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In view of obtaining startup diploma – patent

Theme

Perception of ICZM: Analysis of the socioeconomic and environmental vulnerability of the coastal zone of Skikda province.

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Nada

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Acronyms

ANIREF: Agence Nationale d'Intermédiation et de Régulation Foncière (National Agency for Land Intermediation and Regulation)

ASAL: Algerian Spatial Agency

BPH: The Building, Public Works, and Housing

DPAT: Department of Planning and Territorial Development

DPSB: Directorate of Programming and Budget Monitoring

DRE: Directorate of Water Resources

DWS: Department of Water and Sanitation

FAO: Food and Agriculture Organization

GCS: Global Coordinate System

GIS: Geographic Information System

GS: Geological Survey

Ha: Hectare

ICH: Intangible Cultural Heritage

ICZM: The Integrated Coastal Zone Management

IPCC: The Intergovernmental Panel on Climate Change

IZ: Industrial Zone

Km: Kilometer

MAP: Mediterranean Action Plan

MATE: Ministère de l'Aménagement du Territoire et de l'Environnement

NW: North West

SE: South East

SLR: Sea Level Rise

Socio: Sociological

TEA: Tourism Expansion Area

TM: Thematic Mapper

UAA: Utilized Agricultural Area

UNEP: United Nations Environment Program

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNWTO: United Nations World Tourism Organization

USGS: United States Geological Survey

WGS: World Geodetic System

WHO: World Health Organization

WTS: Water Treatment Station

ZAC: Commercial Activity Zone

Introduction

The coastal zone represents an intermediary area where the land and sea seamlessly merge, acting as a transitional region between the terrestrial and marine components of the Earth's surface (Crossland et al., 2005). This strip of land is considered an "eco-socio system." It is a complex and heterogeneous area where physical, biological, and human elements interact. The coastal region stands apart from other terrestrial spaces due to its interface between land and sea, which gives rise to distinct and specialized environments such as wetlands, estuaries, and intertidal zones. These unique characteristics have resulted in diverse human uses and activities in coastal areas, which are subject to various legal regulations (Paskoff, 1993).

This area represents a valuable asset that generates both practical and economic value, possibly to a greater extent than any other. The coastal region is a finite resource, emphasizing the critical need for a continuous long-term outlook and proactive planning (Hadef et Larbi. 2017). Due to its high vulnerability to a range of hazards, including erosion, flooding, marine submersions, landslides, oil spills, and industrial accidents, the study of risks along coasts encompasses various domains (sciences, practices, policies, etc.) and typically incorporates notions such as hazard, stakes, and vulnerability. However, the definitions of these terms may vary across different sources and evolve over time with ongoing research (Paskoff, 1993).

The immense significance of coastal regions and their susceptibility to various pressures has necessitated nations to take proactive measures and implement strategies to safeguard marine ecosystems from degradation and pressures, while simultaneously preserving the sustainability of socio-economic activities. One of the approaches embraced by countries is the utilization of the integrated coastal management as a means to achieve these objectives. The primary objective of this recent protocol in the Mediterranean is to actively work towards realizing the following vision: "A thriving Mediterranean characterized by productive and ecologically diverse coastal and marine ecosystems that promote sustainable development for the benefit of current and future generations" (UNEP/MAP, 2016-2021). Integrated coastal zone management (ICZM) initiatives have been carried out at the national level, including the development of the national ICZM strategy in 2015 and its revision and validation in 2020 and as part of the Algerian scientific research in this field, the objective of the present research work is to develop a regional socioeconomic and environmental vulnerability for the Skikda province.

Coastal vulnerability studies are conducted to assess the susceptibility of coastal areas to various hazards and to understand the potential impacts of those hazards. These studies help

identify areas that are most at risk and inform decision-making processes related to coastal management, adaptation strategies, and disaster risk reduction. The assessment of coastal zones vulnerability takes into account various factors, including physical, ecological, and socio-economic indicators and leads to empower coastal management by identify high-risk areas and prioritize management strategies accordingly (Jiang et al., 2021).

The Algerian coast spans a coastline of 1622 km, this number has been revised with more precice methodology from the National Institute of Cartography and Remote Sensing and became 2148 Km. This coast accommodates 85% of the country's population, which is concentrated within just 12% of the total land area (Rabehi et *al*., 2018; Djabri et *al*., 2019). However, the utilization and advancement of this coastal region come with inherent risks associated with erosion and potential flooding from the sea. These risks may be exacerbated by the projected rise in sea levels in the Mediterranean Sea (Jimenez & Sánchez-Arcilla, 1997; GIEC, 2014). Therefore, as part of the Algerian scientific research in this field, the objective of the present research work is to develop a regional coastal vulnerability index for the Skikda province.

The choice of the study area is linked, on one hand, to the selection of the scale and, on the other hand, to the sensitivity of the area to various risks and hazards. The anthropogenic influence has deeply marked this zone. This human imprint interacts with the dynamics that regulate coastal evolution, simultaneously modifying its morphology and the processes that govern its development. Indeed, the degree of vulnerability that may affect the Skikda coastal zone depends on the probability of societal elements being threatened and, furthermore, on the area's capacity to respond to the constraints exerted upon it.

To accomplish this task, it is necessary to define the scope of influence by determining the boundaries of the relevant coastal zone and its ecosystems. Additionally, it involves identifying the natural and societal factors that exert pressures on the coastal ecosystem. Understanding the coastal zone requires comprehensive knowledge of its physical characteristics and coastal dynamics, as well as a thorough examination of human activities. This includes assessing the exploitation and management of the coastal environment, the utilization of both renewable (living) and non-renewable (mineral) resources, and evaluating their impacts on the coastal area.

This work manuscript is organized into four chapters:

- The first chapter, based on documentary research (scientific literature review, information collection and sorting), focuses on the concept of Integrated Coastal Zone Management (ICZM), the definition of vulnerability, The Mediterranean and Algerian coastal vulnerability, the GIS using in coastal vulnerability assessment and its sub-vulnerabilities.
- The second chapter concerns the general aspects of the study area.
- The third chapter dedicated to the equipment and methods used for the completion of this work. Regarding the methodology the scope of analysis, data collection for the assessment of the the coastal socioeconomic, environmental and coastal erosion vulnerabilities.
- The forth chapter, based on the analysis of sub-vulnerabilities of each vulnerability using a specific ranking and GIS material and interpret the statistical data in order to compare the coastal and noncoastal areas to finally assess the coastal vulnerability.

I. Chapter I: Concept of ICZM and Coastal vulnerability

I.1. Integrated coastal zone management (ICZM)

The integrated coastal zone management (ICZM) is seen as the major tool for implementing sustainable development in coastal areas (Hatziolos et al., 1998). It is a continuous and dynamic process which is designed to overcome the fragmentation inherent in both the sectorial management approach and the splits in jurisdiction among levels of government at the land-water interface (Cicin-Sain et amp; Knecht, 1998). This is achieved by establishing a system where the decisions made by various sectors and levels of government are aligned and in line with the coastal policies of the respective nation. The ICZM Protocol and its Article 22 state: "The Parties develop policies for the prevention of natural hazards. To this end, they undertake vulnerability and hazard assessments and implement preventive, mitigation, and adaptation measures to address the effects of natural disasters and, in particular, climate change."

On one hand ICZM aims to preserve coastal resources, their ecological functioning and ultimately their values, by properly applying land use planning in a social, institutional and economic context (Skourtos et al., 2005). In the other hand, processes aiming at the sustainable management of coastal zones by reconciling the preservation of fragile and highly coveted coastal ecosystems and the development of the various activities present on the coast by bringing together the actors around this project of sustainable management (Braud, 2013; Calvet, 2014).

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I.2. Vulnerability

The vulnerability and related resilience research on social-ecological systems and the separate literature on vulnerability of livelihoods to poverty. There are common terms across theoretical approaches: vulnerability is most often conceptualized as being constituted by a components that include exposure and sensitivity to perturbations, external stresses, hazards and the capacity to adapt. It is driven by inadvertent or deliberate human action that reinforces self-interest and

the distribution of power in addition to interacting with physical and ecological systems. (Adger, 2006).

Vulnerability, by contrast, is usually portrayed in negative terms as the susceptibility to be harmed. The central idea of the often-cited IPCC definition (McCarthy et al., 2001).

The schema of the IPCC **(figure 1)** combines exposure, hazards and vulnerability. The white text indicates the terms used to describe a specific determinant of risk (i.e., hazard, exposure, and vulnerability). The black text indicates the terms used to describe complex risk. The red text highlights the terms that have been used to describe both the risk itself and a determinant of risk, such as "compound risk" and "compound hazard"(Simpson & al., 2021).

