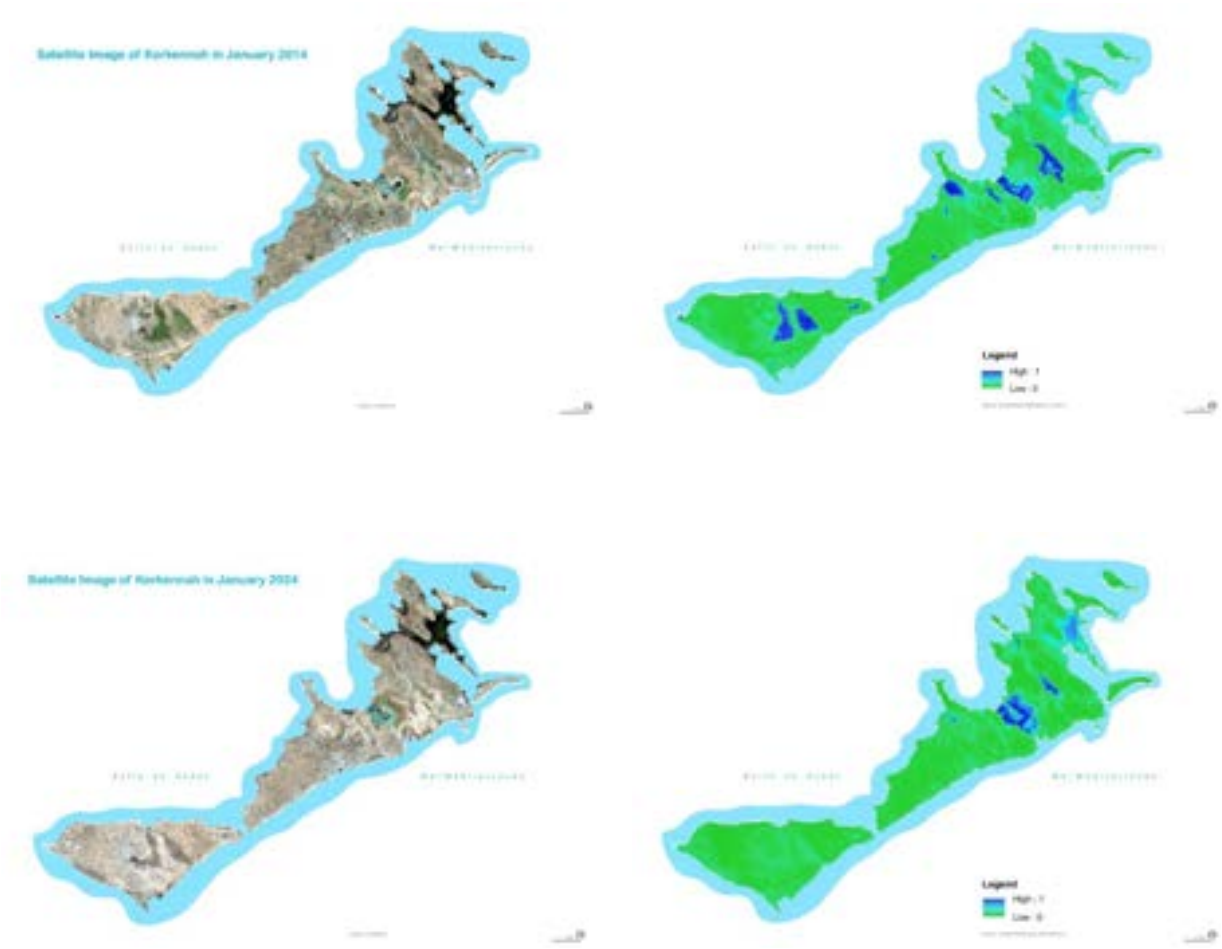
The observed drought conditions pose risks not only to the ecological integrity of wetlands but also to the livelihoods of communities that rely on these resources.

This analysis underscores the urgent need for effective water management strategies to mitigate the impacts of drought on both the environment and local populations.

Why do we use the NDWI (Normalized Difference Water Index)?

The Normalized Difference Water Index (NDWI) is widely used to assess water bodies and monitor changes in wetland health due to its effectiveness in distinguishing aquatic from non-aquatic features in satellite imagery. The primary reasons for using NDWI are:

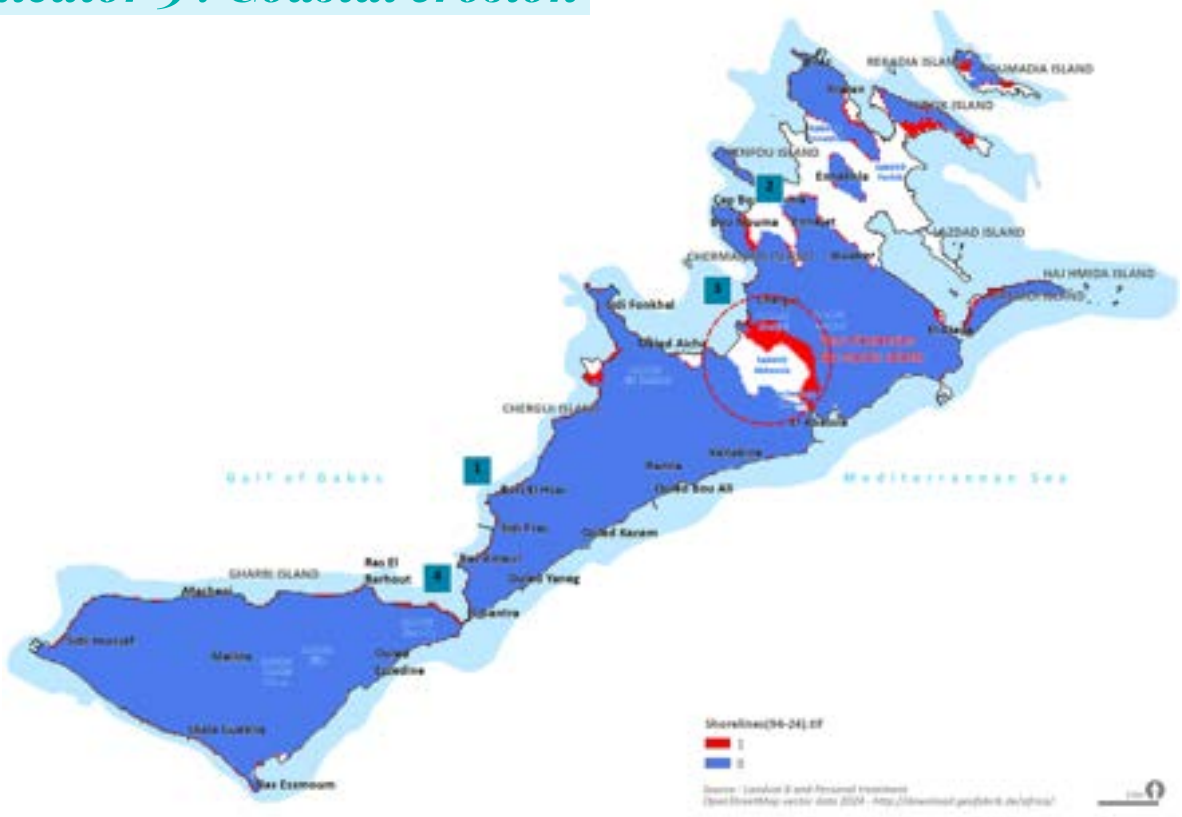
1. Water Sensitivity: NDWI is designed to enhance the visibility of water bodies by utilizing specific wavelengths of light (green and near-infrared). This allows for precise identification of surface water, making it an invaluable tool for wetland monitoring.
2. Change Detection: NDWI is highly effective in detecting temporal changes in water levels and wetland conditions by comparing NDWI values across different years.
3. Environmental Monitoring: The index plays a crucial role in assessing the health of aquatic ecosystems. Changes in NDWI values can indicate stress in wetlands, which may result from climate change, human activities, or natural events.



Map 37 : Soil Moisture Variation Between 2014 (top) and 2024 (bottom)

It appears that the areas most affected by soil drainage are located in Sebkhet Chergui, Sebkhet Alif Ennkhal, Sebkhet Ejlija, and Sebkhet Henchir Salem. These areas have experienced a sharp rise in temperatures in recent years and have been impacted by a decrease in rainfall. The drier and warmer sebkhas no longer play their role in regulating soil salinity, which is affecting the peripheral agricultural areas and threatening their productivity. Wetlands, which are essential for local biodiversity, are also at risk in their ecological role, the foundation of which relies on the degree of soil moisture.

Indicator 5 : Coastal erosion



Map 38: Areas Affected by Coastal Erosion

A detailed examination of shoreline retreat from 1994 to 2024 along the coastline of Kerkennah Island reveals significant geomorphological changes. In 1994, the shoreline exhibited relatively stable conditions, with minimal retreat. However, by 2024, satellite images show substantial shoreline retreat, indicating accelerated coastal erosion. This change is attributed to a combination of factors, including sea-level rise, increased storm intensity, and human activities such as coastal urban development. The implications of this retreat are far-reaching, affecting land use and coastal ecosystems, while posing risks to infrastructure and local communities.

Marine erosion affects all coasts of the island, despite conditions not being particularly favorable for strong erosion (low bathymetry and low water energy). The signs of erosion have been noted primarily in the following areas:

1. Along the rocky cliffs at Borj H'sar (Photo 1) and Kraten (Photo 2), where the evolution of the coastline is clearly visible, thanks to archaeological remains that gradually fall into the water.
2. Along the urbanized coasts, where both residents and public authorities have made attempts to protect the coastline, particularly in Attaya, Bounouma, and Ras Ameur (Photo 3). The retreat of the coastline poses a risk to coastal infrastructure and facilities, as well as to some homes.
3. Along the natural beaches, indirect signs indicate the advance of the coastline, notably through the loss of palm trees and the transformation of the plant landscape (Photo 4).

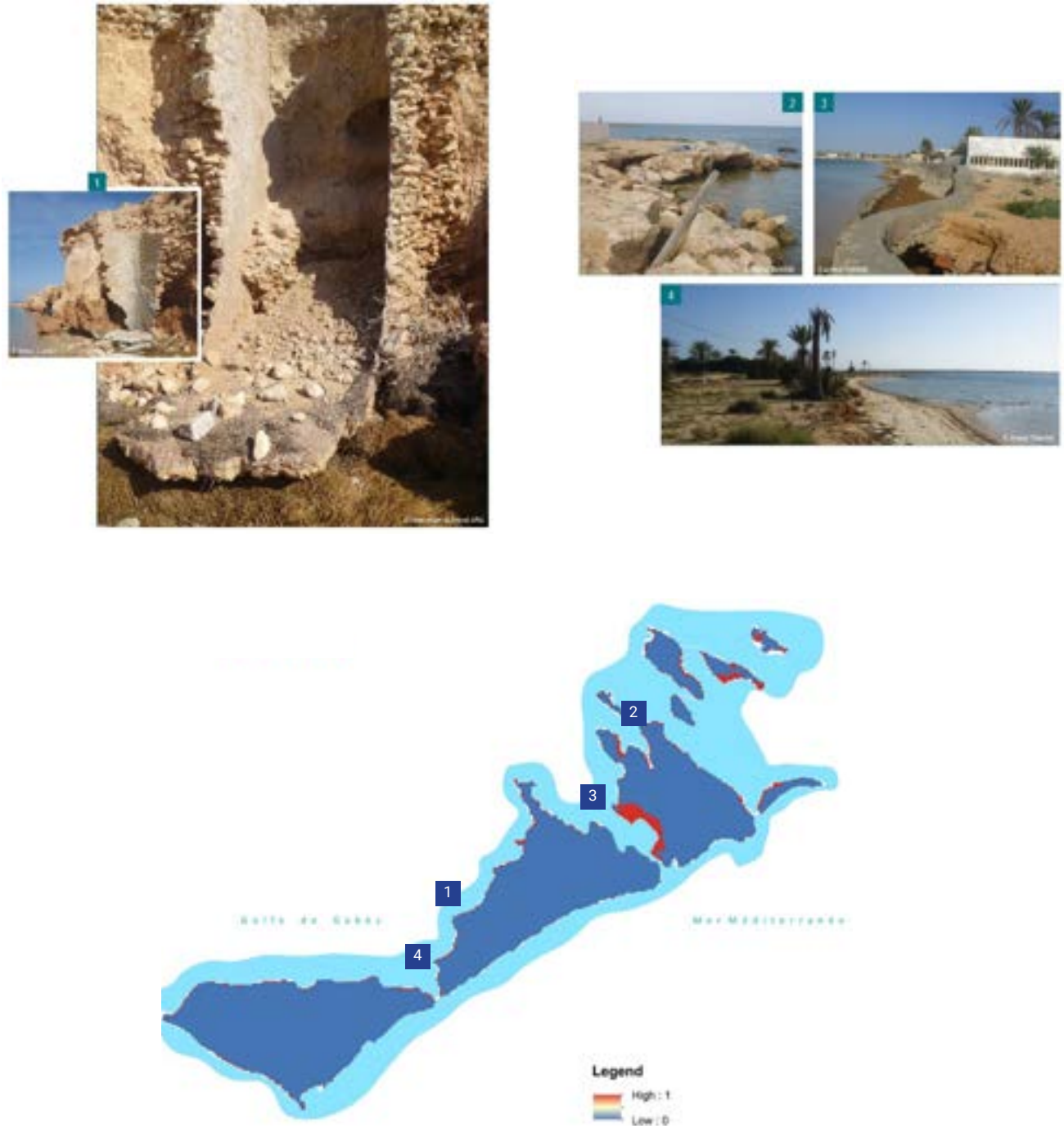
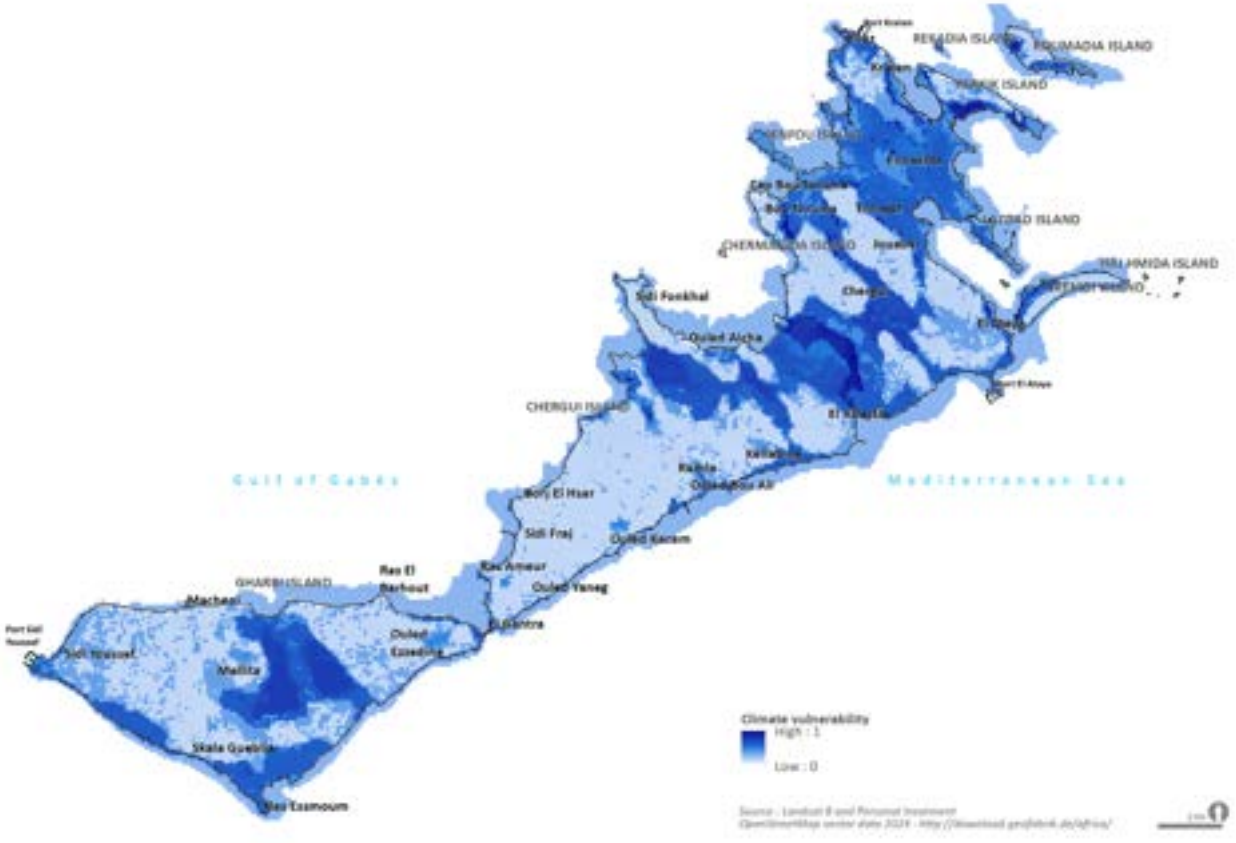


Photo 1: Manifestations of Marine Erosion on Kerkennah Island (Source: Ameur Oueslati, Atlas des vulnérabilités du littoral tunisien, APAL, 2015)

Analysis of the climate change dimension



Map 39: Climate Vulnerability Level of Kerkennah Island

The analysis of the climate change dimension in Kerkennah Island was based on the assessment of five indicators. The following coefficients were assigned to each indicator in constructing the final vulnerability score:

1. Temperature trends: 1
2. Risk of sea level rise: 2
3. Flood risk: 2
4. Risk of drought: 1
5. Risk of coastal erosion: 2

These coefficients were established by the stakeholders to reflect the connection between climate risk and local development challenges. For the consulted stakeholders, it is sea level rise, flooding, and coastal erosion that pose the most significant threats to the island's inhabitants and their activities.