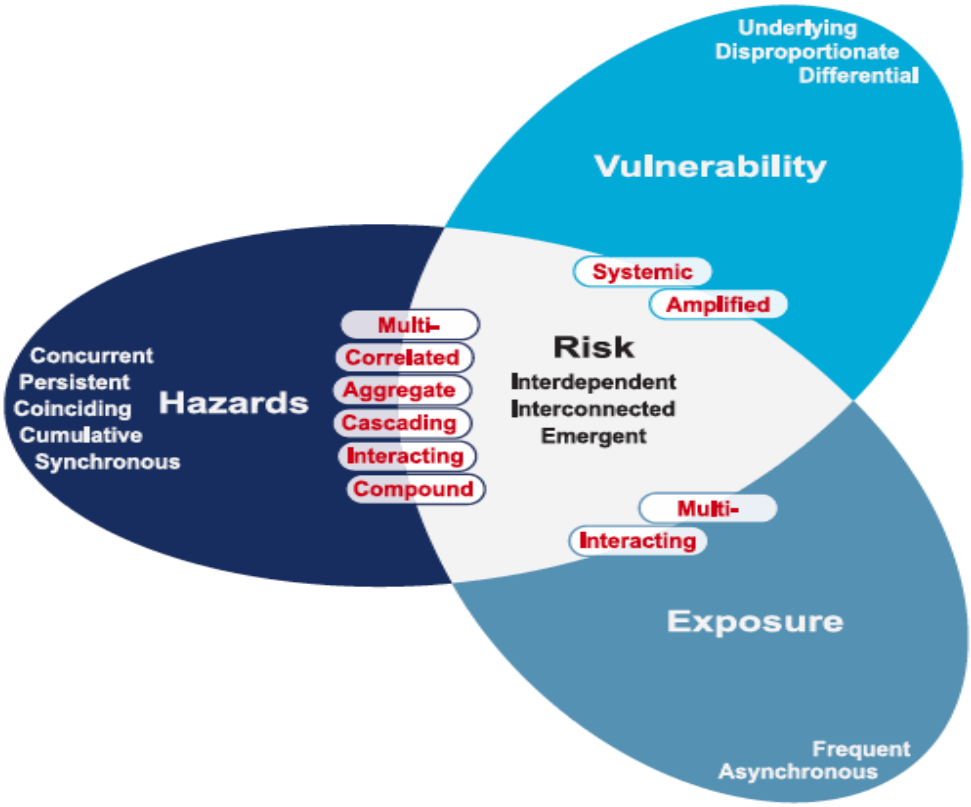

Figure 1: IPCC Risk Framework (Simpson et *al*., 2021).

I.2.1. The Mediterranean vulnerability

The Mediterranean region is characterized by a narrow coastal area that experiences significant population density and the presence of valuable assets. This region undergoes rapid changes in demographics, society, economy, and environment. From 1960 to 2010, the Mediterranean population has doubled from 240 million to 480 million, with a 20% increase in urban

population. The coastal zone of the Mediterranean is particularly affected by demographic and environmental pressures, as over a third of the population resides in administrative regions along the coast that occupy less than 12% of the total territory (Blue Plan, 2012). The concentration of population in these areas is further reinforced by ongoing population growth and migrations (UNEP/MAP, 2012). Additionally, the Mediterranean Coast receives significant tourist influx, with 247 million tourists visiting during the peak season, which exacerbates the aforementioned challenges (UNWTO, 2017).

The issue of resource access arises, encompassing aspects such as land, water resources, and fish stocks. The rapid depletion of these resources has led to the increased expansion of aquaculture, which now contributes to nearly half of the current fisheries production. Consequently, this intensifies the concentration of activities along coastal areas, giving rise to conflicts related to land use (FAO, 2016).

The Mediterranean region is a complex ecosystem with a high biodiversity, which results especially vulnerable to climate change and its impacts (Rahmstorf, 2012; Gualdi et al., 2013). These impacts cause effects in a coastal environment on different levels: bio-geophysical, socio-economical, infrastructures and economic activities. (Travers, 2010). Around 46 % of the Mediterranean coastline is characterized by low-lying sedimentary coasts including beaches, dunes, reefs, lagoons, estuaries and deltas that are more dynamic than rocky coasts because the balance between sea forcing and sediment supply will determine whether the coastline advances (accretion), remains stable, or retreats (erosion) (UNEP-MAP, 2012).

The major impacts of climate change in the Mediterranean coastal regions are produced by the sea level rise and change in Storms frequencies and intensities. Thermal expansion due to ocean temperature increases and mass input due to melting glaciers and ice sheets are the primary components responsible for SLR (Petersen et al., 2007). IPCC reported in 2007 that the Mediterranean is considered itself a “hot spot” for climate change.

I.2.2. Algerian vulnerability (coastal zone)

The coastal zone of Algeria is facing significant socioeconomic and urban development that is causing severe disturbances to the coastal environment caused by pressures arising from both natural factors (such as seismic and tsunami risks, erosion/accretion, and saltwater intrusion)

and human activities (including pollution, loss of biodiversity, and economic impacts) (The absence of comprehensive data, especially long-term records of natural coastal processes, poses challenges for effective decision-making (Sallaye et al., 2022). In numerous instances, the implemented coastal protection measures inadvertently worsen the vulnerability of these areas, particularly when relying on rigid engineering solutions.

I.3. Socio-economic and Environmental vulnerability

The environment is the source of all our raw materials and absorbs the pollution from our activities. In turn, whilst going about our daily business (social and economic) we use the environment and convert its resources and natural services into those that directly support us. The problem is that all of these systems can be damaged, overloaded, or prevented from meeting our needs (Ordonez et al., 2003).

The inclusion of socio-economic variables is of great importance, perhaps even essential, in the development of valid coastal vulnerability indices. (Cooper et McLaughlin, 1998; McLaughlin et al., 2002). Studies of coastal management problems have shown that different human and social reactions will manifest themselves according to the size of the population of the affected area, the economic activity within the area, and the prevailing social conditions". (Cooke et Doornkamp, 1990). Coastal and marine environmental management requires a comprehensive approach that integrates all its components. The concept of coastal vulnerability is based on human value judgments concerning risk to various elements of the natural and human environment from a variety of sources. The quantification of vulnerability largely depends on the conception of the source of the risk and what element of value to humans is threatened (Green et Mcfadden, 2007).

The vulnerability of the environmental, social and economic systems is made up of more than just the risk of disasters and good or bad management. It is not just about climate change, or globalization, or trade agreements. It must also include an understanding of how well any system (environmental, social and economic) can cope with any hazards that may come its way and that might harm it. It would be impossible to work towards good quality of life and growth for countries under a sustainable development model if no account were made of the damage that can occur from internal and outside influences (Weichselgartner, 2001).

I.4. Socio-economic vulnerability

Is a component which assesses the vulnerability of coastal communities based on their level of social and economic development. It takes into account various social and economic factors that influence the vulnerability of coastal communities to the impacts of coastal hazards and climate change. These factors may include population density, poverty rates, income levels, education levels, and access to basic services such as healthcare, sanitation, and clean water. In our study we chose six variables which are (population, cultural heritage, roads, railways, land use and conservation status (McLaughlin et al., 2010).

I.4.1. Population

In the context of demographics, population refers to the total number of people living in a specific geographic area, such as a country, city, or region. It includes individuals of all ages, genders, and backgrounds within that defined area (WHO).

I.4.2. Cultural heritage

Includes artefacts, monuments, a group of buildings and sites, museums that have a diversity of values including symbolic, historic, artistic, aesthetic, ethnological or anthropological, scientific and social significance. It includes tangible heritage (movable, immobile and underwater), intangible cultural heritage embedded into cultural, and natural heritage artefacts, sites or monuments. It covers industrial heritage and cave paintings. (UNESCO, 2009).

I.4.3. Land use

Areas, or residential areas. s characterized by the arrangements, activities, and inputs people undertake in a certain land cover type to produce, change or maintain it. Natural scientists define land use in terms of syndromes of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology, and biodiversity. (Nedd, 2021).

I.5. GIS using in coastal vulnerability assessment

Since vulnerability is affected by a diverse range of parameters, it is common for geographic information systems (GIS) to be used as a vehicle for integration of data and the creation of indices that express their combined effect (Thumerer et al., 2000; Bryan et al., 2001).

II. Chapter II: Study Area

II.1. Brief history of Skikda

The establishment of Rusicade or Skikda dates back to ancient times, possibly during the Phoenician period between the 12th and 8th centuries BCE. The Phoenicians likely chose this location for their trading post due to its elevated position overlooking the sea. They constructed forts like Stora and Collo to facilitate their commercial activities.

During the Numidian period, the Carthaginians reinforced these forts, particularly Stora. This marked the true beginning of urbanization. In 45 BCE, following its colonization by the Romans, Rusicade became part of a confederation comprising four Roman colonies: Rusicade (Skikda), Chullu (Collo), Milev (Mila), and Cirta (Constantine).

Around the 5th century CE (439), Rusicade is believed to have been destroyed by the Vandals, who devastated much of the North African coast.

Today, remnants of the Roman era can still be found, such as the remarkably preserved Roman theater and marble statues that miraculously escaped looting and vandalism. After the decline of the Roman Empire, the Byzantines briefly dominated the region before their influence waned.

The Arabization of the Skikda region took place with the arrival of Islam. The tribes in the area belonged to the Katana tribal confederation, which welcomed the Shiite leader Aheid Allah El Fatimi. The Almohads played a significant role in settling the originally nomadic Hilalian tribes.

The history of the Turks in the region remains unclear, although it is known that they settled in El Qol (Collo).

In 1938, the site of ancient Rusicade was occupied by colonial troops. The city was initially named Port de France and later renamed Philippe Ville in honor of King Louis Philippe.

During the War of Liberation, Skikda witnessed heroic moments, including the notable operation on August 20, 1955. However, it also experienced tragic events like the massacre at the municipal stadium.

Today, the province still bears traces of the Phoenician and Roman civilizations that significantly influenced the region, particularly in Skikda, Collo, and Stora (MATE, 2005).

II.2. Geographic presentation

Skikda is a coastal city located in the northeastern region of Algeria. It is limited to the north by the sea Mediterranean, to the east by the state of Annaba, to the west by the state of Jijel, to the south by Constantine and Guelma, and by Mila to the southwest, between altitudes 36°5N and 36°15N and longitudes 7°15E and 7°30 E (figure 2). Covering a total area of 4137.68 km2 with a fringe coastline 142 km long, representing 12% of the Algerian coastline (Rahmoune, 2017).

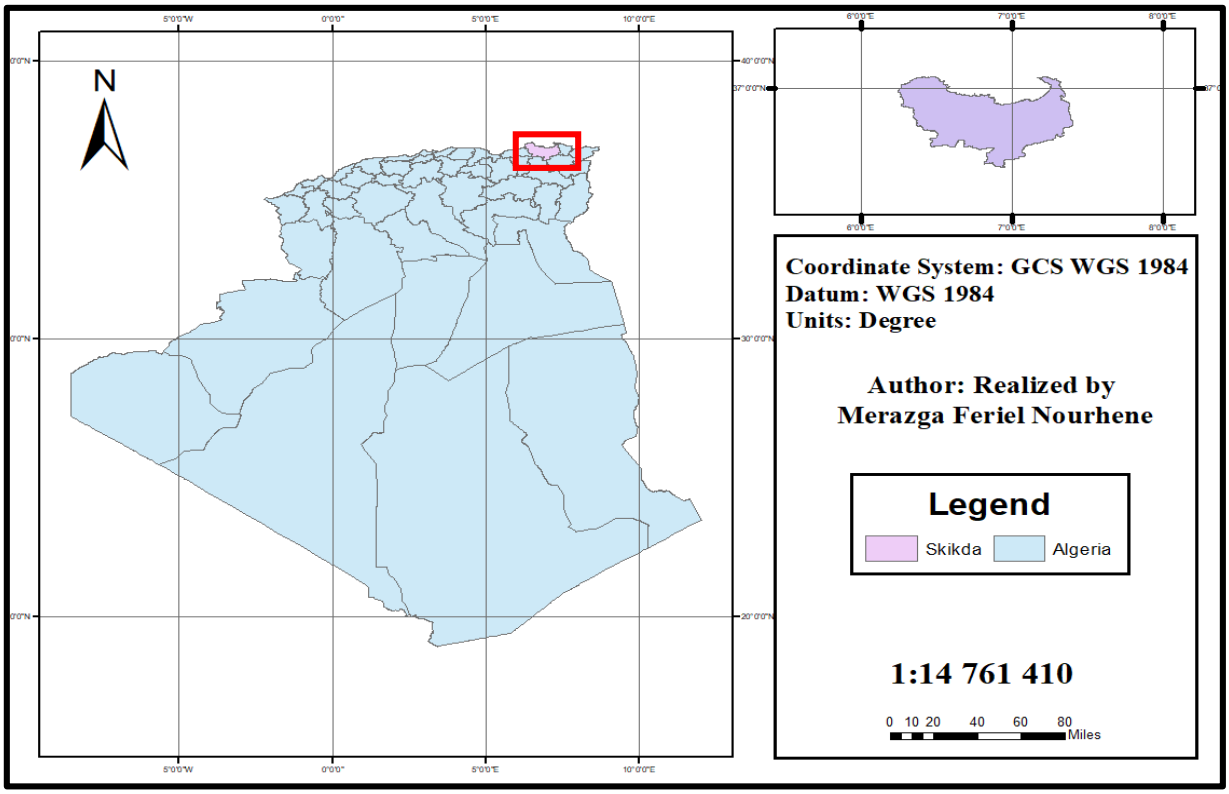

Figure 2: Localization of Skikda in Algeria.

- **Administrative organization**

The map **(figure 3)** illustrates the administrative organization with 38 municipality. Among Skikda's municipalities, there are 14 coastal municipalities; El Marsa, Benazouz, Djendel, Filfila, Skikda, Ain Zouit, Tamalous, Kerkera, Collo, Cheraia, Kenoua, Ouled Attia, Khenag Mayoun Oued Zhour.

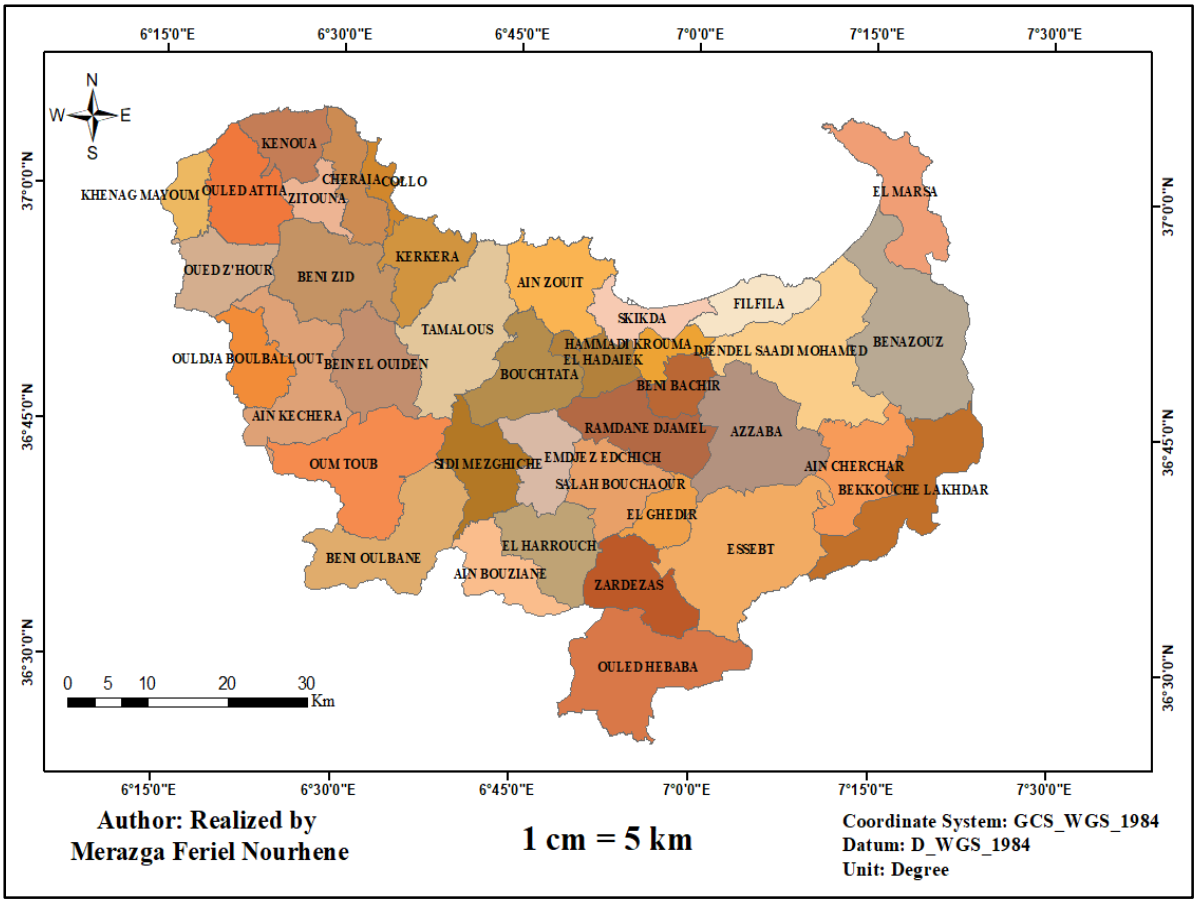

Figure 3: Administrative organisation of Skikda.

II.3. Coastline and beaches description

In fact, the coastline of Skikda is dotted with beaches of fine sand. To the east, it is the big beach of Larbi Ben M'hidi (Jeanne d'Arc Beach), to the West in the direction of Stora several picturesque beaches: Stora, Great Beach, and so on. Some beaches were unfortunately greatly diminished due to the installation of the petrochemical complex like beaches of Larbi Ben M'Hidi and those of Stora following the extension of its port. The **(table 1)** includes all the beachs of Skikda coastline.

Table 1: Beachs of Skikda (MATE, 2005).