As a result, the areas most affected by climate change in Kerkennah are the coastal regions (specifically the coasts from Ouled Kacem to El Ataya, the islets of Gremdi, Ferkik, Roumadia, and Rkadya, as well as the Kraten coast), wetlands, and depressions (sebkhas). These areas are particularly impacted by flooding, marine erosion, and are at risk of sea level rise due to their flat and low topography.

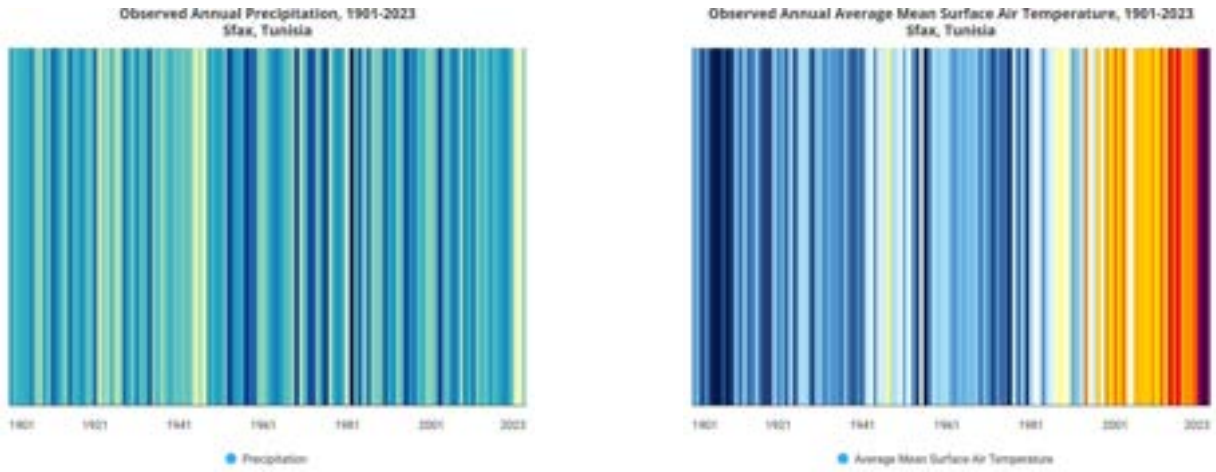
The interior highlands are not exempt. Palm groves and agricultural areas, especially around Mellita and south of Sidi Founkhal, are vulnerable to drought and rising temperatures, posing a threat to agricultural activities and local biodiversity.

Climate change : future vulnerabilities

Kerkennah Island is increasingly vulnerable to the impacts of climate change, with observable trends indicating rising sea levels, higher temperatures, and an increased risk of drought. According to the Climate Change Knowledge Portal, average surface air temperatures in the region have risen by nearly two degrees over the past 40 years, while rainfall has decreased from 300mm in the 1960s to less than 200mm in recent years.

As global temperatures rise, the islands' low-lying topography makes them particularly vulnerable to coastal flooding and erosion. These conditions threaten not only the natural landscape but also the livelihoods of local communities who depend on agriculture, fishing, and tourism.

Furthermore, the increasing frequency and severity of droughts pose significant challenges to freshwater availability and agricultural productivity, exacerbating food security concerns. The combination of sea level rise and prolonged droughts can lead to saltwater intrusion, further compromising freshwater resources and agricultural land. Together, these factors underscore the urgent need for effective adaptation strategies and sustainable management practices to mitigate the adverse effects of climate change on Kerkennah Island and safeguard its ecological and economic future.



Graph 1 : Observed Changes in Annual Precipitation and Average Temperatures in the Sfax Region (Source: Climate Change Knowledge Portal)

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05

BIODIVERSITY DIMENSION

The Biodiversity Dimension

The Kerkennah Archipelago is recognized for its remarkable biodiversity, hosting a wide variety of marine and terrestrial species, some of which are endemic or threatened. The assessment of biodiversity vulnerability on Kerkennah Island was based on the evaluation of three indicators:

1. The average abundance of species

This indicator measures the health of ecosystems, reflecting both the diversity and the ecological integrity of habitats. A high species abundance indicates a balanced and functional environment, while a decline may signal ecological threats or disturbances. Accurately mapping species has proven challenging due to a lack of specific spatial data. This is largely because the archipelago is often considered as a single unit in biodiversity studies, limiting the ability to distinguish and analyze species distribution across the different islands and islets. This shortcoming makes it difficult to precisely identify the distribution and ecological richness of each zone.
To address the lack of direct spatial data, we relied on existing literature describing the habitats of each species, allowing us to overlay species onto appropriate habitats and thereby produce a more accurate estimate of their potential distribution.

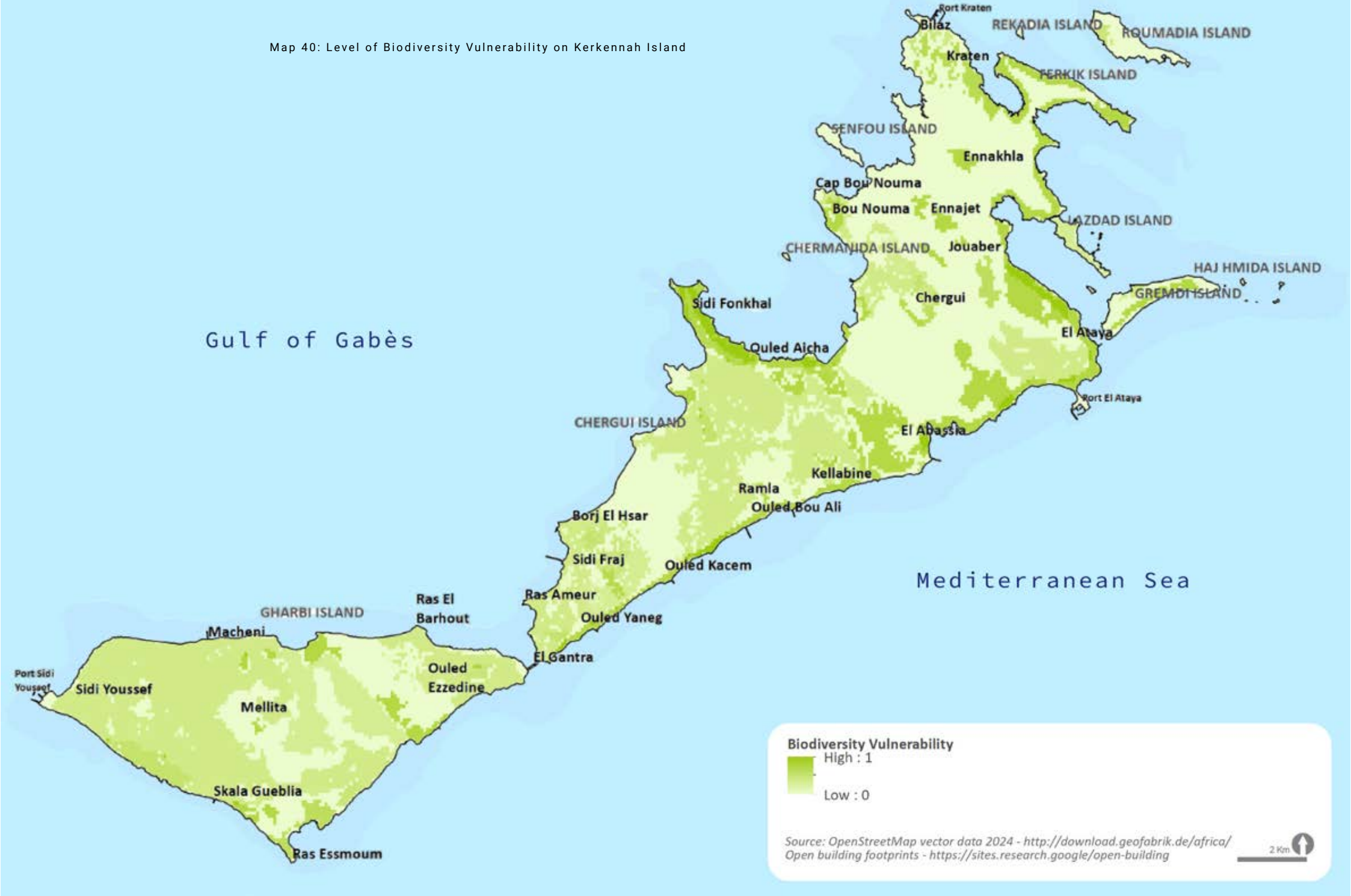
2. The connectivity of biodiversity

Ecological connectivity is a key factor in the preservation of species in Kerkennah. Marine habitats—such as Posidonia meadows and rocky reefs—are interconnected, enabling the flow of nutrients and the maintenance of biodiversity. These ecosystems serve as breeding and nursery areas for many marine species.
Similarly, terrestrial ecosystems, including saline steppes and specific plant formations, also contribute to ecological connectivity by offering refuges for migratory birds and endemic species.

3. Protected areas / Conservation zones

The Kerkennah Islands were designated as an Important Bird Area (IBA) in 2001, underscoring their significance for avifauna. In 2012, they were also classified as a Wetland of International Importance under the Ramsar Convention, recognizing the ecological value of the archipelago's sebkhas and wetlands.
In 2023, the northern islets of Kerkennah were added to the list of future Coastal Marine Protected Areas (CMPAs), with the aim of enhancing the protection of marine and coastal biodiversity from human pressures such as overfishing and pollution

Map 40: Level of Biodiversity Vulnerability on Kerkennah Island



Indicators

Indicator 1 : Average Abundance of Species

The marine fauna of the archipelago harbors remarkable biodiversity, including emblematic species and taxa of commercial interest. Among these, Pinna nobilis, associated with Posidonia meadows, stands out as one of the most notable heritage species (Ben Mustapha et al., 2003). Other economically exploited species, such as the Common Octopus *(Octopus vulgaris)* and the Common Cuttlefish *(Sepia officinalis)*, are also present (Ramos-Esplá et al., 2000).
A synthesis of available knowledge has identified several taxonomic groups, including 31 species of ascidians, 24 species of crustaceans, 20 species of echinoderms, 7 species of anthozoans, 11 species of annelids, and 4 species of bryozoans (Ben Mustapha et al., 2003).

The ichthyological fauna of the archipelago is particularly diverse. Taktek et al. (2020) recorded 17 species of elasmobranchs during a landing monitoring campaign in 2019, including 12 species of rays and 5 species of sharks, among them the Great White Shark *(Carcharodon carcharias)* and the Sandbar Shark *(Carcharhinus plumbeus)*. The latter appears to be the most frequently landed species, with 569 individuals captured during the study. The total number of species recorded represents over 35% of the elasmobranch fauna of the Gulf of Gabes.

Regarding marine mammals, the archipelago is a favorable area for the feeding and reproduction of the Bottlenose Dolphin *(Tursiops truncatus)* (Ben Naceur et al., 2004). In addition, several strandings of cetaceans—including Fin Whales *(Balaenoptera physalus)*—have been reported along the coasts of the archipelago during the 20th century, particularly in 1949, 1956, and 1976 (Ktari-Chakroun, 1980).

Although the number of mollusk species recorded in the Gulf of Gabes has been estimated at 171 (Afli et al., 2005), no specific inventory appears to have been conducted for the Kerkennah archipelago. A preliminary list compiled from various studies (Aloui Bejaoui and Afli, 2012; El Lakhrach et al., 2012a, b; SPA/RAC & UNEP/MAP, 2015; APAL, 2001 and 2015; El Lakhrach et al., 2019), as well as other works, identified 37 species of gastropods, 15 species of bivalves, 3 species of cephalopods, and 2 species of polyplacophores.

As for the sponge fauna, a coastal inventory conducted by Ben Mustapha and Afli (2007) identified 50 species, mainly associated with Posidonia meadows. Among the species most heavily fished and targeted by fishing efforts in the Kerkennah area are two sponges in particular: Spongia officinalis and Hippospongia communis. All of these species are harvested during regulated fishing seasons, which are annually overseen by the fisheries administration (DGPA/CRDA-Sfax, local fishing district).

However, fish stocks—particularly due to a combination of natural and anthropogenic disturbances and their amplification—have experienced a significant decline in recent years. With the persistence of the threats and disruptions that caused this decline, and their likely intensification in the future, a collapse of many fishing activities is expected in the coming years.

This could lead to heavier socio-economic repercussions and the transformation of economic activities, replacing traditional practices—such as artisanal fishing and charfia fishing—with the forced adoption, even by the most conscientious fishers, of prohibited and destructive fishing techniques.

It is important to emphasize that the richness and diversity of the archipelago's marine fauna are closely tied to the quality of benthic habitats, such as Posidonia meadows (Posidonia oceanica) and reef formations, whether of biological origin (oyster or mussel beds) or geological. These ecosystems play a fundamental ecological role—not only as feeding, breeding, and nursery areas for many species—but also as natural barriers against coastal erosion.

Seagrass beds, in particular, help dissipate wave energy and stabilize sediments, thereby limiting coastal retreat and reducing the impact of marine storms (Boudouresque et al., 2006). Although this aspect is not included in the quantitative Marine Vulnerability Assessment (MVA), it is reasonable to assume that the degradation of these key habitats could increase the vulnerability of certain coastal areas of the Kerkennah archipelago, especially along the northern shoreline, which is more exposed to wave action and storms.
A qualitative approach suggests a correlation between the health of these marine ecosystems and the safety of coastal areas—a link that deserves further investigation in future studies.

Map41: Degree of Vulnerability of Marine Habitats.

The vulnerability map of terrestrial habitats was developed based on the potential number of species inhabiting them. This potential number refers to the estimated species richness per habitat, derived from the compilation and analysis of data from scientific literature and available technical reports on the archipelago's biodiversity.

This is a qualitative approach, based on cross-referencing existing inventories with descriptions of suitable habitats, enabling the estimation of species likely to be present—even in the absence of exhaustive field surveys.
Areas characterized by rich and diverse biodiversity require specific protection measures and have therefore been assigned a high vulnerability score.

The terrestrial fauna of Kerkennah consists mainly of species adapted to the harsh conditions imposed by the arid climate. Reptiles such as the ocellated lizard *(Timon lepidus)* and the ladder snake *(Zamenis scalaris)* are particularly well-suited to this environment. These species seek refuge in rocky areas and crevices, where they can shelter from extreme temperatures.
The Kerkennah archipelago is recognized as a critical area for bird conservation, designated as an Important Bird and Biodiversity Area (IBA). This designation is due to the presence of numerous sebkhas, which cover about one-third of the archipelago's total area and provide ideal wintering conditions for many species of waterbirds, thanks to the permanent presence of water.

These wetlands host a variety of migratory and resident bird species, such as the great cormorant *(Phalacrocorax carbo),* gulls, and terns, including the slender-billed gull *(Larus genei),* the lesser black-backed gull *(Larus fuscus)*, the yellow-legged gull *(Larus michahellis)*, the Caspian tern *(Sterna caspia)*, and the sandwich tern *(Sterna sandvicensis).*

In addition to these species, other birds also nest on the archipelago, such as the kestrel *(Falco tinnunculus),* the cream-colored courser *(Cursorius cursor),* the European bee-eater *(Merops apiaster),* and the great grey shrike (*Lanius excubitor).*

Furthermore, Kerkennah serves as a major stopover site for hundreds of thousands of migratory passerines during the spring and autumn migrations. During these periods, the archipelago becomes a key crossing point for many birds arriving from Europe, including waders and waterbirds such as the Eurasian spoonbill *(Platalea leucorodia)*, the grey heron *(Ardea cinerea)*, and various gulls, shorebirds, and terns *(Sternidae)*.

A 2009 census revealed that the archipelago hosts approximately 1% of the global population of Eurasian spoonbills, with 176 individuals, and 1% of the population of slender-billed gulls, with 1,981 individuals.

A recent study highlights the importance of the northeastern part of the archipelago for birdlife, identifying notable species such as the Eurasian stone-curlew *(Burhinus oedicnemus),* which is very abundant in the area, along with various tern species that are relatively rare and localized in the Maghreb.

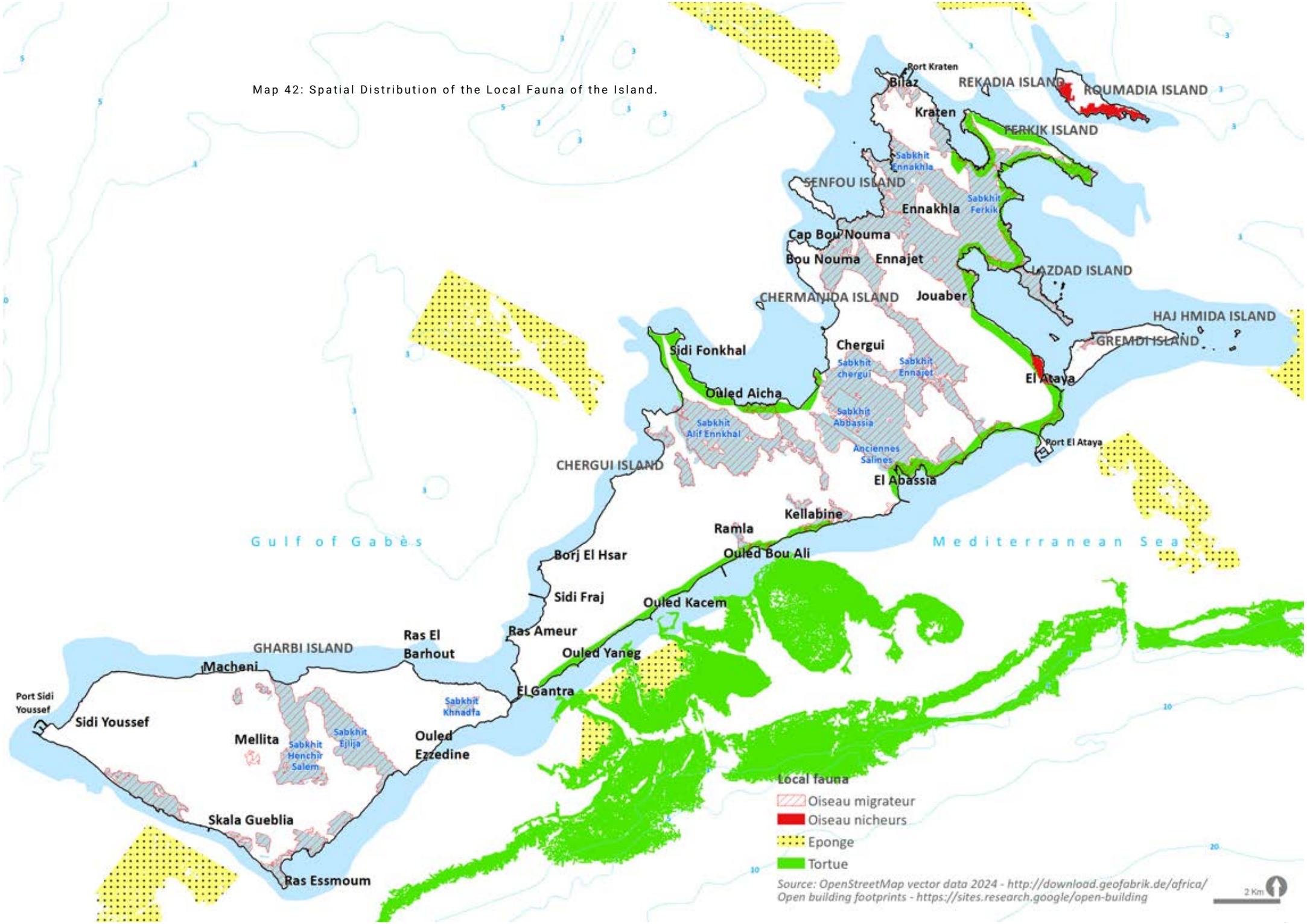
Other notable species include the Kentish plover *(Charadrius alexandrinus)*, the common redshank *(Tringa totanus),* the great cormorant *(Phalacrocorax carbo)*, and the tawny pipit (Anthus campestris), with wintering populations reaching up to 10,000 individuals.

According to Wetlands International (2003) and DGEQV (2012), the number of birds using the archipelago during the wintering and breeding seasons can reach 8,000 individuals across all species.
In particular, the islets of Gremdi, Roumadiya, and Sefnou are among the richest in breeding species, hosting nearly half of the nesting species found in the archipelago. This diversity is attributed to a heterogeneity of habitats, including rocky outcrops and shrubby vegetation formations.

The islets are colonized by various specific species: the Kentish plover *(Charadrius alexandrinus)* is present on all the islets of the archipelago, while the yellow-legged gull *(Larus michahellis),* though widespread, does not appear to breed on Sefnou. The crested lark *(Galerida cristata),* which favors the saline steppes of sansouires *(salt march vegetation),* is particularly common on the northeastern islets, notably Gremdi, Roumadiya, and Sefnou.

The great crested grebe *(Podiceps cristatus)* has been observed in Roumadiya, where small bodies of water occupy the salt flats. Finally, the black-eared wheatear *(Oenanthe hispanica)*, a rock-dwelling species, appears to breed in the small rocky outcrops of Gremdi.
Terrestrial mammals are less diverse on the islands, but

Map 42: Spatial Distribution of the Local Fauna of the Island.



species such as the Algerian hedgehog *(Atelerix algirus)* and various rodents have adapted to the arid conditions and limited water availability.

However, despite this remarkable faunal richness, the integrity of the archipelago's terrestrial ecosystems is showing signs of gradual degradation. Urban development pressure—although relatively limited compared to other coastal regions—has contributed to the fragmentation of certain habitats, including sansouire areas and coastal vegetation formations.
Climate change is compounding these pressures, with rising temperatures and reduced annual rainfall intensifying the aridification of the environment. These factors are reducing food resources and nesting sites available to several bird species.
Recent observations also suggest changes in avifaunal migratory patterns. Some migratory species, once present in large numbers, are seeing population declines, while others are altering their wintering periods or migratory routes—likely in response to regional climate variations and habitat degradation along their migration corridors.

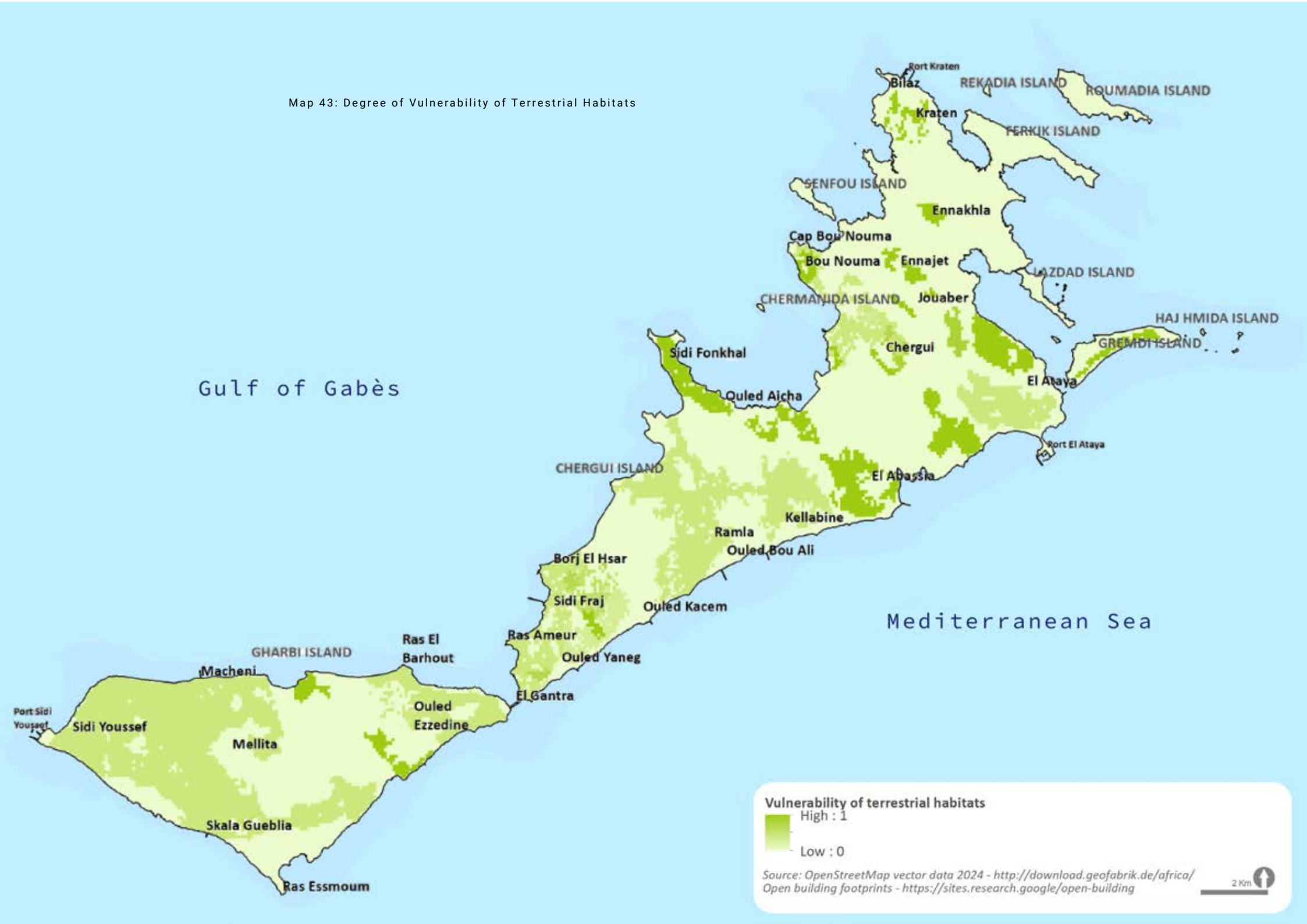
The loss of terrestrial biodiversity on the islands could have significant consequences for ecosystem services. For example, the decline in bird populations could negatively impact birdwatching tourism, which represents a potential source of income for local communities.

Moreover, degraded habitats may lose their capacity to regulate air and water quality, thereby exacerbating already precarious environmental conditions.

Finally, the phenomenon of coastal erosion—particularly pronounced in certain parts of the archipelago—contributes to the retreat of essential coastal habitats, such as beaches and dunes, which serve as breeding sites for several species, including the Kentish plover *(Charadrius alexandrinus)*.

This loss of habitat results in reduced breeding populations and increased vulnerability of local species. Continued erosion could also promote the salinization of inland soils, indirectly affecting vegetation and the associated fauna.

Map 43: Degree of Vulnerability of Terrestrial Habitats



Indicator 2 : Biodiversity Connectivity

The vegetation of the Kerkennah archipelago is dominated by halophyte species, i.e. plants adapted to saline soils. Among the most common species are glasswort *(Salicornia spp.)*, sea soda *(Suaeda maritima),* and false purslane *(Halimione portulacoides).* These plants play a crucial role in stabilizing soils and reducing erosion, while providing habitat for various animal species. The higher areas, less affected by salinity, are home to xerophilic vegetation, typical of arid Mediterranean environments, which are not only resistant to drought, but also to intense sunshine and saline winds. The esparto plant association *(Lygeum spartum – Alfa Mahboula)*, dotted with spontaneous palms *(Phoenix dactylifera – date palm),* is a typical formation of the Kerkennah archipelago. This alliance is divided into four distinct groupings, differentiated by the dominance of characteristic species. The first group is marked by the abundance of white sagebrush *(Artemisia herba-alba),* while the second is distinguished by the dominant presence of the white zygophyll *(Zygophyllum album).*

The third is dominated by the cylindrical imperium *(Imperata cylindrica),* and finally, the fourth grouping is characterized by the predominance of the sea rush *(Juncus maritimus).* These groupings reflect a floristic diversity adapted to the particular ecological conditions of the archipelago. Most of this vegetation grows along the coasts.

However, the analysis of vegetation cover and ecological corridor maps of the archipelago highlights several issues related to habitat fragmentation. Green spaces—essential for maintaining ecological connectivity between different areas of the archipelago—are becoming increasingly fragmented, particularly near inhabited zones and human infrastructure.

Although urban expansion on Kerkennah remains relatively moderate, it tends to encroach upon coastal green areas and sebkhas, causing breaks in the ecological corridors that connect terrestrial habitats to wetlands. This fragmentation restricts the movement of many animal species, limits opportunities for plant dispersal, and weakens the overall resilience of ecosystems in the face of environmental pressures, including climate change.

Furthermore, the gradual disappearance of certain vegetation types—such as sansouires and spontaneous palm groves—poses a direct threat to local biodiversity. These habitats act as green corridors, enabling genetic exchanges between animal and plant populations. The reduction of these natural corridors could therefore lead to biodiversity loss and compromise key ecosystem services, such as soil stabilization, air quality regulation, and protection against coastal erosion.

At the same time, the degradation of coastal wetlands—considered "blue corridors"—is reducing available habitat for aquatic species and waterbirds. These zones are particularly vulnerable to increasing soil salinization and fluctuations in water levels, both of which are being intensified by climate change and the overexploitation of local water resources.
Rising salinity hinders the natural regeneration of halophytic plant species, while unstable water levels disrupt the life cycles of animal species—including migratory birds—that depend on these habitats for wintering and breeding.
If these dynamics persist, the increasing fragmentation—combined with mounting environmental pressures—could permanently compromise the ecological balance of the archipelago.
This would affect not only biodiversity, but also human activities such as traditional fishing, which relies on coastal ecosystems, and ecotourism, which depends on the richness of Kerkennah's flora and fauna.

The marine flora of Kerkennah is dominated by Posidonia meadows *(Posidonia oceanica),* a species endemic to the Mediterranean. These underwater meadows form dense seagrass beds that are among the most productive and biologically diverse ecosystems in the Mediterranean Sea.

Posidonia plays a fundamental role in stabilizing marine sediments, producing oxygen, and sequestering carbon. These seagrass meadows also provide essential habitat for a wide range of marine species, while contributing to coastal protection against erosion.

In addition to Posidonia, the waters of Kerkennah host various species of red, brown, and green algae, which thrive on rocky substrates and within seagrass beds. Limestone *(calcareous)* algae, in particular, play a vital role in the formation of biogenic reefs, which serve as shelters for many marine species.