Beach	Municipalities	Main caracteristics
Sidi Akacha	El Marsa	It is a straight beach composed exclusively of pebbles, with a length of 5000 meters and an average width of 5 meters. It is bordered at the back by the road.
Boumeroun e	El Marsa	The Boumerouane beach is rocky in nature and extends for a length of 100 meters.
Marsa	El Marsa	It is a sandy beach located to the east of Port El Marsa, which has a cross-sectional profile over a length of 500 meters and a width of 20 meters.
Marsadelle	El Marsa	This beach extends for a length of 500 meters. Its fine sand is mixed with very fine golden particles. Constructions are reported in the back of the beach. This beach is characterized by small-scale fishing activities, which constitute the main source of income for the locality. Fishing is

		practiced using flat-bottomed boats hauled directly onto the beach by manpower.
Cheikh Rabah	El Marsa	It is a sandy beach with a length of 500 meters and a width of 10 meters.
Kef Fatma	Ben Azzouz	Kef Fatma beach extends for a length of 500 meters. Its fine sand is mixed with debris and solid waste, forming a thin layer. This is due to the excessive extraction of sand from the beach.
Guerbes	Djendel	Guerbes beach has a more or less concave profile. It extends for a length of 1000 meters and a width of 20 meters. It is a beach composed solely of sand and bordered at the back by dunes. It is limited to the west by the cliff of the holy ruins.
Oued Saboune	Fil Fila	It is a sandy beach that extends for a length of 350 meters and a width of 15 meters. It is limited to the east by the cliff of Ras Dzira ed Dib.
Oued Righa	Fil Fila	This sandy beach extends for a length of 500 meters and a width to the west of the beach Les Platanes.
Les Platanes	Fil Fila	Les Platanes beach forms a cross-sectional profile and extends for a length of 400 meters with an average width of 8 meters. It is composed of fine sand with the presence of a few scattered pebbles to the east of the beach. The beach is bordered by dunes that are interrupted by the road.
Guigue	Skikda	Guigue beach has a straight profile over a length of 400 meters and a width of 15 meters. It is composed of medium-sized sand with a few pebbles accumulated in the upper part of the foreshore.
Militaire 1	Skikda	The Militaire 1 beach has a transversal profile and has a length of 300 meters and a width of 10 meters. It is exclusively composed of fine sand.
Ben M'hidi	Skikda	It is a sandy beach that extends for a length of 800 meters and a width of 10 meters. The road has been constructed right at the edge of the shore, significantly reducing the width of the foreshore.
Sirène	Skikda	The Sirène beach has a length of 500 meters and a width of 20 meters, with a transversal profile. It is composed of coarse sand. Seafront promenades have been built on the upper part of the beach.
Embouchure Oued Saf-Saf	Skikda	This beach is located to the west of the Saf-Saf port, where the Saf-Saf river directly flows into it. It is mainly composed of medium sand and extends for a length of 200 meters with an average width of 30 meters. Tree debris is washed up on the beach.
Ilot des Chèvres	Skikda	The Ilot des Chèvres beach is shaped like a cove, composed exclusively of sand, and stretches for a length of 600 meters with a reduced width of 5 meters.
Château Vert	Skikda	The Château beach is a beach with medium sand. It extends for a length of 300 meters and has an average width of 15 meters. It is located to the west of the port of Skikda.
Casino	Skikda	It is a beach with medium sand that extends for a length of 200 meters and has an average width of 15 meters.
Militaire 2	Skikda	This coastline with fine sand is straight and extends for a length of 100 meters with an average width of 10 meters.
Paradis	Skikda	It is a beach with medium sand that extends for a length of 300 meters and has an average width of 7 meters.
Biquini	Skikda	It is a beach with medium sand that extends for a length of 200 meters.
Stora	Skikda	Stora Beach is located to the east of the Stora port and is bordered to the east by rock blocks. This beach, with medium sand, extends for a length of 150 meters and has a width of 6 meters.
Molo	Skikda	The Molo beach extends for a length of 150 meters and has a width that does not exceed 5 meters. Its sediment is primarily composed of fine sand with the presence of scattered pebbles.

Large Beach (Grande plage)	Ain-Zouit	The large beach is shaped like an open cove towards the north and stretches for a length of 1000 meters. It is exclusively composed of medium sand. The coastline becomes rocky in front of the cliffs at both ends of the beach.
Oued Tanger	Ain-Zouit	The Oued Tanger beach is straight and has a regular slope from south to north. It is composed of fine sand and extends for a length of 2000 meters.
Ben Zouit	Tamalous	Ben Zouit beach is shaped like an open cove towards the north, with a length of 2200 meters and a width of 50 meters. Its sediment is primarily composed of fine sand. Sparse vegetation, such as sea purslane and wild cucumber, helps stabilize the sand on this beach.
Taleza	Collo	Taléza beach has a more or less concave transversal profile. It extends for a very significant length of 3000 meters and has a width of 50 meters. It is composed exclusively of fine sand. The back of the beach has a fairly flat aspect, allowing for the installation of a concrete plant for the production of tetrapods and artificial blocks in the eastern part of the beach.
R'mimla	Collo	It is a sandy beach that extends for a length of 100 meters and has a width of 10 meters.
Baie des Jeunes Filles	Collo	It is a sandy beach shaped like a cove. It extends for a length of 1030 meters and has a width of 20 meters. Two discharges are reported: the first one represents the discharge of domestic water from the Bougaroun hotel, and the second discharge is through the Sial River.
Tamanart	Cheraia	Tamanart beach consists of two arc-shaped beaches with a length of 1000 meters and an average width of 30 meters, separated by a rocky coastline that stretches for 300 meters. It is characterized by the predominance of coarse sand with the presence of pebbles at the mouth of the Tamanart River.
Zeroual	Cheraia	This coastline with fine sand is characterized by the presence of several scattered rocks. It extends for a length of 150 meters with a maximum width of 5 meters.
Marset Zitoune	Khenak Mayoun	It is a sandy beach that extends for a length of 1000 meters. It is bordered to the east by the Oulad Atia cliff and to the west by the Terhane cliff.
Oued Z'hour	Khenak Mayoun	Oued Z'hour beach is shaped like a cove and bordered to the west by the Oued Z'hour. It is composed of medium sand and extends for a length of 500 meters with a width of 40 meters.

II.4. Natural characteristics & climatic conditions

II.4.1. Landforms and morphology

Eastern Algerian coastal areas known for their mountainous landscapes present rare coastal plains with small areas. The mountain peaks of the state range in altitude from 500 to 600 m. The mountainous country constitutes a real physical and natural barrier (Kef Sidi Driss, Kef Toumiet, Djendel El-Ali, the massif of Collo and Djebel Edough). The valleys, numbering three, are heading South-North around the wadis Safsafsaf, Guebli and El Kebir. The plains exist only at the sub-regions of Collo, Skikda, Ain Charchar and Ben Azzouz. These are small coastal or inland plains closed to the markets of the most important wadis (ANIREF. 2020).

II.4.2. Climate

The Mediterranean city belongs to the humid and sub-humid bioclimatic domains, its climate is mild and temperate at the coastal level and cold at the inside as shown in **(figure 4)**.The wet floor covers the western mountainous area as well as the summits to the east and south. The sub-humid domain prevails over the 4/5th of the territory of the state with rainfall between 1000 and 1500 mm/year. Under the influence of the sea, temperatures are mild in winter (11°C in January) and warm in summer (24°C in August) on the coast where thermal amplitudes are low. They are milder in winter (9°C) and warmer in summer (27°C) in the interior where the amplitudes are more pronounced.

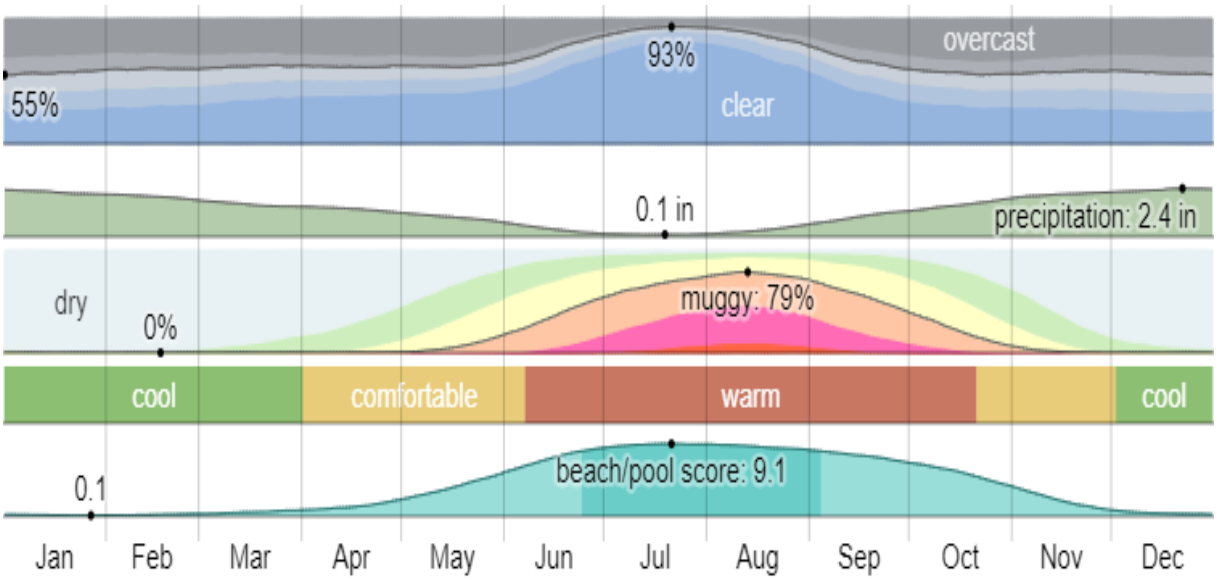

Figure 4: Climate of Skikdain 2022 (https://weatherspark.com/y/53041/Average-Weather-in-Skikda-Algeria-Year-Round).