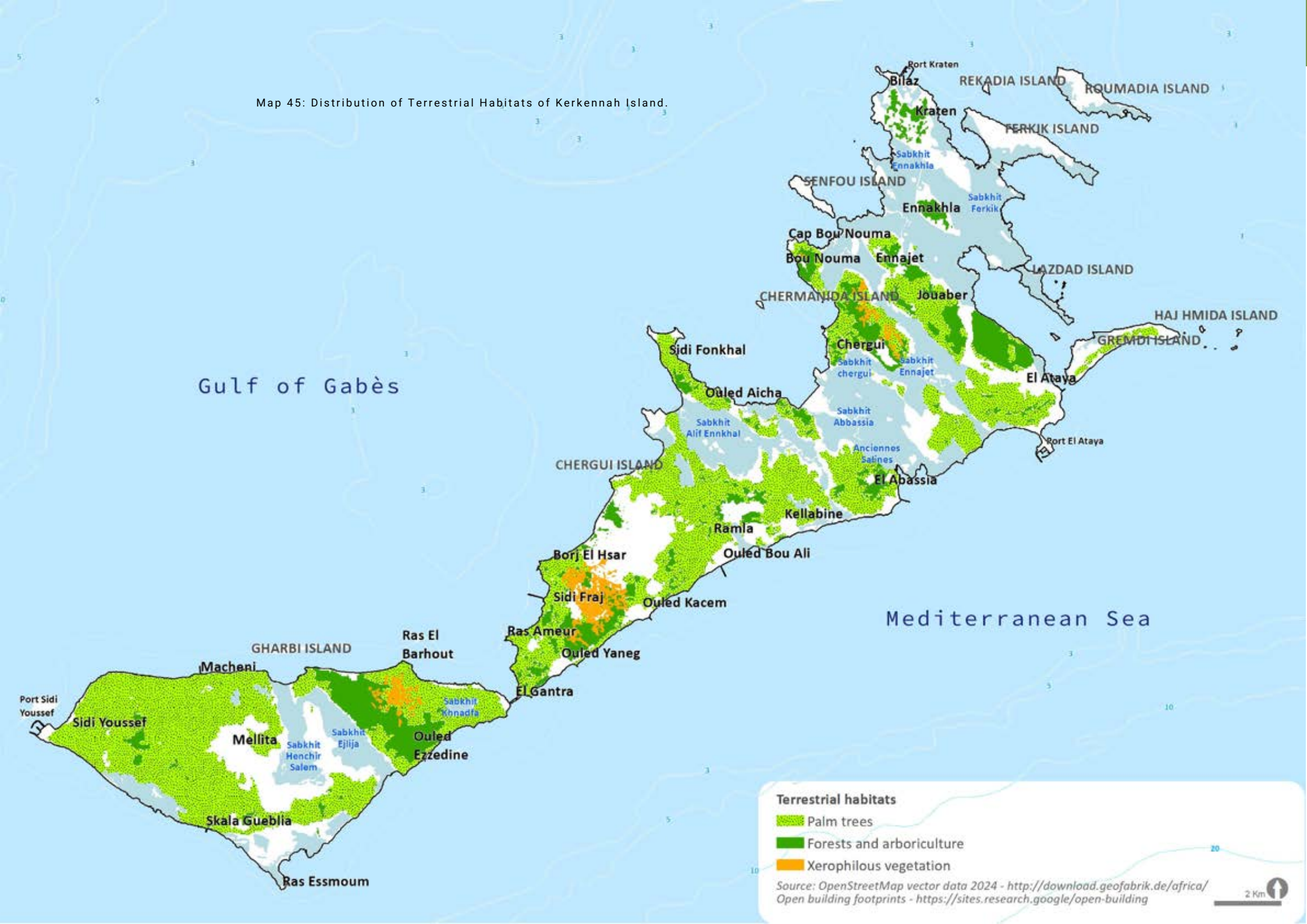
The interactions between marine flora and fauna in the waters of Kerkennah are complex and essential to maintaining the health of the ecosystem. For example, Posidonia meadows not only provide habitat and protection from predators for

juvenile fish, but also serve as a food source for various species of marine herbivores.

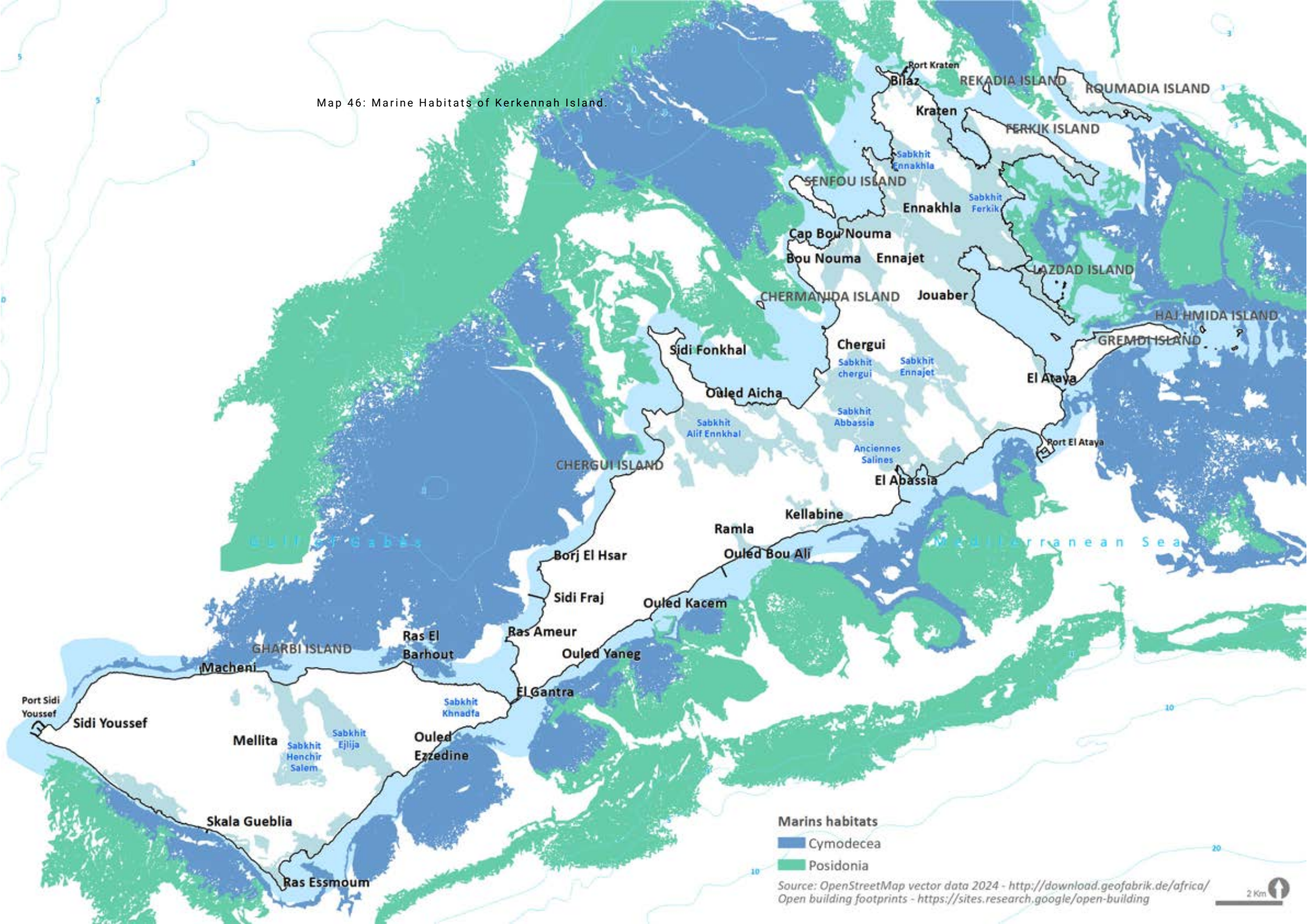
Additionally, marine invertebrates that inhabit seagrass beds and biogenic reefs play a crucial role in nutrient cycling by breaking down organic matter and contributing to the fertility of the marine environment. These symbiotic and trophic relationships highlight the importance of each component of this ecosystem in sustaining its overall balance and health.

MAP 44: Vulnerability of the Ecological Corridors of Kerkennah Island

Map 45: Distribution of Terrestrial Habitats of Kerkennah Island.



Map 46: Marine Habitats of Kerkennah Island.



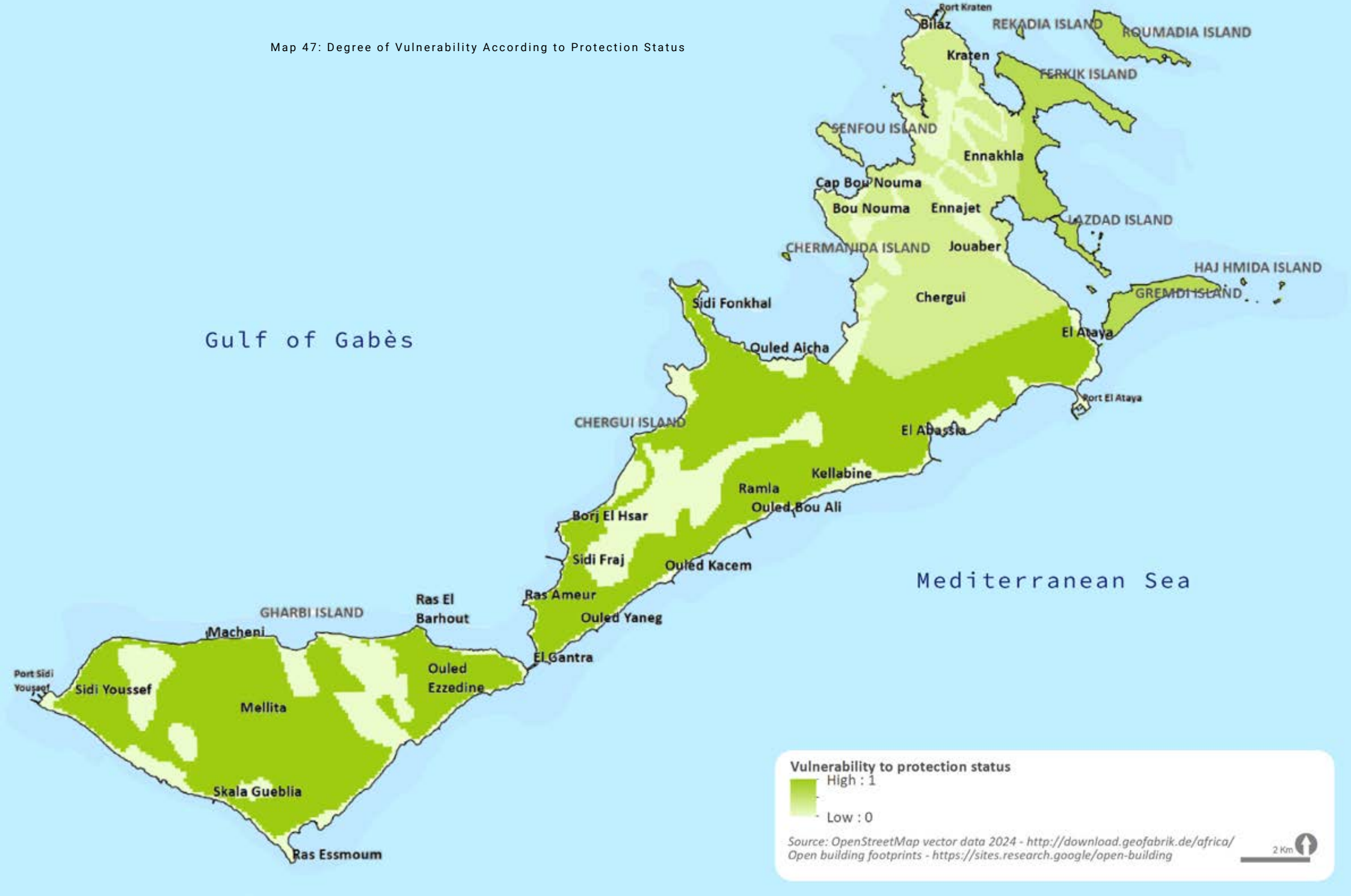
Indicator 3 : Protected Areas/Conservation Areas

The Kerkennah Archipelago, rich in biodiversity and of significant ecological importance, is subject to various protection and conservation measures in line with national and international conventions.

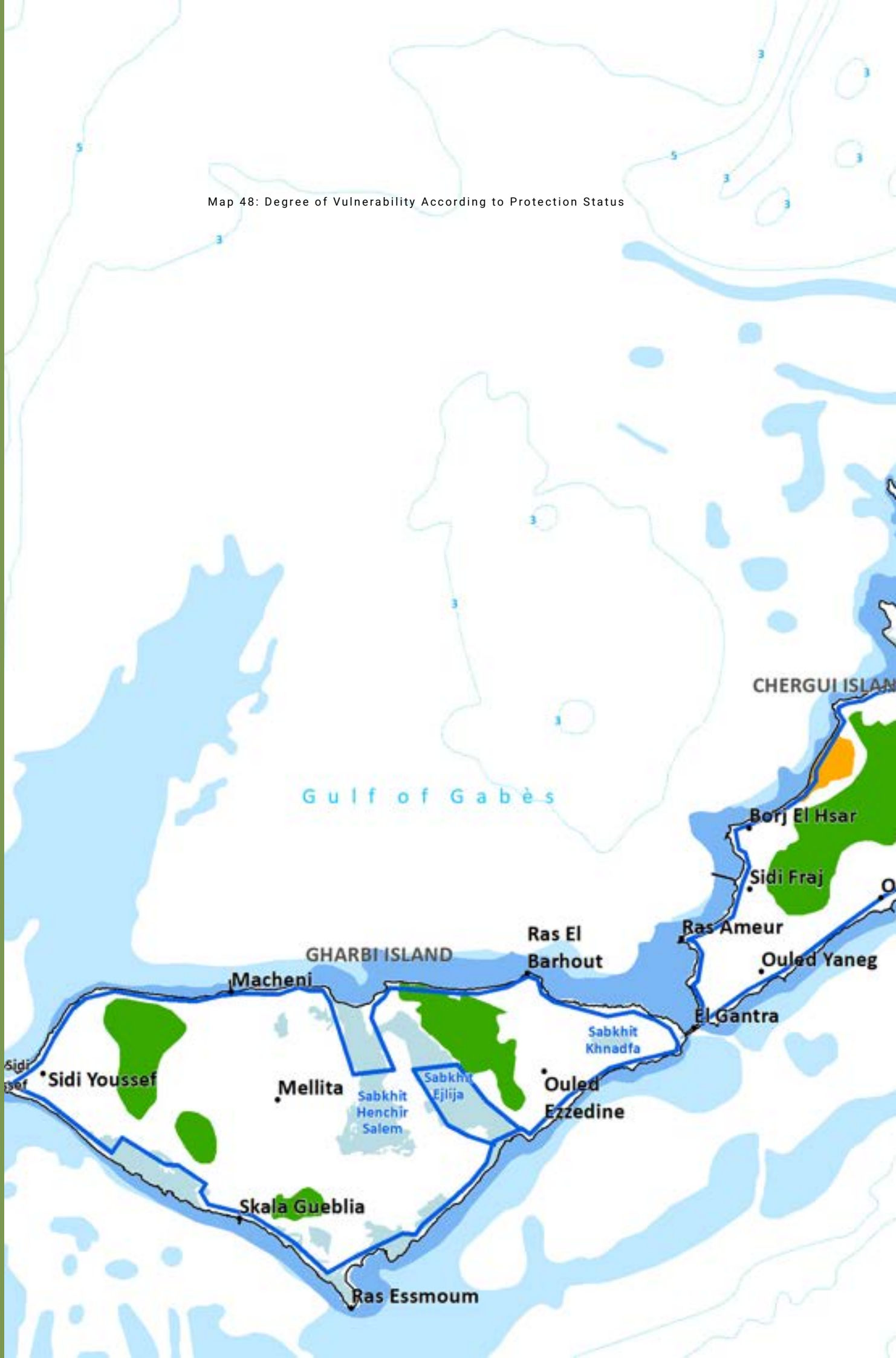
These initiatives aim to preserve the fragile habitats and the endemic or threatened species that inhabit this unique ecosystem.

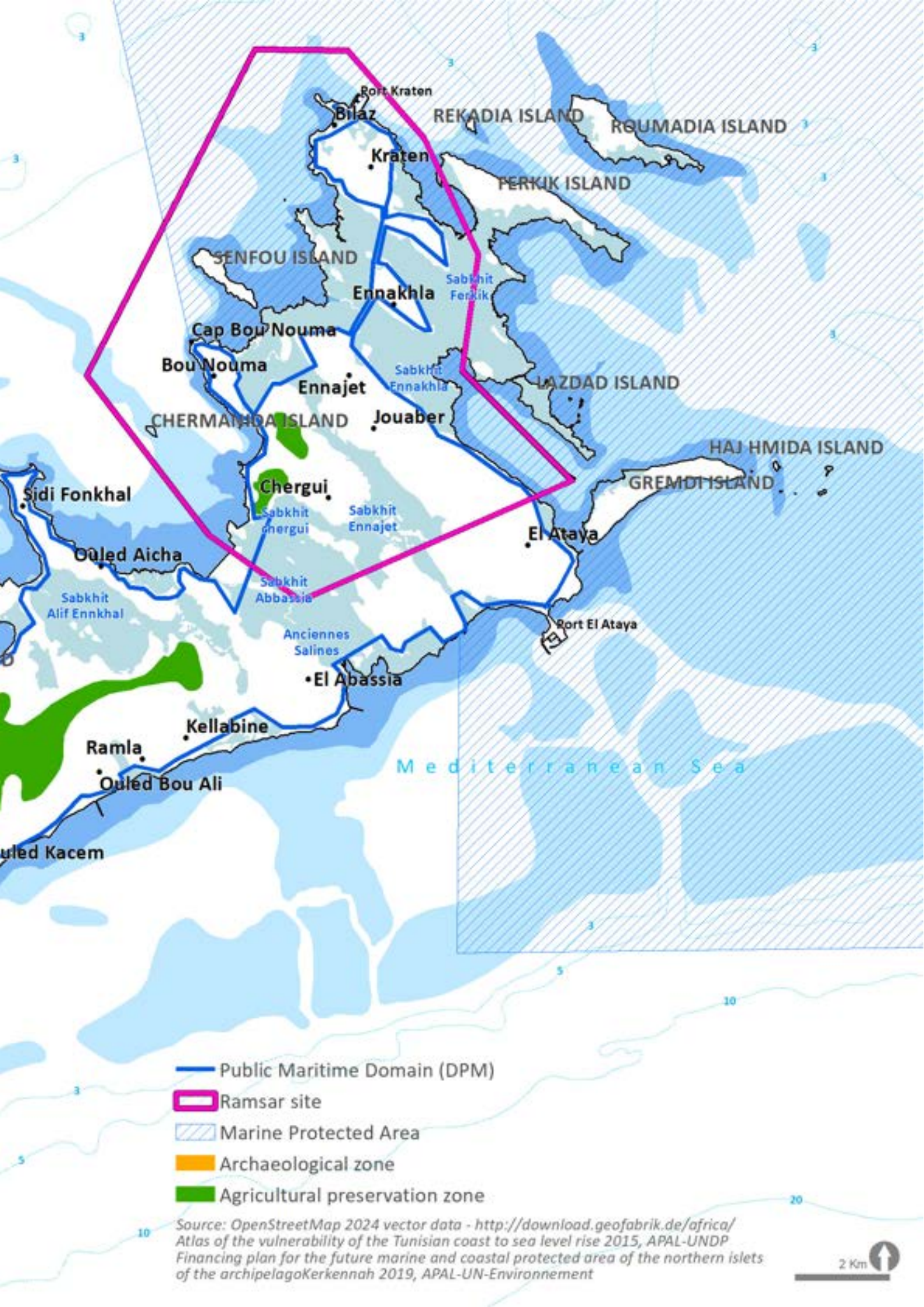
1. Important Bird and Biodiversity Areas (IBAs): In 2001, the Kerkennah Islands were designated as an Important Bird and Biodiversity Area (IBA). This classification, established by BirdLife International, highlights the significance of the archipelago for avifauna—particularly for waterbirds that rely on the extensive sebkhas for wintering and nesting. This recognition strengthens conservation efforts and underscores the need to protect these critical habitats.
2. Ramsar Convention: In 2012, the Kerkennah Archipelago was designated a Wetland of International Importance under the Ramsar Convention. Adopted in 1971 and entering into force in 1975, the convention seeks to protect wetlands that play a vital role in biodiversity conservation and in maintaining ecological balance. Kerkennah's designation under the Ramsar Convention acknowledges the ecological importance of the archipelago's sebkhas and other wetlands, which are essential habitats for many species of migratory birds.
3. Coastal Marine Protected Areas (CMPA): More recently, in 2023, the northern islets of Kerkennah were added to the list of future Coastal Marine Protected Areas (CMPA). This designation, governed by Tunisian legislation, aims to protect marine and coastal ecosystems from anthropogenic pressures such as overfishing, pollution, and climate change. The creation of these CMPAs is part of a co-management initiative between the Coastal Protection and Planning Agency (APAL) and the Kraten Association for the Sustainable Development of Culture and Leisure (AKDDCL). This partnership seeks to ensure sustainable management of the area by actively involving local communities in the conservation of natural resources.
4. Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD): The Kerkennah Archipelago is also subject to the provisions of the Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD), adopted under the Barcelona Convention for the Protection of the Mediterranean Sea.This protocol, which entered into force in 1986, encourages Mediterranean countries to establish protected areas to safeguard marine and coastal biodiversity. With its wealth of endemic and endangered species, the archipelago benefits from this enhanced protection, which helps preserve its fragile ecosystems.

Map 47: Degree of Vulnerability According to Protection Status



Map 48: Degree of Vulnerability According to Protection Status




Port Kraten
Bilaz
REKADIA ISLAND
ROUMADIA ISLAND
Kraten
FERKIK ISLAND
SENFOU ISLAND
Sabkhit Ferkik
Ennakhla
Cap Bou Nouma
Bou Nouma
Ennajet
Sabkhit Ennakhla
LAZDAD ISLAND
CHERMAIHDA ISLAND
Jouaber
HAJ HMIDA ISLAND
GREMDI ISLAND
Sidi Fonkhal
Chergui
Sabkhit Chergui
Sabkhit Ennajet
El Ataya
Ouled Aicha
Sabkhit Abbassia
Sabkhit Alif Ennkhal
Port El Ataya
Anciennes Salines
El Abassia
Kellabine
Ramla
Ouled Bou Ali
uled Kacem
M e d i t e r r a n e a n S e a
Public Maritime Domain (DPM)
Ramsar site
Marine Protected Area
Archaeological zone
Agricultural preservation zone
Source: OpenStreetMap 2024 vector data - http://download.geofabrik.de/africa/
Atlas of the vulnerability of the Tunisian coast to sea level rise 2015, APAL-UNDP
Financing plan for the future marine and coastal protected area of the northern islets of the archipelagoKerkennah 2019, APAL-UN-Environnement
2 Km

Analysis of the "Biodiversity" Dimension

The analysis of the biodiversity dimension of Kerkennah Island was based on the evaluation of two indicators. The following weights were assigned to each indicator in calculating the final vulnerability score:

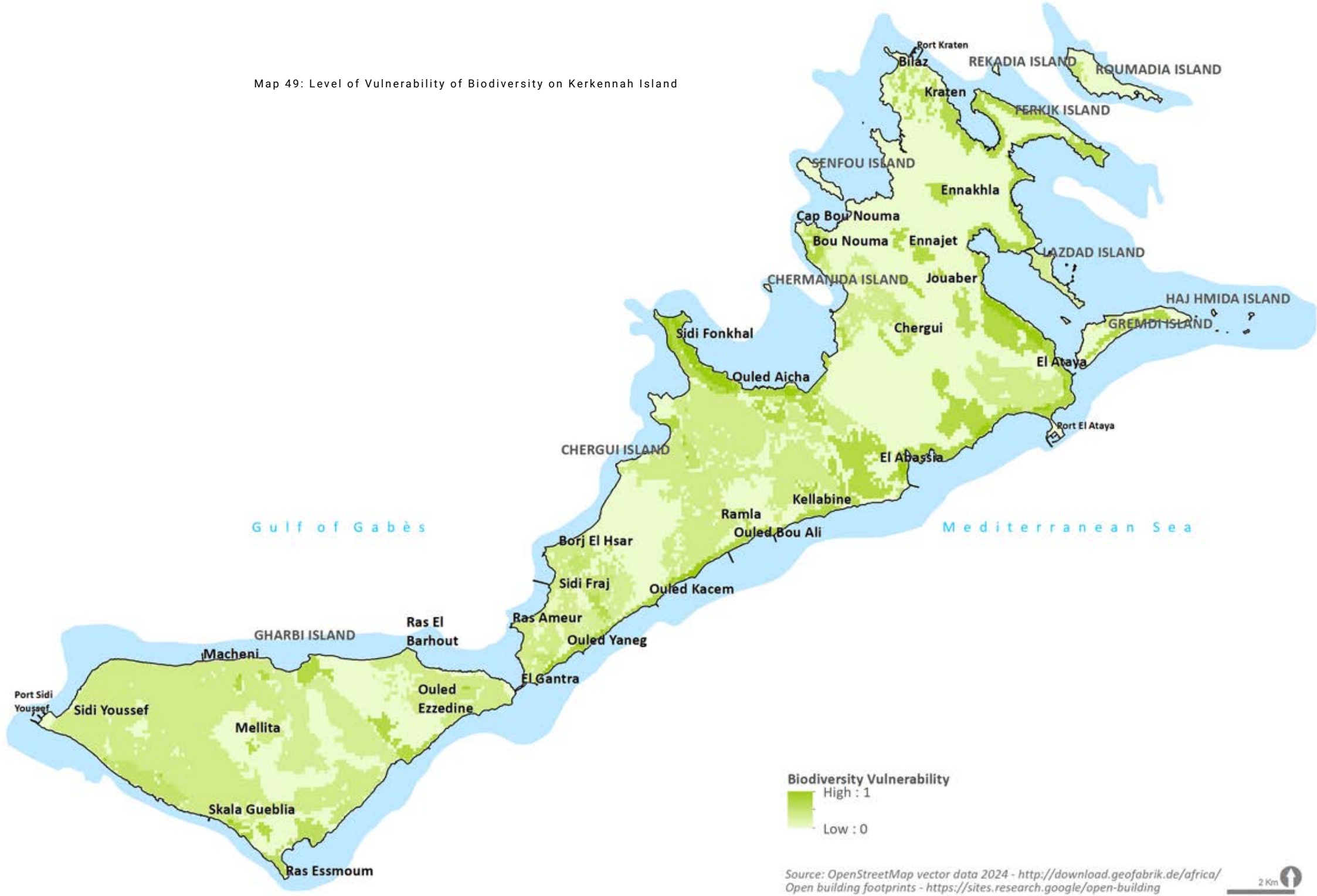
1. Average species abundance: 1
2. Biodiversity connectivity: 1

The "protected areas" indicator was not used in calculating the final score because, although the island benefits from several protection and enhancement measures, these have not yet produced convincing results.

The analysis reveals that the Kerkennah Archipelago hosts several species and types of fragile habitats, both terrestrial and marine,

- Sebkhas and Coastal Wetlands: Sebkhas, or saline depressions, cover about one-third of the archipelago's total area. These zones, often intermittently flooded, are dominated by saline soils and support a specialized biodiversity of flora and fauna. They offer ideal breeding conditions for several species of waterbirds, particularly during the winter season. However, increasing salinization and variability in water levels pose significant threats to these habitats.
- Saline Steppes: Saline steppes, or sansouires, characterize certain islands such as Gremdi and Roumadiya. These ecosystems, composed of vegetation adapted to saline soils, are essential for the reproduction of specific bird and insect species. Saline steppes are particularly vulnerable to climate change and anthropogenic pressures, which can disrupt their structure and ecological function.
- Seabed and Shoals: The underwater plateau surrounding the Kerkennah Archipelago consists of shallow shoals and tidal channels. These areas are vital for marine species such as fish and invertebrates, offering breeding habitats and food sources. Overfishing, pollution, and climate change pose major threats to these marine ecosystems.
- Posidonia oceanica: Posidonia oceanica seagrass beds are threatened by pollution, ocean warming, and human activities such as anchoring and dredging.
- Cymodocea nodosa: This seagrass species is endangered by coastal disturbances, including urbanization and pollution.
- Great Cormorant *(Phalacrocorax carbo)*: This species uses the sebkhas of Kerkennah as nesting and wintering grounds. Its population is sensitive to changes in habitat conditions.
- Eurasian Spoonbill *(Platalea leucorodia)*: Representing about 1% of the global population, this migratory bird relies on the archipelago's wetlands as a critical stopover site during migration.
- Slender-billed Gull *(Larus genei)*: Although present in the archipelago, this species is also experiencing a regional population decline.

Map 49: Level of Vulnerability of Biodiversity on Kerkennah Island



Future Biodiversity Vulnerabilities

The Kerkennah Archipelago faces significant future vulnerabilities, stemming from a combination of natural phenomena and anthropogenic pressures that could have profound impacts on its ecosystems and biodiversity.

Among these vulnerabilities, sea level rise is one of the most concerning. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), published in 2014, sea level is projected to rise between 26 and 55 cm under the RCP2.6 scenario (low emissions), and between 45 and 82 cm under the RCP8.5 scenario (high emissions). When combined with the archipelago's natural subsidence, this rise increases the risk of saline water intrusion into groundwater. Such intrusion could compromise freshwater resources essential for agriculture and human consumption, while also accelerating soil salinization.

At the same time, coastal erosion—already worsened by inappropriate construction practices and disrupted sediment dynamics—is expected to intensify in the coming years. Rising sea levels, coupled with extreme weather events, pose a direct threat to coastal habitats such as wetlands and beaches. These areas are critical for nesting birds and breeding marine species. The loss of such habitats could lead to a sharp decline in biodiversity, destabilizing established ecological balances.
Soil salinization also represents a major threat to the archipelago's agriculture and vegetation. Unsustainable irrigation practices and rising groundwater levels aggravate this phenomenon, degrading soil quality and compromising crop viability. This poses a risk to palm groves, which are not only economically vital but also support local biodiversity.

In addition, marine ecosystems—particularly Posidonia oceanica seagrass beds—are under increasing pressure. These seagrass meadows, which provide essential habitat for a wide range of marine species, are threatened by rising water temperatures, salinity fluctuations, and human activities such as intensive fishing and pollution. The degradation of these habitats could not only lead to a decline in marine biodiversity, but also disrupt the vital ecosystem services they offer, including coastal erosion protection and water filtration.

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06

INTERSECTING VULNERABILITIES

Intersecting Vulnerabilities : Urbanization and Climate Change

Human occupation of the island is reflected in two main forms: urbanization on the one hand, and agricultural exploitation on the other.

Regarding urbanization, the areas most vulnerable to climate change are:

1. The new coastal urban extensions, particularly along the southern coasts (1) and along the northern coasts along the El Hsar – El Kantra – Sidi Founkhal – Ras Ammeur tourist axis (2), are generally informally occupied. These areas are often located far from urban infrastructure and services and are situated in sites that are vulnerable to climate-related risks such as marine erosion, sea level rise, and flooding. The communities and infrastructure in these localities are not only highlight exposed to risks but are highly sensitive to the shocks and stresses that more frequent, severe and prolonged extreme weather events are causing. For example, the intense urban heat stress coupled with the lack of active or passive cooling solutions (such as air conditioning units in residential, commercial or administrative buildings) in these areas puts groups, such as women, the elderly, children, and persons with disabilities at heightened risk of heat stress and the adverse health impacts. Their adaptive capacity is limited due to insufficient resources and limited access to climate-resilient infrastructure, further constraining their ability to anticipate, cope with, or recover from adverse climate-related impacts.
2. The seafronts of historic centers are experiencing an increasing concentration of inhabitants, infrastructure, and facilities, progressively occupying low-lying areas that had previously been spared from urbanization—this is notably the case in Erramla (3), El Ataya (4), and Kraten (5). These urbanisation trends are intensifying exposure to sea level rise, coastal erosion, storm surges, and flooding, particularly in zones that naturally acted as buffers between the sea and inland areas. The increasing density of built-up areas and population in these hazard-prone zones reduces the capacity of ecosystems to absorb shocks and places additional pressure on already limited and inadequate infrastructure systems. Combined with poor drainage, and the lack of early warning and emergency response systems, this pattern of development significantly increases the climate vulnerability of these communities and assets.