The relative humidity in Skikda province reaches a significantly high level, averaging at 65.5% and ranging between a minimum of 68.91% and a maximum of 75.34% **(figure 5).** The presence of the sea plays a crucial role in maintaining such elevated humidity during the summer season, effectively reducing the duration of dry spells in the summer (O.N.M., 2012).

The coastal region of Skikda province is particularly prone to strong and destructive winds, with speeds reaching up to 130 km/h. These winds cause extensive damage along both the coast and inland areas. The prevailing wind direction predominantly ranges from southwest to southeast (Touati et al., 2004).

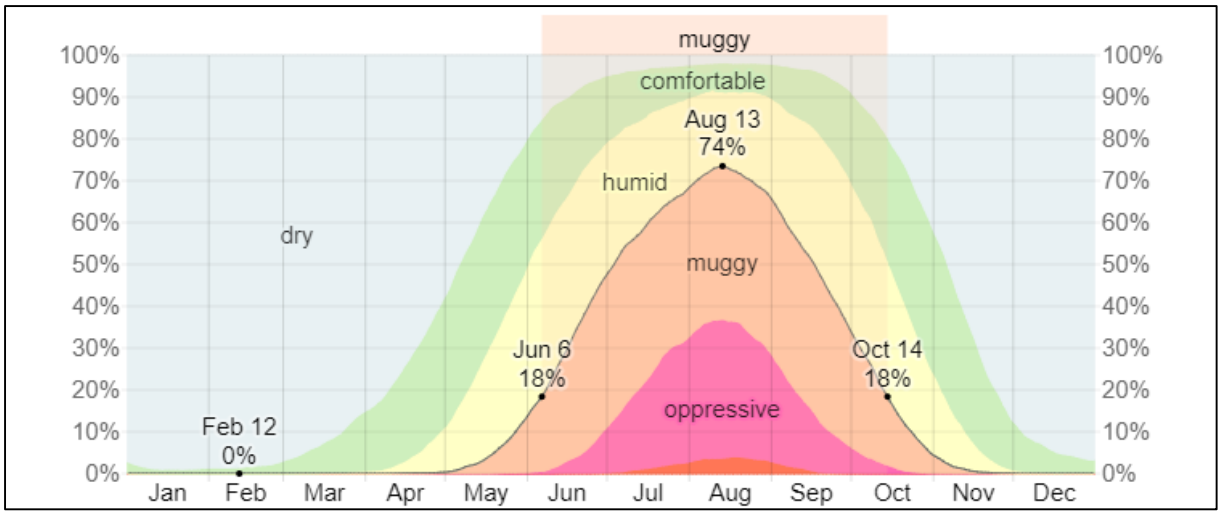

Figure 5: Humidity Comfort Levels in Skikda (https://weatherspark.com/y/53041/Average-Weather-in-Skikda-Algeria-Year-Round).

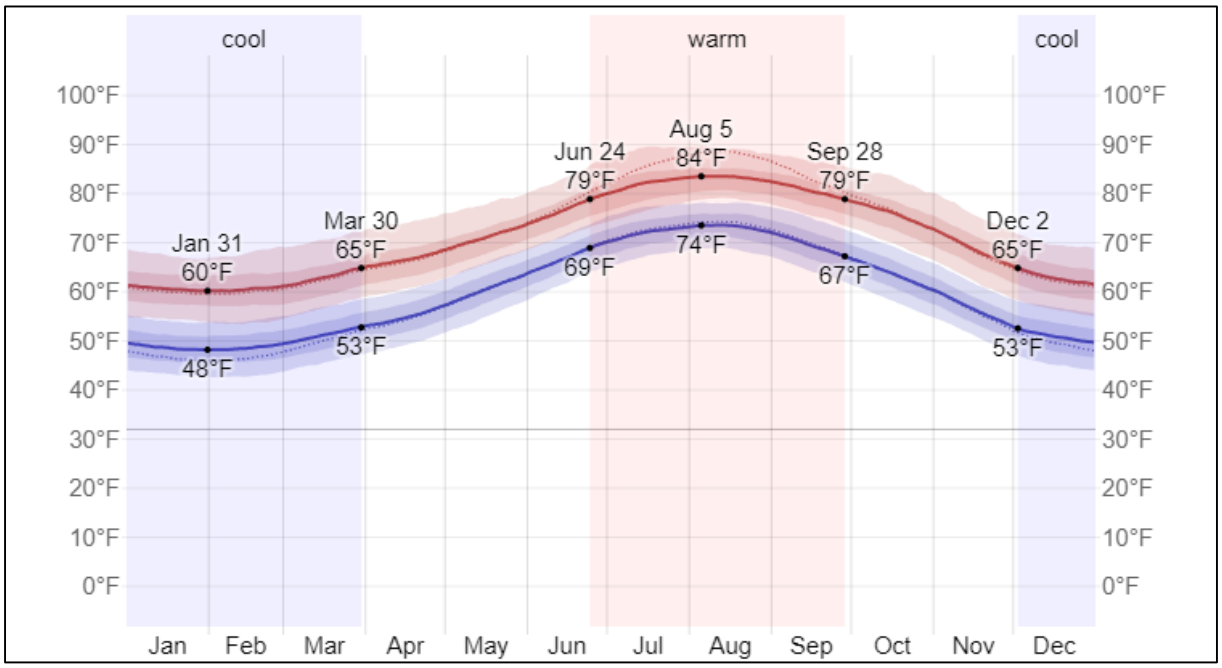

Figure 6: Average High and Low Temperature at Skikda (https://weatherspark.com/y/53041/Average-Weather-in-Skikda-Algeria-Year-Round).

III. Chapter III: Methodology of research

III.1. Study methodology

The information required to create a comprehensive vulnerability assessment consists of both qualitative and quantitative data, which are often accessible in various scales.

The methodology of this work **(figure 7)** consists of several basic steps aimed at identifying the risks and hazards of the study area and achieving the objectives of the assessment of Coastal erosion, Socioeconomic and environmental vulnerability.

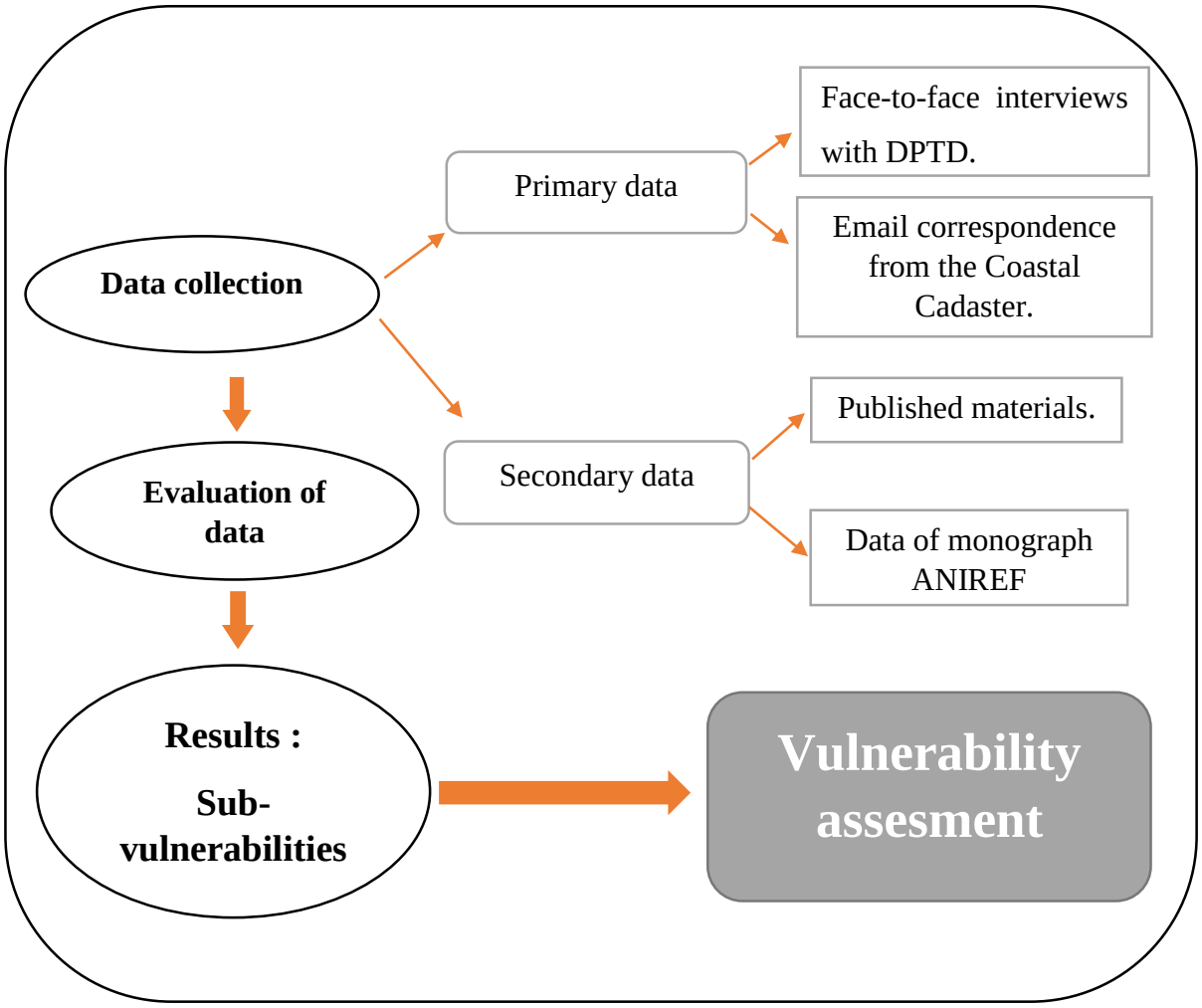

Figure 7: Methodology of coastal vulnerability assessment.

III.2. Vulnerability ranking

In order to assess the study's zone vulnerability. We chose 3 vulnerabilities (Socioeconomic, environmental and coastal erosion) divided into sub-vulnerabilities. The table below **(table 2)** schematizes the vulnerability ranking, we chose the ranking model of (McLaughlin et al. 2010).

Table 2: Vulnerability ranking (McLaughlin et al .2010).

Vulnerabilities	Sub-vulnerabilities	Ranking					Final Vulnerability
		1	2	3	4	5	
		Non-vulnerable	Low Vulnerable	Moderatly vulnerable	Vulnerable	high vulnerability	
coastal erosion vulnerablity							
Socio-economic cumulative vulnerability	Population						
	Activities						
	Toutism						
	Cultural heritage						
	Industry						
	Land use						
Environmental cumulative vulnerability	Agriculture						
	Forests						
	Water ressourses						
	Fishing						
	Landfills						
	Ecological assesment						

III.3. Selection of reference years

In order to demonstrate the evolution of the main variables of the coastal vulnerability, we worked with consecutive years between 1977 and 2020.

For the assessment of socioeconomic vulnerability the data selected were:

- Population variables: we took the population of 1977, 1987, 2008 and 2020.
- Activieties: we worked with the data of 2020
- Tourism, Cultural heritage, Industry: the data selected were of 2020.
- Landuse: Data of 1990, 2000, 2010, 2020.

For the assessment of environmental vulnerability the data selected were:

- All the data were of the year 2020.

III.4. Data collection

III.4.1. Primary data

The data collection was carried out after visits to State headquarters and DPTD of Skikda to retrieve the main data, which are: Population, activities, Natural and industrial potentials and landuse of the municipalities of Skikda. The way the data was organized and the accuracy of the results achieved were greatly impacted by the administrative framework and legal responsibilities of the various institutions involved of the wilaya.

Primary and secondary data of Skikda province were collected for the preparation of Socioeconomic and environmental study through the following means:

- Face-to-face interviews.
- Gathering information through email correspondence with relevant institutions.

III.4.1.1. Department of Planning and Territorial Development (DPTD)

Is an organization that was initially established as the "NPC" (National Planning Council). In the 1990s, it evolved into the Ministry of Planning. Today, the organization is part of the Ministry of Finance (Ben Aknoun), specifically under the "DBG" (Directorate of Budget Management). The DPAT has three main functions:

- Mastery of statistical information, including its processing and dissemination.
- Development of development programs along with their financing plans.
- Territorial planning.

III.4.1.2. The National Land Intermediation and Regulation Agency (ANIREF)

The ANIREF was created by Executive Decree No. 07-119 on April 23, 2007, and subsequently amended and supplemented by Executive Decree No. 12-126 on March 19, 2012. It is a public establishment with industrial and commercial characteristics. The role of the ANIREF is the management of a public service activity.

III.4.1.3. The Coastal Cadaster

The Coastal Cadaster of the Ministry of the Environment is developed by the National Agency for Territorial Planning (ANAT) and the National Center for Applied Studies and Research in Urban Planning (CNERU), is a tool for coastal management and planning. It includes:

- Delimitation of the coastal space through its components.
- Ecological assessment.
- Occupation assessment.
- Action Plan: This involves identifying immediate actions, upgrading measures, and establishing a project portfolio.

III.4.2. Secondary data

Secondary data sources encompass various published documents, including official publications by government institutions, research findings, scientific publications, and data from universities and researchers. The way the data was organized and the accuracy of the results achieved were greatly impacted by the administrative framework and legal responsibilities of the various institutions involved of the wilaya of Skikda.

III.4.3. Variables

III.4.3.1. Socioeconomic variables

For the assessment of socioeconomic vulnerability, we chose six variables, which are: Population, tourism, activities, industry land use and cultural heritage **(table 3).**

Table 3: Socioeconomic data collection and treatment.

Variable	Collected data	Data treatment
Population	Population data of Skikda's municipalities and the total population of the wilaya of years 1977, 1987, 2008 and 2020.	Illustration of the population's distribution, we presented every year's number of habitant on maps using GIS Software (ArcGIS)
Activities	Labor force in Skikda Unemployed population	Presentation of the input data in a graph in order to interpret the Skikda's
Tourism potential	Number and localization of toursm expansion Zones	Presenting the localization of TEA in A map using ARCgis software.
Cultural heritage	Cultural landmarks existing in Skikda	Using ARCgis We presented the localization of the cultural landmarks in every municipality.
Industry potential	- Existing industrial areas, existing business/industrial and the petroleum industry	- Main industrial activities. - Existing industrial zones. - Existing business/industrial Zones. - Petroleum industry.
Landuse	- Maps of landuse for the years 1990, 2000, 2010 and 2020 - Table containing the land areas of vegetation, urbanisation, agriculture, bare lands, water bodies and forest	- Comparison and interpretation these maps to see the evolution of land use. - We presented the table in a bar graph and interpreted the evolution of the land use.

III.4.3.2. Treatment methodology of land use maps.

Steps of analysis and treatment of the satellite images :

- **Acquisition of satellite images Landsat**

- Year 1990 : USGS Landsat 5_TM with a Treatment level 1
- Year 2000 : USGS Landsat 5_TM with a Treatment level 1
- Year 2010 : USGS Landsat 5_TM with a Treatment level 1
- Year 2020 : USGS Landsat8_OIL with a Treatment level 2

- **Layer staking :** Toolbox > Open> selection of the 7 bands TIFF
- **Image cropping:** in order to to extract the study zone.
- **Supervised classification:** in ENVI software and with the Maximum Likelihood classification.

III.4.3.4. Environmental variables

Table 4: Environmental data collection and treatment.

Variable	Input Data	Treatment of data
Water resources	Collection of data of water recourses including sanitation, dams and drinking water supply.	Interpretation of the input data in order to determine the skikda's vulnerability of water.
Agriculture and forests	Data of agriculture and forests areas in the municipalities of Skikda.	Presentation of the input data in four maps using ARCgis software in order to compare between the distribution of the agriculture and forests area in coastal and non-coastal municipalities
• **Fishing resources**		The data explains the ecological and pollution level of the wilaya.

III.4.4. Final vulnerability map

The assessment of the final vulnerability map was with data crossing of soscioeconomic, environmental and coastal erosion variables. This crossing is the average of ecological sensitivity, socioenvironmental pressures and stressors and coastal erosion pression on the coastline of Skikda. By combining these different data sources, we could gain a comprehensive understanding of the multifaceted factors contributing to this coastal vulnerability. Lastly, by amalgamating these datasets we could illustrate this sensitivity in a map which demonstrates the level of vulnerability of Skikda’s coastline.

IV. Chapter IV: RESULTS & DISCUSSION

IV.1. Assessment of Socioeconomic sub-vulnerability

Like every coastal area, Skikda attracts population, investors and tourists. it has a great impotantnce in the Algerian economy because of its petroleum industry and it’s

IV.1.1. Population

IV.1.1.1. Population

Since 1977 to 2020, Skikda has encountered a significant demographic change due to its strategic position. Over this period, the population has steadily increased, driven by factors such as natural population growth, migration, and urbanization. The region's economic development, employment opportunities, and infrastructure enhancements have likely contributed to attracting people to Skikda, resulting in a significant population increase by 2020. It is worth noting that various factors, including government policies, industrial development, and socio-economic conditions, have played a role in shaping the population dynamics of Skikda during this time.