For the second type of land use, the most vulnerable agricultural areas are located in:

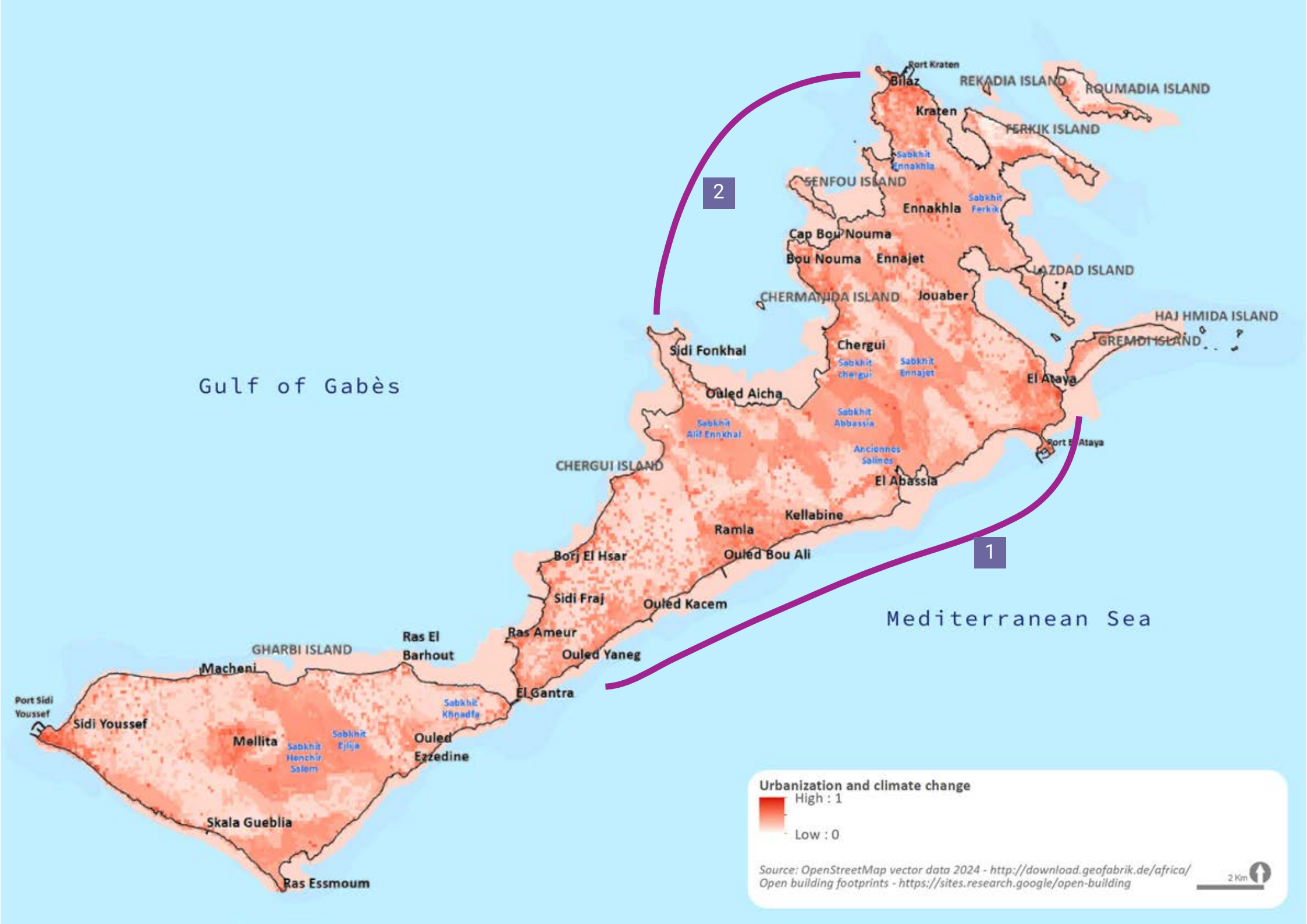
- The L'Attaya - Ennajet - Chergui axis.
- Farmland north of Ramla
- The farmlands around Mellita.

These areas are affected by urban sprawl and/or the impacts of climate change, which are reducing their agricultural productivity—particularly through soil salinization. Recent shifts in farming practices, including the conversion of palm groves into olive groves and the development of irrigated perimeters using brackish water from deep wells in Melitta and Ramla, have accelerated salinization. This process is further exacerbated by climate change through the intrusion of seawater.

The literature indicates that "the spatial expansion of salinity is linked to natural phenomena (such as the spread of sebkhas), which are intensified by human activities (including the abandonment of traditional practices and poor irrigation water management)[8]."

These processes are contributing to growing climate vulnerability by degrading land and water resources, potentially undermining food security, and weakening the resilience of local and traditional livelihoods. The land use changes have increased the sensitivity of these communities to climate shocks, while limiting their adaptive capacity through the removal or reduction of ecosystem services. The result is likely to be a reinforcing cycle of environmental degradation and socioeconomic fragility, leaving the people residing in these areas less able to cope with or recover from the future, more frequent climate-related stresses.

8 https://doi.org/10.4000/mappemonde.2409


Gulf of Gabès
Mediterranean Sea
Port Kraten
Bilaz
REKADIA ISLAND
ROUMADIA ISLAND
Kraten
FERKIK ISLAND
Sabkhit Ennakhla
SENFOU ISLAND
Ennakhla
Sabkhit Ferkik
Cap Bou Nouma
Bou Nouma
Ennajet
LAZDAD ISLAND
CHERMANIDA ISLAND
Jouaber
HAJ HMIDA ISLAND
GREMDI ISLAND
Sidi Fonkhal
Chergui
Sabkhit chergui
Sabkhit Ennajet
El Ataya
Ouled Aicha
Sabkhit Abbassia
Sabkhit Alif Ennkhal
Anciennes Salines
Port El Ataya
CHERGUI ISLAND
El Abassia
Kellabine
Ramla
Ouled Bou Ali
Borj El Hsar
Sidi Fraj
Ouled Kacem
Ras Ameur
Ouled Yaneg
Ras El Barhout
GHARBI ISLAND
Macheni
El Gantra
Sabkhit Khnadfa
Port Sidi Youssef
Sidi Youssef
Mellita
Sabkhit Henchir Salem
Sabkhit Ejlja
Ouled Ezzedine
Skala Gueblia
Ras Essmoum
2
1
Urbanization and climate change
High : 1
Low : 0
Source: OpenStreetMap vector data 2024 - http://download.geofabrik.de/africa/
Open building footprints - https://sites.research.google/open-building
2 Km

Intersecting vulnerabilities : Climate and Biodiversity

The environmental fragility of the Kerkennah Archipelago results from the interaction of natural and human factors. The archipelago is characterized by a low-lying topography, with its highest points located inland, notably at Ouled Ezzeddine (13 m) and east of Sidi Fraj (11 m).

Sebkhas and chotts cover approximately one-third of the archipelago's surface, primarily concentrated along the coast. These chotts, dominated by dense halophytic vegetation forming schorres, increase the vulnerability of the land to sea level rise—a direct consequence of climate change.

This vulnerability is evident in the significant rise in temperatures, leading to higher sea levels and the gradual intrusion of seawater onto the land. This phenomenon affects more than 78 km of fragile coastline, including 65 km that are particularly low-lying and prone to erosion. A simulated sea level rise of 50 centimeters could result in the loss of 4,500 hectares—approximately 30% of the archipelago's total area.

It is also important to note that the sea is encroaching upon the land in Kerkennah due to particularly active marine erosion. The irregularity of the coastline and the diversity of its morphology highlight the archipelago's exposure to strong erosive dynamics. This erosion is visible in the contrast between the very straight eastern coasts and the highly indented western and northern coasts, creating a landscape of headlands (or rass) and coves.

The coastline is marked by cliffs, rocky zones, sebkhas, and coastal marshes. Beaches are discontinuous, narrow, and shallow. At Borj Lahsar and Kraten, archaeological remains illustrate the extent of coastal erosion—for example, at low tide, the ruins of an ancient structure can be seen approximately 200 meters offshore at Borj Lahsar.

Other signs of erosion are visible in the vegetation affected by seawater, such as palm trees felled near the sebkhas. This active erosion further accentuates the fragility of the archipelago's coastline. It is driven by rising sea levels, the subsidence of the archipelago, low rainfall, and the absence of a dense hydrographic network. Human factors also contribute to the problem, including the extraction of marine sandstones and coastal sands for construction, as well as port developments that have disrupted the littoral currents responsible for sediment transport.

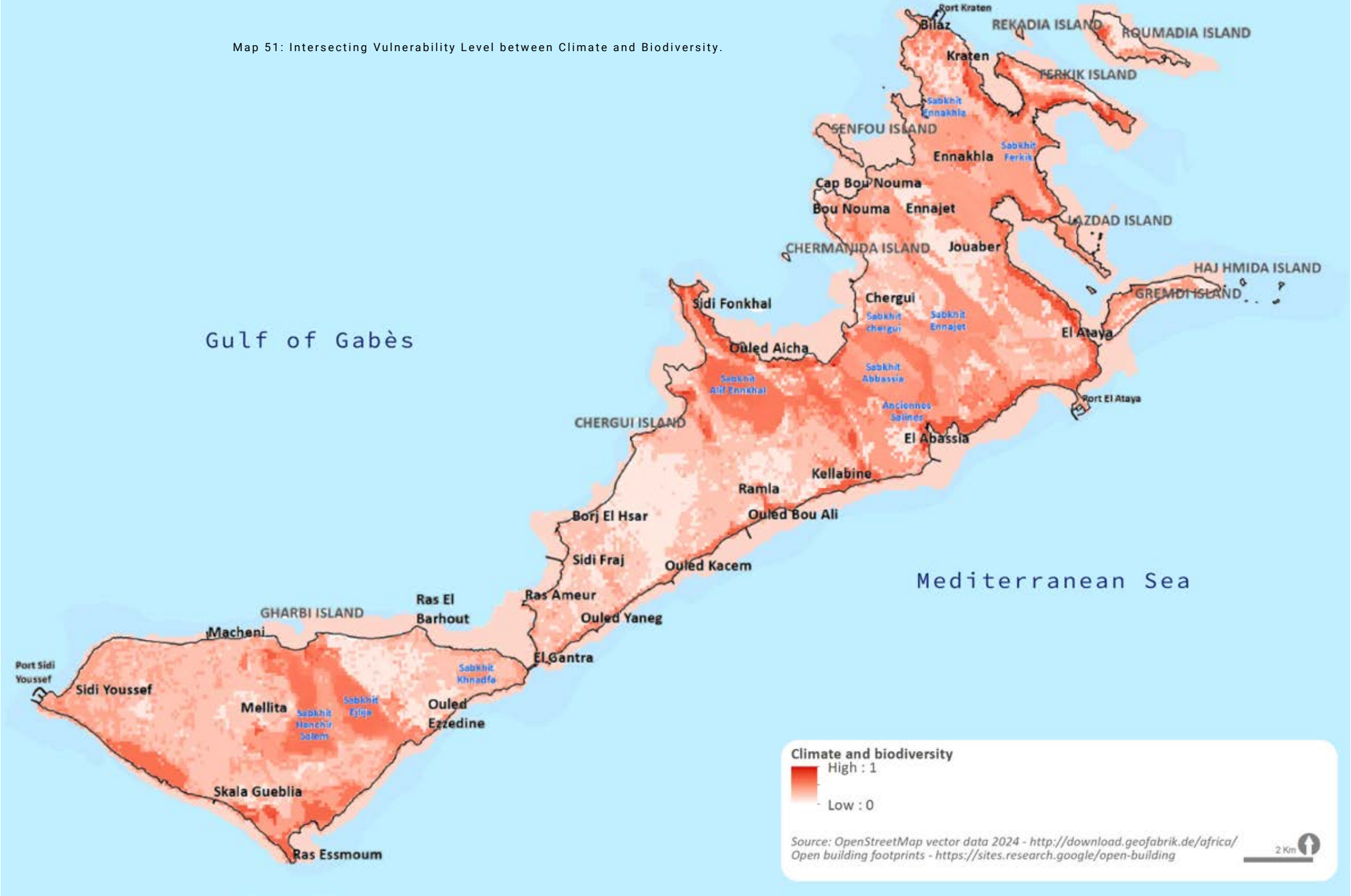
On the other hand, water scarcity and salinization pose serious threats to oasis life on the islands of Chergui and Gharbi. With annual rainfall of less than 200 mm, a significant hydrographic network has not been able to develop. The water table lies less than 3 meters deep and is barely 1 meter thick. However, its use remains limited, and any overexploitation would risk further increasing salinity.

Sebkhas, which cover vast areas of the archipelago, serve as key indicators of the progressive salinization of the land. This phenomenon is also affecting vegetation, as shown by the presence of palm tree roots in salty soils on the islet of Gremdi.

Rising salinization is degrading soil quality and compromising the archipelago's ecological richness, contributing to the expansion of sebkhas. This trend is leading to the decline—and in some cases, local extinction—of small woody and herbaceous thermo-xerophilic steppe species, a phenomenon partly attributable to these eustatic changes.

The convergence of climate-related hazards—such as sea level rise, coastal erosion, salinization, and water scarcity—with the degradation of critical ecosystems like sebkhas and coastal marshes creates intersecting, multilayered vulnerability hotspots across the Kerkennah Archipelago. These hotspots are particularly acute in areas where biodiversity loss undermines the natural buffers that support climate resilience. For instance, the degradation of halophytic vegetation and the expansion of sebkhas reduce the land's capacity to absorb storm surges and retain soil moisture, intensifying both ecological fragility and socio-economic exposure. The resulting pressures are not evenly distributed but instead compound in zones where low-lying settlements, fragile biodiversity, and subsistence livelihoods—especially those reliant on oases and coastal resources—coexist. These intersections amplify the risks of livelihood collapse, displacement, and long-term degradation of both ecosystems and human well-being, underlining the urgent need for integrated approaches to resilience-building in these critical transition zones.

Map 51: Intersecting Vulnerability Level between Climate and Biodiversity.



Intersecting Vulnerabilities : Urbanization and Biodiversity

In addition to natural vulnerabilities, human occupation of the archipelago has exacerbated the situation, triggering a cascade of environmental and ecological changes with harmful consequences for many aspects of biodiversity.

Human pressure on Kerkennah dates back to ancient times. The archipelago's development in terms of fishing, urbanization, and tourism illustrates the significant role humans have played in increasing the fragility of Kerkennah's biodiversity.

Fishing, the main economic activity of the archipelago since antiquity, was once based on techniques that respected the marine ecosystem. However, the expansion of the fishing fleet and the adoption of more intensive practices have led to a substantial decline in fish stocks. This decline resulted in a gradual reduction of the fleet beginning in the 2000s.

Today, most boats use gear such as tartaronne (Meditteranean fishing trap, also known as kys) and inappropriate nets, which have a destructive impact on marine resources and underwater flora. These practices are contributing to a rising vulnerability index in the ports of the Kerkennah Islands, including El Attaya, Sidi Youssef, and Kraten. Furthermore, port infrastructure has altered natural currents around the archipelago, disrupting sediment transport and exacerbating coastal erosion. These changes interfere with natural ecological processes and hinder the regeneration of marine ecosystems.

In addition, urban expansion and development of tourism infrastructure—particularly on Chergui Island—have contributed to the degradation and fragmentation of coastal habitats. Wetlands, which serve as vital refuges for migratory birds, are increasingly affected by land conversion for residential and economic development. The degradation of these critical wetlands also reduces vital resilience-building ecosystem services, such as natural water filtration, flood attenuation, shoreline stabilization, and carbon sequestration – thereby increasing the vulnerability of both human and ecological systems to climate-related hazards, coastal and inland flooding, storm surges, sea level rise, saltwater intrusion, and extreme heat.

Pressure on Posidonia oceanica meadows along the coast is particularly high due to coastal pollution linked to human activities. The development of roads and buildings has also reduced ecological connectivity between Chergui and its surrounding islets, limiting species migration and dispersal.

The Ouled Aïcha area, southeast of Sidi Founkhal, is increasingly impacted by urban expansion and the growth of tourism infrastructure in the Kerkennah region. Urbanization in this area is threatening coastal ecosystems, particularly wetlands and sebkhas, which play a crucial role in water regulation and in supporting migratory bird species. Land conversion for residential and commercial purposes has led to habitat fragmentation, disrupting connectivity between terrestrial and marine ecosystems.

Marine ecosystems in the Brenka zone, west of Sidi Founkhal—notably the Posidonia oceanica meadows—are under growing pressure from coastal pollution, especially due to poorly treated effluents from nearby urban and tourism developments.

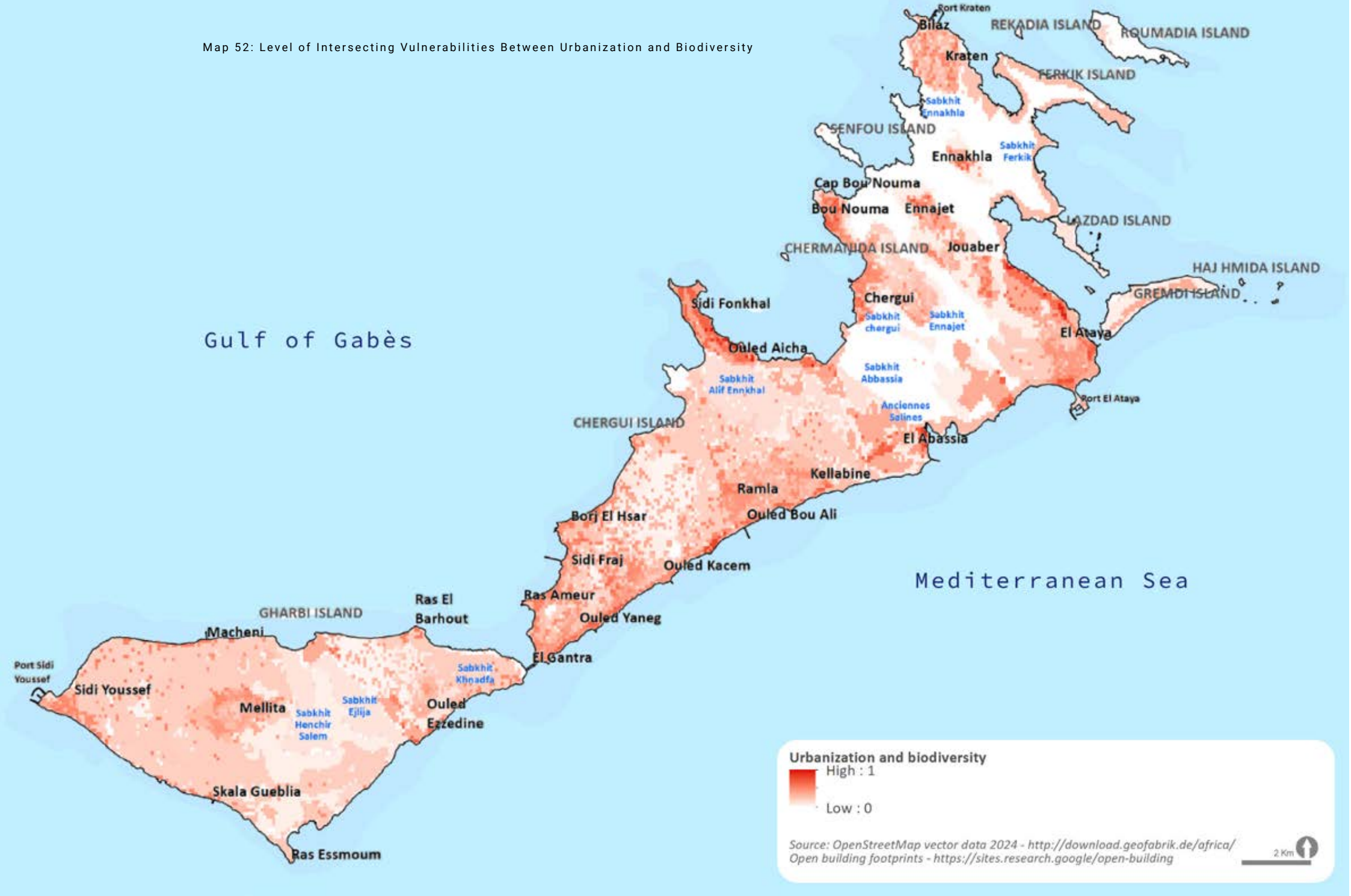
To the northeast of Chergui Island, the town of Kraten has seen increased infrastructure development, largely driven by fishing and tourism activities. The Posidonia oceanica meadows along the Kraten coastline are under intense pressure from human activities. Domestic effluents, solid waste, and pollution from fishing boats and tourist facilities are degrading these vital habitats.

Moreover, intensive fishing in the region—particularly around Kraten—has contributed to the decline in fish populations, impacting both the marine ecosystem and the local community, which relies heavily on this activity for its livelihood.

Gharbi Island is also facing increasing pressure from urban development. Urbanization directly affects sebkha areas, which are critical habitats for migratory birds and halophytic species. Increased construction near sebkhas disrupts the water balance and accelerates soil salinization.

In the past, the illegal extraction of sand from Gharbi's beaches for construction purposes has contributed to rapid coastal erosion, threatening nesting sites for both marine and avian species. Additionally, pollution from urban effluents and the lack of proper waste management have contributed to the degradation of both terrestrial and marine ecosystems.

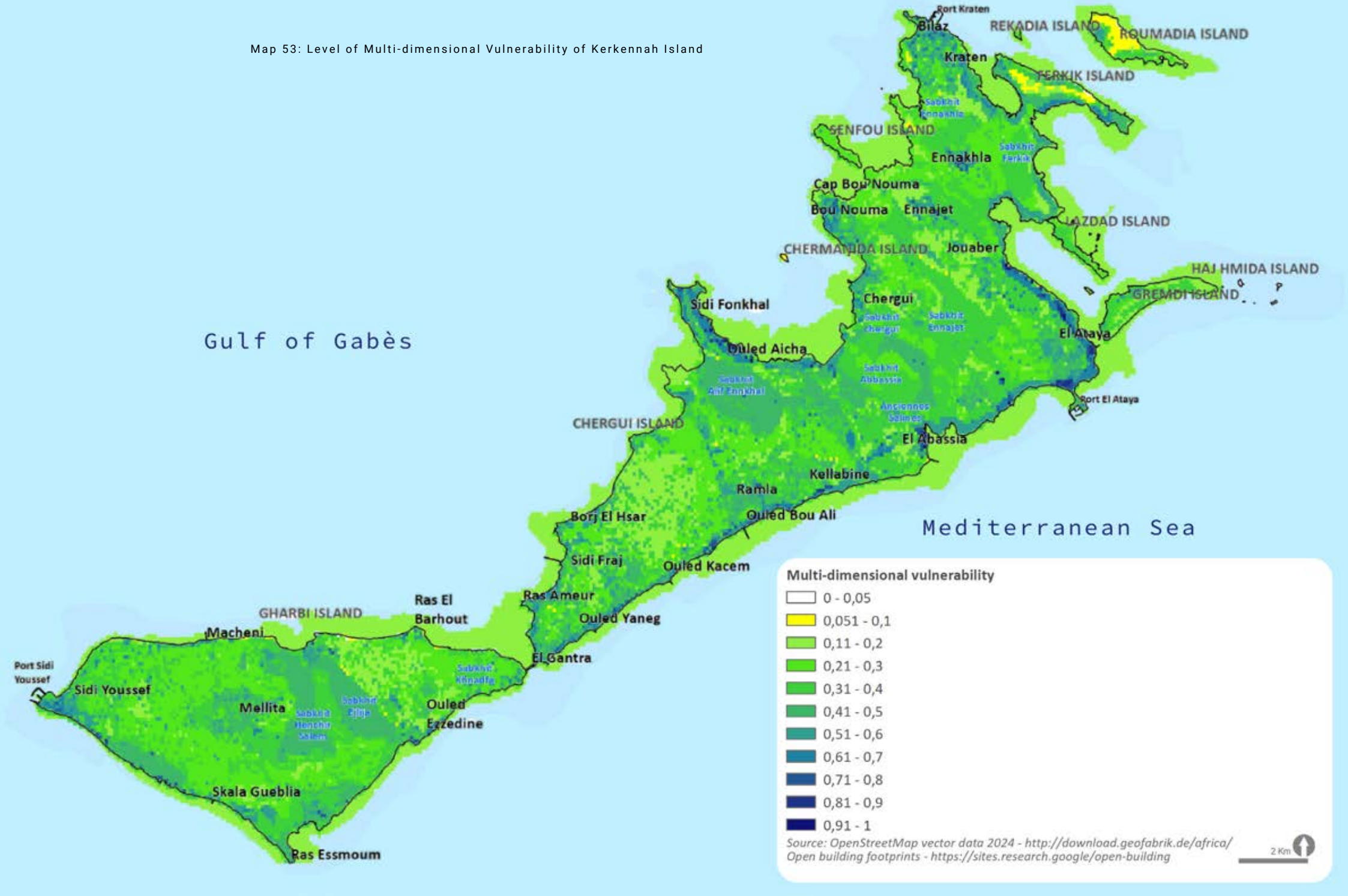
Map 52: Level of Intersecting Vulnerabilities Between Urbanization and Biodiversity



In Roumadya, north of Chergui, habitats are particularly vulnerable due to their proximity to human activities. Although the area is sparsely populated, seasonal tourism infrastructure and fishing activities exert increasing pressure on marine biodiversity—especially on Posidonia oceanica meadows. This vulnerability is compounded by pollution from fishing vessels and the dumping of solid waste on the islet, which weakens coastal ecosystems.
Sefnou, while less affected by urbanization than Chergui or Gharbi, is beginning to experience the impacts of infrastructure expansion. Coastal pollution originating from Chergui and Gharbi affects surrounding waters, disrupting Posidonia meadows and the marine species that inhabit them.

Smaller islets—such as Lazdad, Ramadiya, Hajr el Ouest, Gremdi, and Chehimi—remain largely in their natural state but are increasingly vulnerable to the indirect impacts of urbanization on the main islands. Marine pollution from Chergui and Gharbi, along with the effects of seasonal tourism, is placing mounting pressure on these islets. The marine ecosystems surrounding these small islands are often disrupted by pollution and the degradation of Posidonia meadows, threatening local biodiversity.

Map 53: Level of Multi-dimensional Vulnerability of Kerkennah Island



Multilayered Vulnerability Hotspots

The intersection of climate, biodiversity, and urban development in Kerkennah presents major challenges that require coordinated interventions to limit environmental impacts and support sustainable and equitable development. The evolution of fishing practices, the development of infrastructure, and the growth of urbanization have weakened marine and coastal ecosystems. The degradation of fishery resources—partly due to the use of unsustainable techniques such as kys—highlights the urgent need to rethink these economic activities and adopt sustainable practices that respect biodiversity.

Moreover, urban expansion and port infrastructure disrupt natural processes, such as sediment transport, thereby contributing to coastal erosion and the loss of natural habitats. This situation increases the vulnerability of ecosystems to extreme climate events, such as storms and sea level rise.
It is essential to implement adaptation measures to protect coastal areas while promoting development strategies that integrate biodiversity conservation.

Local stakeholders—including fishers, urban planners, and policymakers—must collaborate to develop land-use plans that consider the region's ecological specificities. This could involve establishing protected areas, regulating fishing practices, and adopting nature-based solutions to manage erosion and restore habitats.

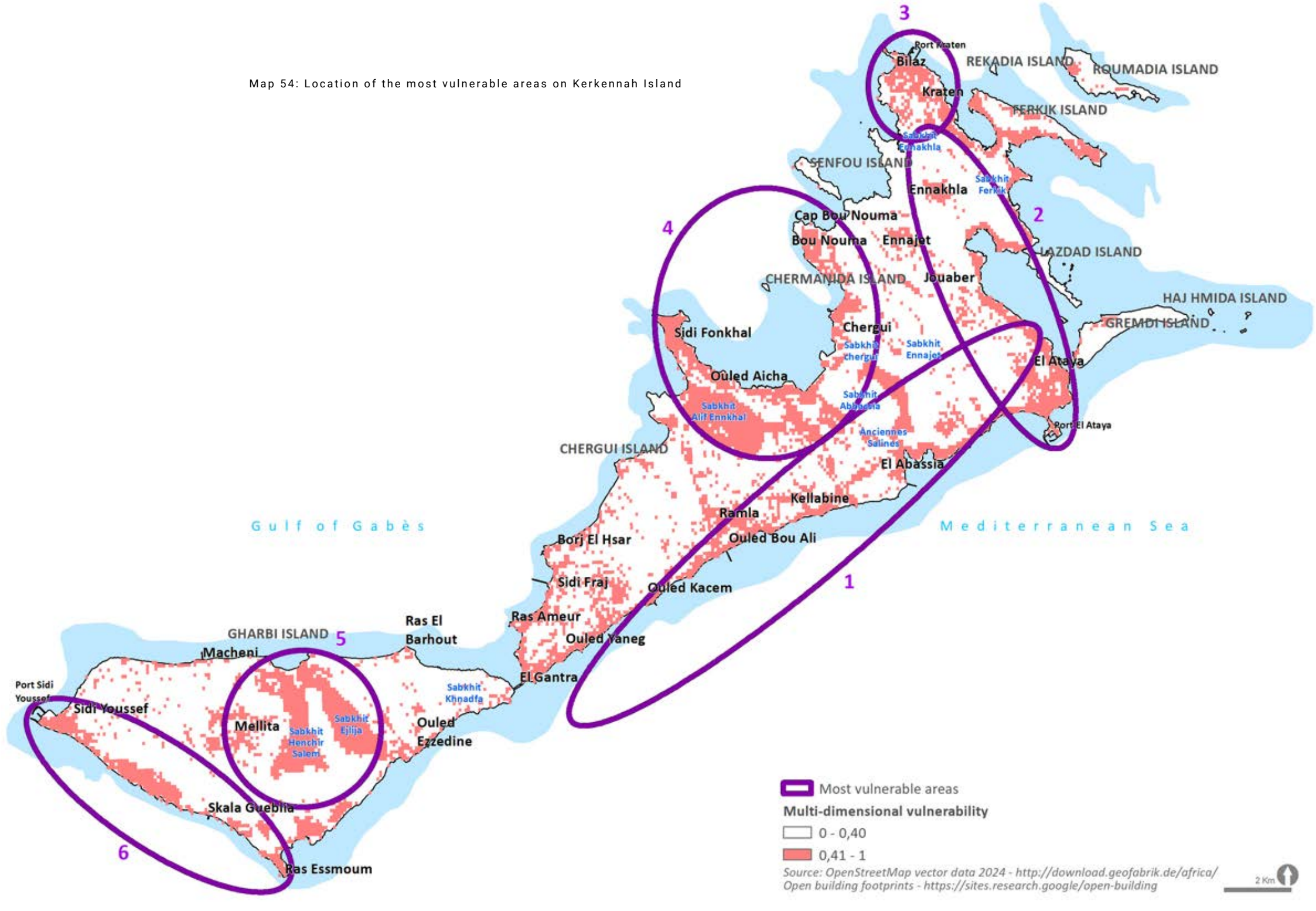
At the same time, raising awareness within local communities about environmental issues and the importance of biodiversity is essential. Educational initiatives and training programs can help promote sustainable alternatives and strengthen community engagement in conservation efforts.