In 1977, the population of Skikda was stationed in Skikda municipality with more than 100000 habitant and Azzaba with more than 25000 habitant **(figure 9).** In 1987 the population increased in last both municipalities and in el Harrouch and Tamalous with More than 25000 habitant for each **(figure 10).** The number of habitants kept increasing in 2008 in the last cited municipalities, for Tamalous and Azzaba the number rose to more than 50000 habitants for each municipalities and more than 25000 habitants in Collo, Kerkera, Filfila, Hamadi Krouma, Ben Azzouz, Ain kechera, Beni Ouelbene, Sidi Mezghiche, Oum Toub, Ramdane Djamel and Salah Bouchour **(figure 11).**

By 2020, the population of Skikda had reached 1115380 habitant indicating a significant increase compared to the population in 1977. The Skikda municipality is the most stationed municipality with more than 100000habitant , Azzaba, el Harrouch and Tamalous with more than 50000 and Collo, Kerkera, Filfila, Hamadi Krouma, Ben Azzouz, Ain kechera, Beni Ouelbene, Sidi Mezghiche, Oum Toub, Ramdane Djamel, Salah Bouchour, Bein El Ouidene and Bni ZId With more than 25000 for each **(figure 12).**

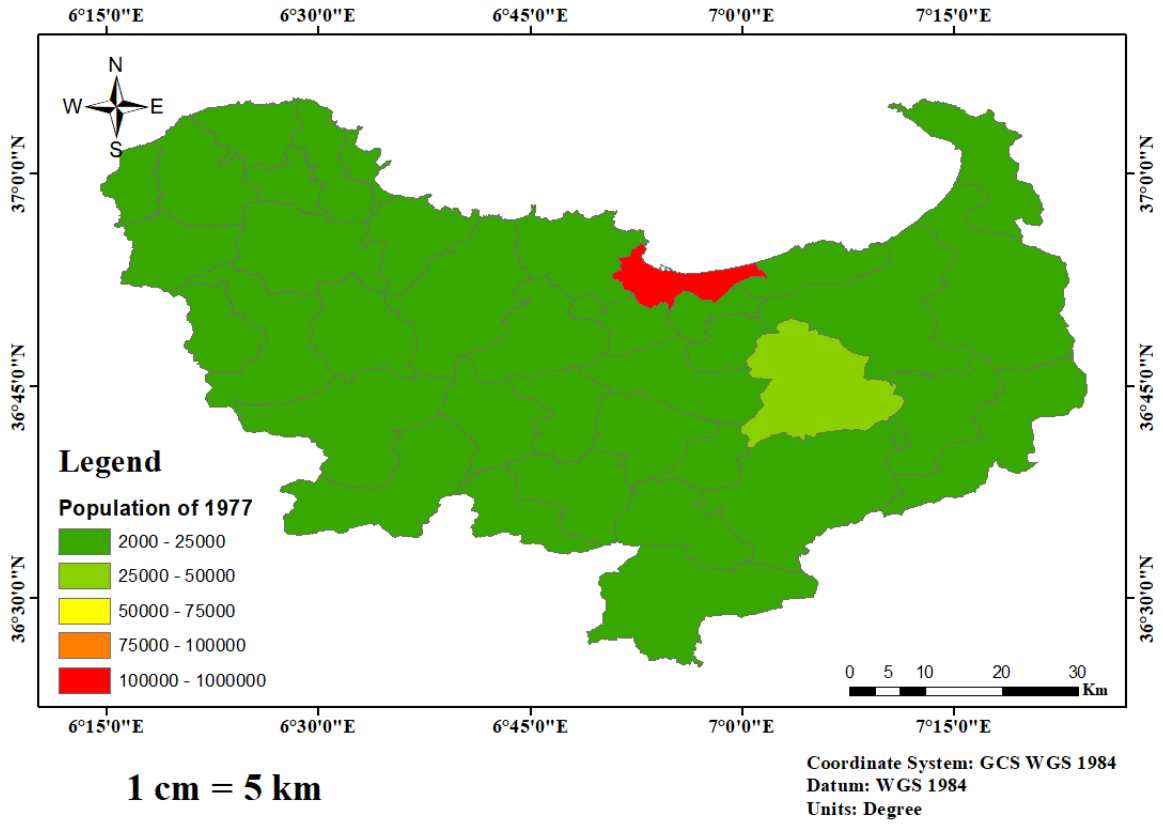

Figure 8: Distribution of population in Skikda's municipalities in 1977.

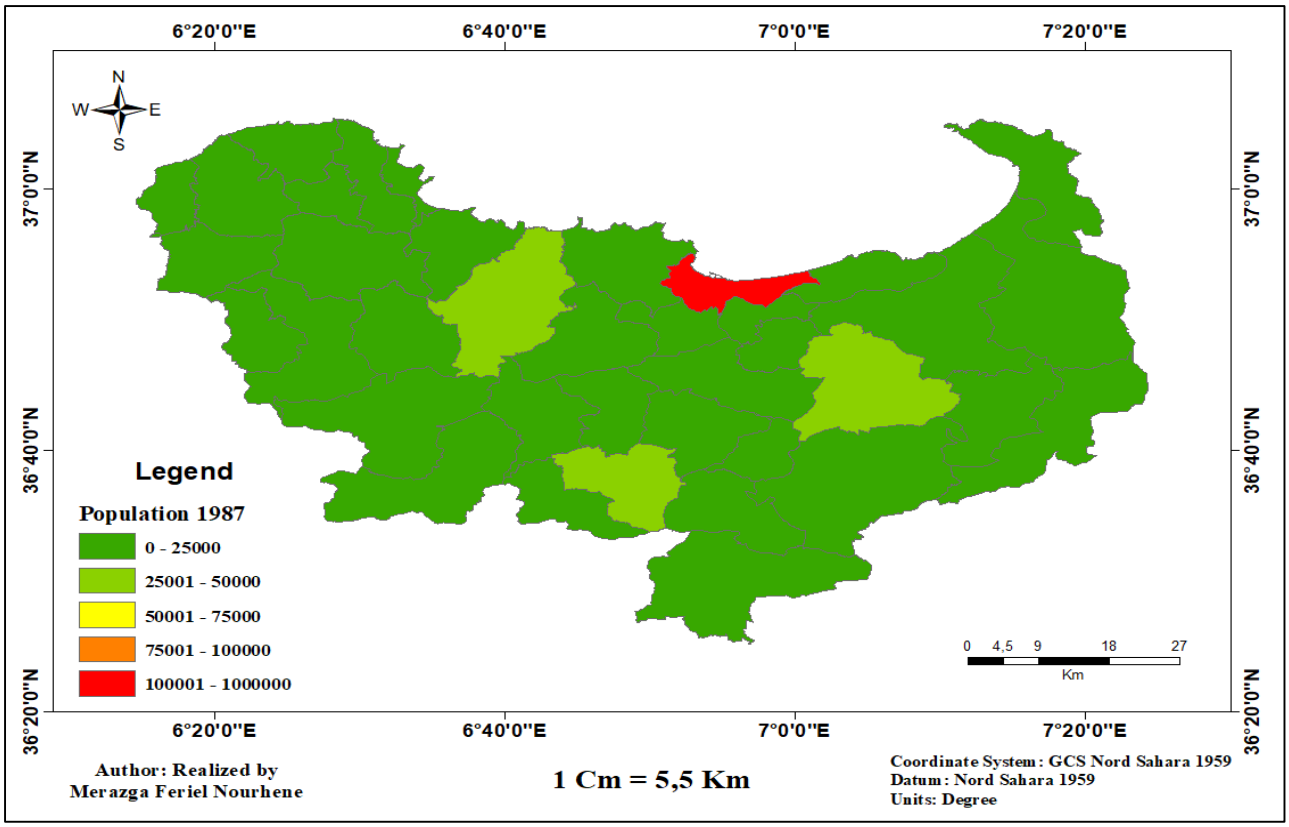

Figure 9: Population distribution map of Skikda's municipalities in 1987.

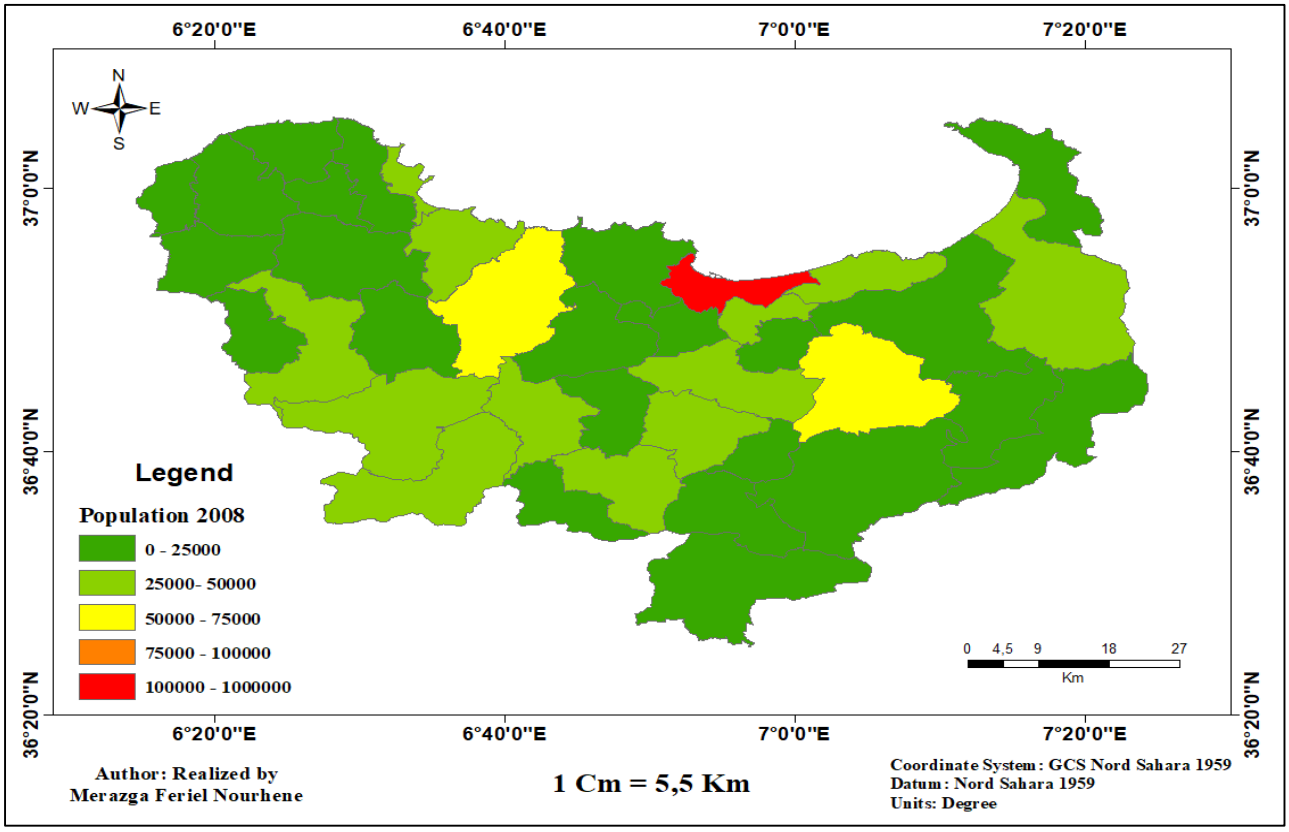

Figure 10: Population distribution of Skikda's municipalities in 2008.