Finally, it is crucial to mobilize partnerships with non-governmental organizations, academic institutions, and donors who can provide valuable support for the implementation of projects aimed at fostering a harmonious coexistence between people and nature in Kerkennah.

The success of this approach depends on an integrated vision that values both human needs and ecosystem health, ensuring a sustainable future for generations to come.
The multi-dimensional analysis of the vulnerability of Kerkennah Island reveals that the most vulnerable areas are:

1. The southern coasts of the island, where most of the coastal population, infrastructure, and facilities are concentrated, face significant risks related to flooding and sea level rise—particularly in the Ramla and El Ataya areas. This zone, extending from El Kantra to El Ataya, is relatively dense in both population and economic activity and is experiencing one of the fastest growth rates on the island. It is also home to fragile habitats vital for local wildlife, including turtles (coastal beaches), migratory birds (wetlands), and nesting birds (north of El Ataya). This southern zone's concentration of human settlement and infrastructure creates a complex risk landscape where climate hazards intersect with socio-economic vulnerabilities. The rapid urban growth exacerbates exposure to coastal flooding, storm surges, and sea level rise, which threaten critical infrastructure such as housing, roads, and local businesses. The dense population amplifies potential human losses and displacement risks, while economic activities—often dependent on fisheries, agriculture, and tourism—face disruption. Moreover, the ecological significance of this area adds another dimension of vulnerability: the fragile coastal habitats that support endangered species like turtles and migratory birds are highly sensitive to even small changes in sea levels, water quality, and human disturbance. Loss of these habitats would not only undermine biodiversity but also diminish natural coastal defenses, reducing ecosystem-based resilience and affecting livelihoods that depend on these ecosystems. The interconnection between human and ecological vulnerability thus creates a multilayered hotspot where socio-economic stability and biodiversity conservation must be jointly addressed to build resilience.
2. The eastern coast of the island, stretching from El Ataya in the south to Ennajet in the north, remains relatively untouched by urbanization. Rich in biodiversity, this area is nonetheless vulnerable due to human activities that exert significant pressure on the local ecosystem. The foreshore is particularly affected by eutrophication, triggered by alterations in tidal flow caused by the bridge connecting Ennajet to Kraten. While the eastern coast has so far avoided extensive urban development, its ecological vulnerability is increasing due to indirect human impacts that disrupt natural processes. The eutrophication of the foreshore—caused by nutrient accumulation and altered tidal dynamics—is an example of how infrastructure

Map 54: Location of the most vulnerable areas on Kerkennah Island



development, even if limited, can trigger cascading ecological effects. This nutrient overload promotes algal blooms, which reduce oxygen levels in the water, harming aquatic life and weakening ecosystem productivity. The disruption of tidal flow affects sediment transport and water circulation, altering the delicate balance of salinity and nutrient exchange that sustains coastal wetlands and seagrass beds. These ecosystems provide essential services such as carbon sequestration, nursery grounds for fish, and water filtration. The fragility of this habitat means that any additional pressures—such as potential future urban encroachment, tourism development, or pollution—could push the system beyond a tipping point, resulting in biodiversity loss and reduced ecosystem resilience. These environmental changes will ultimately impact local communities that rely on these natural resources for fishing and agriculture, creating an intertwined socio-ecological vulnerability hotspot that requires proactive management.

3. Kraten, located at the extreme north of the island, has traditionally maintained a balance between dispersed urbanization and natural environments such as wetlands, agricultural zones, and the foreshore. In recent years, however, the area has experienced rapid densification and accelerated anthropization. Being relatively isolated and lacking access to public services, Kraten faces compounded vulnerabilities—both social and environmental—particularly from rising sea levels. Urbanization is increasingly encroaching on the terrestrial habitats of local fauna. Kraten's evolving landscape illustrates how emerging urban pressures intersect with pre-existing social and ecological vulnerabilities to create a multilayered hotspot. The rapid densification and expansion of built environments reduce the availability of natural buffers such as wetlands, which serve as critical zones for flood mitigation, groundwater recharge, and biodiversity habitat. This encroachment not only diminishes ecosystem functions but also fragments habitats, threatening species diversity and ecological connectivity essential for resilience. Social vulnerabilities are heightened by the area's relative isolation and limited infrastructure, which restrict residents' access to healthcare, emergency services, and livelihood opportunities. This makes communities more sensitive to climate impacts, with fewer resources or institutional capacity to adapt. The combination of environmental degradation and socio-economic marginalization means that Kraten's residents face heightened risks from sea level rise, coastal flooding, and saltwater intrusion, potentially leading to displacement, loss of livelihoods, and deteriorating living conditions. Addressing Kraten's vulnerability requires integrated strategies that simultaneously protect natural ecosystems, improve social services, and manage urban growth sustainably.
4. The gulf area from Cap Bounouma to Sidi Founkhal, located along the northern coast, was historically uninhabited but has seen rapid urban expansion in recent years—especially in Bounouma—and the emergence of new tourism developments, including the future tourist zone of Sidi Founkhal. The area is also affected by the environmental and visual impacts of salt flats, which have significantly disrupted sea currents by closing off the foreshore that once connected the northern and southern seas of the island. Comprising palm groves, orchards, and wetlands, this territory serves as a key habitat for local flora and fauna. The rapid urbanization and tourism development along the northern gulf coast represent a new frontier of vulnerability that intertwines ecological disruption with socio-economic change. This historically pristine area has seen transformations that disrupt hydrological and sedimentary systems critical to maintaining coastal resilience. The alteration of sea currents by the closure of the foreshore—largely due to the expansion of salt flats—has fragmented marine connectivity, affecting nutrient cycling, fish migration, and shoreline stability. This hydrodynamic disruption exacerbates coastal erosion and habitat loss, threatening palm groves, orchards, and wetlands that underpin local biodiversity and provide essential ecosystem services such as carbon storage, soil stabilization, and water regulation. The influx of urban and tourism infrastructure places additional pressure on freshwater resources, land availability, and waste management systems, which are often insufficiently developed to handle rapid growth. These dynamics generate a multilayered vulnerability hotspot where economic aspirations for tourism and development clash with the imperative to preserve ecological integrity and community livelihoods. Without careful planning and investment in sustainable infrastructure, the area risks long-term environmental degradation, loss of cultural heritage, and increasing vulnerability to climate shocks.
5. The center of Gharbi Island, particularly the two sebkhas of Henchir Salem and Ejlija, is directly affected by rising sea levels.
6. The southwestern coast of Gharbi Island, stretching from Sidi Youssef to Ras Essmoum, is a relatively urbanized area. It features a succession of agricultural zones and wetlands along a coastline that provides natural shelters for the fleet of small boats used by local fishermen.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07

STAKEHOLDERS ENGAGEMENT

Stakeholder validation workshop

On December 23, 2024, a local workshop to validate the MVA was held to which the local monitoring committee composed of [integrate the list of those present or their qualities] was invited.

The workshop lasted one day with the following key moments: [Integrate the program of the day].

At the end of the work of the steering committee and the exchanges with stakeholders, several recommendations were made to strengthen the relevance, effectiveness and implementation of the Multilayered Vulnerability assessment (MVA) process in Kerkennah.

From a methodological point of view, the members of the committee insist on the need to improve the scientific rigor of the analyses by integrating measurable and temporal indicators, particularly for climate risks and biodiversity. As such, they acknowledge the absence of local territorialized data and recommend the implementation of practical methods for the continuous collection of concrete data (rainfall, temperature, sea level) to anticipate future vulnerabilities. In this respect, and to ensure the sustainability of risk assessment, the committee recommends the creation of a local vulnerability observatory, in conjunction with universities and research centers. This will make it possible to fill gaps in spatial data and to ensure that analyses are regularly updated. Kerkennah is thus envisaged as a territory that is a witness to the effects of climate change and can play a laboratory role on a national and regional scale.

On priority actions, members support the integration of nature-based solutions: wetland restoration, planting of native species resistant to salinity, and measures to combat coastal erosion. However, they are asking for more technical details on certain measures. According to them, the implementation of the action plan requires specific support for the municipality, both institutionally and financially, to facilitate partnership arrangements and the mobilization of funds.

Finally, the committee reaffirms the importance of basing interventions on a coherent reading of the territory, considering continuous functional entities such as the Ataya–Ennajet–Chergui axis. He validated a series of priority areas of intervention (Kraten, Attaya, Ramla, Mellita, Dahmanine, etc.), while recalling that community mobilization, especially of young people, is an essential lever for successful adaptation and resilience efforts.

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Stakeholder Feedback

The Multilayered Assessment (MVA) report of the Kerkennah Archipelago, enriched by inputs from participatory workshops held in 2024 and 2025, was disseminated and presented to stakeholders across three institutional levels:

- **Local level:** to the steering committee and municipal services of Kerkennah, on December 23, 2024;
- **Regional level:** to the authorities of the Sfax Governorate, on February 21, 2025;
- **Central level:** to the relevant ministries, on March 7, 2025.

These presentations provided valuable space for dialogue to assess the relevance of the MVA findings and to validate the proposed strategic directions through four main axes:

- The relevance of the indicators used to assess the different dimensions of vulnerability (climate, urbanization, biodiversity) in light of the territorial specificities of Kerkennah;
- The quality of the analyses and the robustness of the conclusions drawn;
- The coherence in the selection of areas identified as most vulnerable;
- The validation of the proposed action plan, including the prioritization of measures to be undertaken.

All consulted stakeholders highlighted the rigor of the methodology and the added value of the MVA in guiding public development policies in Kerkennah, particularly in the field of spatial planning. The produced mapping database, illustrating urban, climate, and ecological vulnerabilities, is now considered an asset for supporting decision-making and strengthening institutional accountability to citizens.

Two institutions have already expressed their intention to integrate the MVA findings into their strategic planning processes:

- ***The Municipality of Kerkennah***, which has initiated a revision of its Urban Development Plans (Plan d'Aménagement Urbain - PAU);
- ***The General Directorate for Spatial Planning, Ministry of Equipment,*** which has launched the development of a master plan for the sensitive zone of Kerkennah.

Furthermore, stakeholders emphasized the importance of institutionalizing the monitoring and evaluation process of risks and addressing data gaps, particularly regarding biodiversity and climate-related dimensions. The establishment of a local vulnerability observation system, in partnership with universities and research centers, was strongly recommended. This system could position Kerkennah as a pilot territory for observing the impacts of climate change at both national and regional levels.

Finally, although the projects proposed in the action plan were deemed relevant, participants expressed concerns regarding the feasibility of their implementation, due to the limited technical and financial resources available at the local level. To overcome these challenges, stakeholders called for the development of innovative institutional and financial frameworks that promote synergy among public, private, and civil society actors. The municipality, in particular, expressed the need for targeted technical support in this area.


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08

CONCLUSIONS & RECOMMENDATIONS

Conclusion and Recommendations

The diagnostic conducted as part of the Multilayered Assessment (MVA) of the Kerkennah Archipelago highlights a territorial context marked by the convergence of climate, urban, and ecological vulnerabilities. This low-lying island territory, characterized by a unique ecosystem and an economy still largely dependent on vulnerable natural resources, is experiencing severe impacts from climate change, unregulated urbanization, and increasing pressure on biodiversity.

Despite these fragilities, Kerkennah offers considerable potential to initiate innovative resilience strategies, building on its natural and cultural heritage, the engagement of local stakeholders, and the strong interest of both local and national institutions. Based on the process and discussions held with stakeholders, the following strategic recommendations are proposed:

1. Strengthen Local Resilience Governance

It is essential to support the municipality in its capacity for integrated territorial planning and management. This includes assistance with revising Urban Development Plans (PAU) to integrate vulnerabilities identified through the MVA, establishing a local vulnerability observatory, and creating multi-stakeholder governance mechanisms.

2. Establish a Local Environmental and Climate Monitoring System

The lack of localized data significantly hinders ongoing and relevant risk assessment. Developing a partnership with universities, research centers, and technical agencies to create a spatialized vulnerability observation platform would be a key leverage point. Kerkennah could serve as a laboratory territory for climate adaptation at the Mediterranean scale.

3. Protect and Restore Critical Ecosystems

Wetlands, sebkhas, and Posidonia meadows should be subject to enhanced protection programs, aligned with Ramsar Convention standards and Coastal Marine Protected Area (CMPA) practices. Ecological restoration projects based on nature-based solutions should be prioritized.

4. Guide Urbanization Toward Sustainability

It is imperative to curb urban expansion in areas with high ecological value or high climate risk. Future spatial planning should promote thoughtful densification of existing urban fabrics, combat informal housing, and prioritize investment in public services in underserved areas.

5. Strengthen Socio-Economic Resilience

The transition to a sustainable island economy requires the promotion of well-managed ecotourism, the valorization of traditional craftsmanship, the sustainable modernization of fisheries, and support for resilient agriculture. Environmentally respectful value chains that generate local employment should be supported.

6. Mobilize Diversified Resources

Resilience ambitions can only be realized through innovative financial mechanisms. It is recommended to develop a portfolio of "bankable" projects to attract public (national and international) and private financing. Support from donors, technical agencies, and the private sector is essential.

Toward Collaborative Implementation

Stakeholder consultations confirmed strong local ownership of the process and a willingness to use the MVA as a decision-support tool for both the municipality and the State. The MVA thus becomes a strategic compass to guide development policies, integrate risk into planning and development projects, and anticipate future environmental shocks. Success now depends on targeted support and shared leadership in implementation.

Kerkennah, an emblematic and fragile territory, can become a model for climate adaptation in Mediterranean islands and coastal areas. Achieving this vision will require firm commitments, multisectoral coordination, and collective action grounded in knowledge, innovation, and solidarity.


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WAY FORWARD

Way Forward

The Multilayered Vulnerability Assessment (MVA) of the Kerkennah archipelago has enabled the rigorous identification of the most sensitive areas, key risk factors, and strategic levers for action to strengthen territorial resilience in the face of climate, environmental, and urban challenges. This diagnostic provides a robust and widely consulted scientific foundation, essential for guiding public policies, informing territorial planning documents, and shaping future interventions.

The next logical step in this process is the formulation and implementation of the Urban Resilience Action Plan (URAP), the direct operational follow-up to the MVA. While the MVA focused on identifying vulnerabilities and localizing hotspots, the URAP proposes concrete solutions and details the operational steps required to reduce risks, enhance community resilience, and restore ecosystems. Structured around strategic objectives validated with stakeholders, the URAP becomes the shared reference framework for collective action.

To sustain this momentum and embed resilience into the development trajectory, four immediate priorities have been identified:

1. Integrate MVA and URAP findings into territorial planning
Urban planning tools — particularly the revision of Urban Development masterplans (in Tunisia refered to in french as Plan d'aménagement Urbain - PAU) — must reflect the vulnerability maps generated through the MVA. This includes adapting land-use regulations to climate hazards and biodiversity considerations. Regulatory zoning must be aligned with risk diagnostics to enable safer, more sustainable development pathways.

2.Establish a local vulnerability observatory
A local observatory should be created to institutionalize the process by monitoring environmental and climate indicators over time. It will play a central role in evaluating the impact of URAP-led actions and should be supported by universities, research institutions, national agencies, and local citizens to ensure inclusive governance.

3. Launch pilot projects with high demonstrative value
The first 15 projects, identified in collaboration with the municipality and validated by the steering committee, serve to test the approaches proposed by the URAP. These projects, often based on nature-based solutions, have strong replication potential at the scale of the archipelago and beyond.

4.Mobilize adapted financing and establish institutional frameworks
Delivering on the URAP portfolio requires a comprehensive and ambitious financing strategy, combining public resources, international funding mechanisms, decentralized cooperation, and private sector partnerships. Technical assistance will be essential to develop bankable project proposals and support the municipality in building innovative institutional arrangements.

The URAP thus serves as the operational roadmap to translate the MVA's findings into action. It marks the transition from assessment to implementation within a systemic and inclusive resilience framework.


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