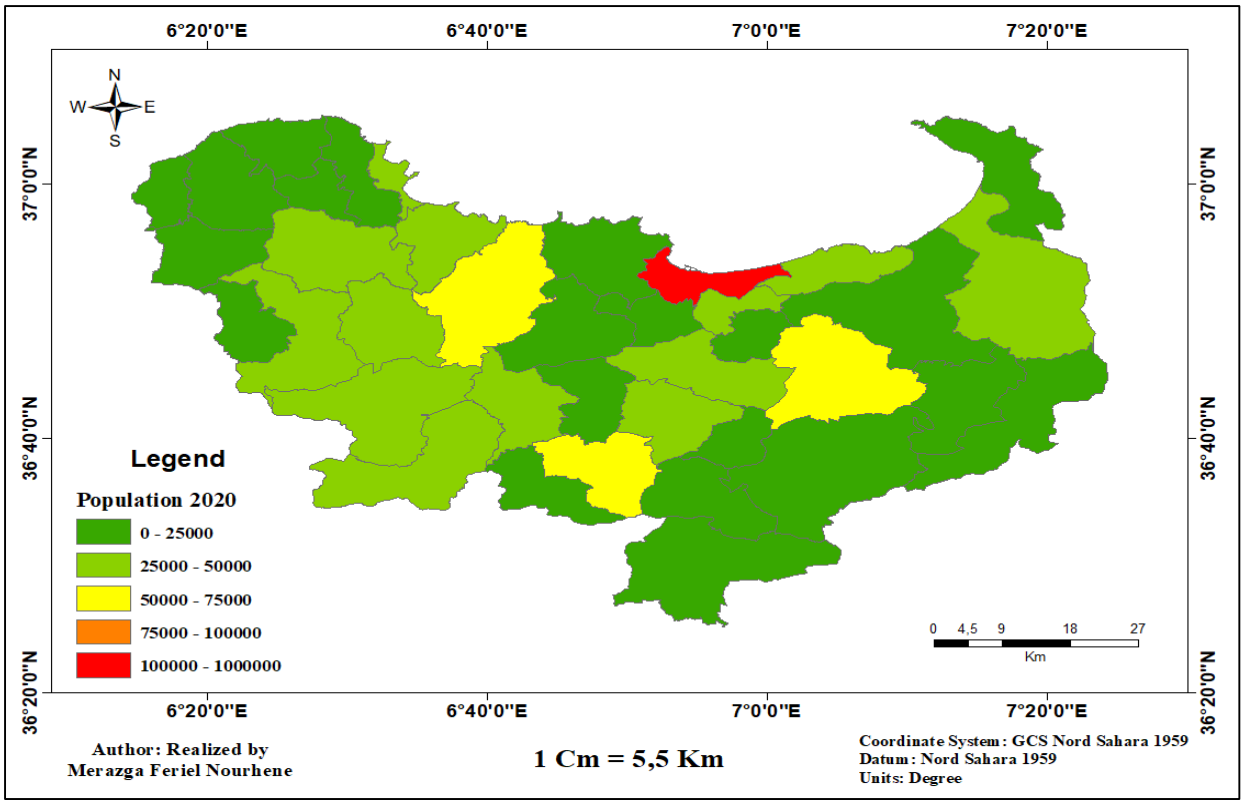

Figure 11: Population distribution of Skikda's municipalities in 2020.

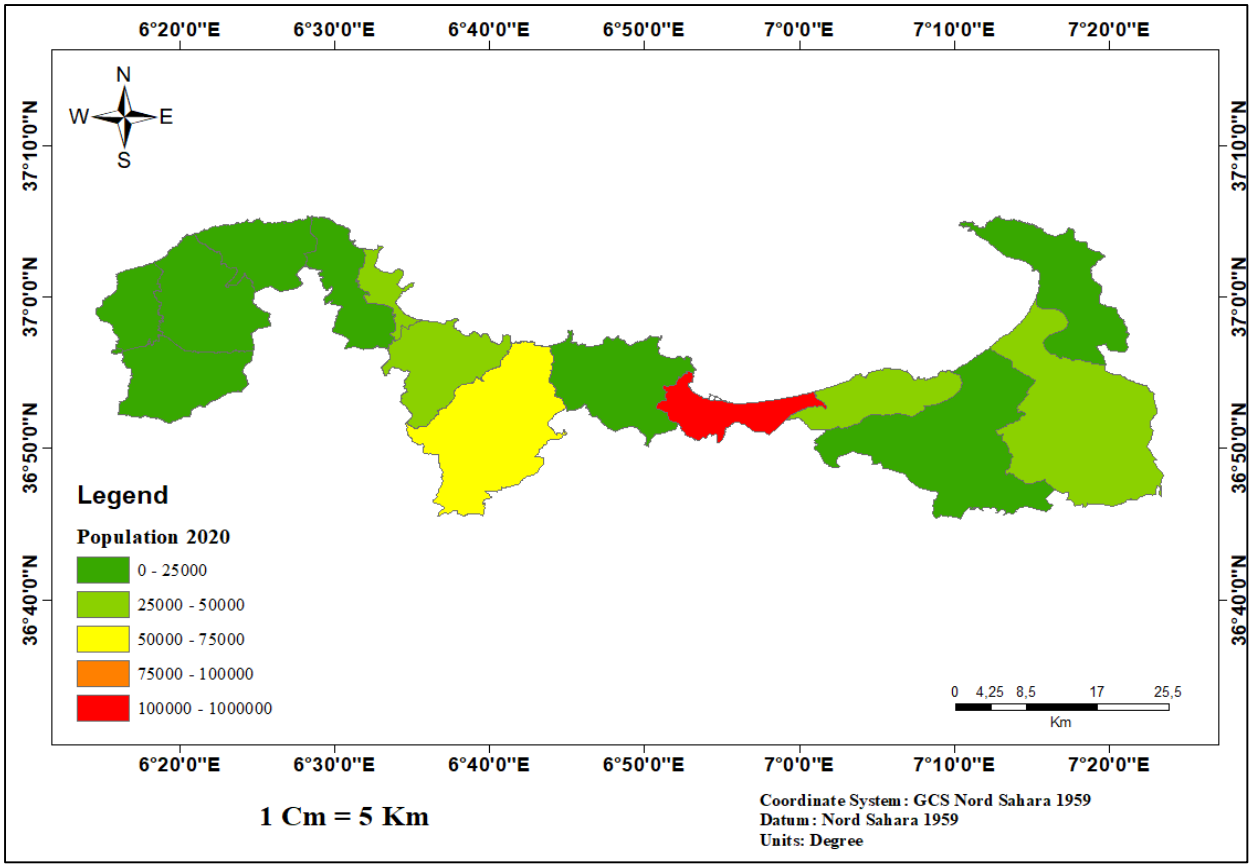

Figure 12: Population distribution of Skikda's coastal municipalities in 2020.

IV.1.1.2. Demographic evolution

- **Overall population growth**

The population of Skikda from 1977 until 2020 has tripled going through different variations in the given time.The graphs **(figure 13, 14)** demonstrates that in 1977 the population was 467600. Then, in 1988 it rose to 622510. The number kept increasing to achieve 899816 in 2008 and 1115380 in 2020.

We note that the population of coastal municipalities is about 30 % of the total one. However, the density of coastal municipalities population it's more than the total. Given that there are a lot of influencing factors:

1. Population growth: Increasing population in cities leads to higher population density.
2. Economic development: The influx of companies, commercial establishments, and industries to cities promotes economic growth and attracts more workers and residents to the city.
3. Employment opportunities: Job opportunities are one of the main driving forces for population migration to cities.
4. Housing shortage: Scarcity of housing in cities leads to increased population density.
5. Inadequate infrastructure: There may be a lack of infrastructure in cities, such as roads, schools, hospitals, and public transportation.
6. Cultural and social factors: Cultural and social factors may play a role in attracting people to cities. Cities can be centers for cultural, entertainment, and educational activities, making them attractive destinations for individuals.
7. Distribution of wealth and poverty: Unequal distribution of wealth and poverty can lead to population concentration in cities. When there are significant economic and social gaps between urban and rural areas, individuals tend to migrate towards cities in search of better opportunities.

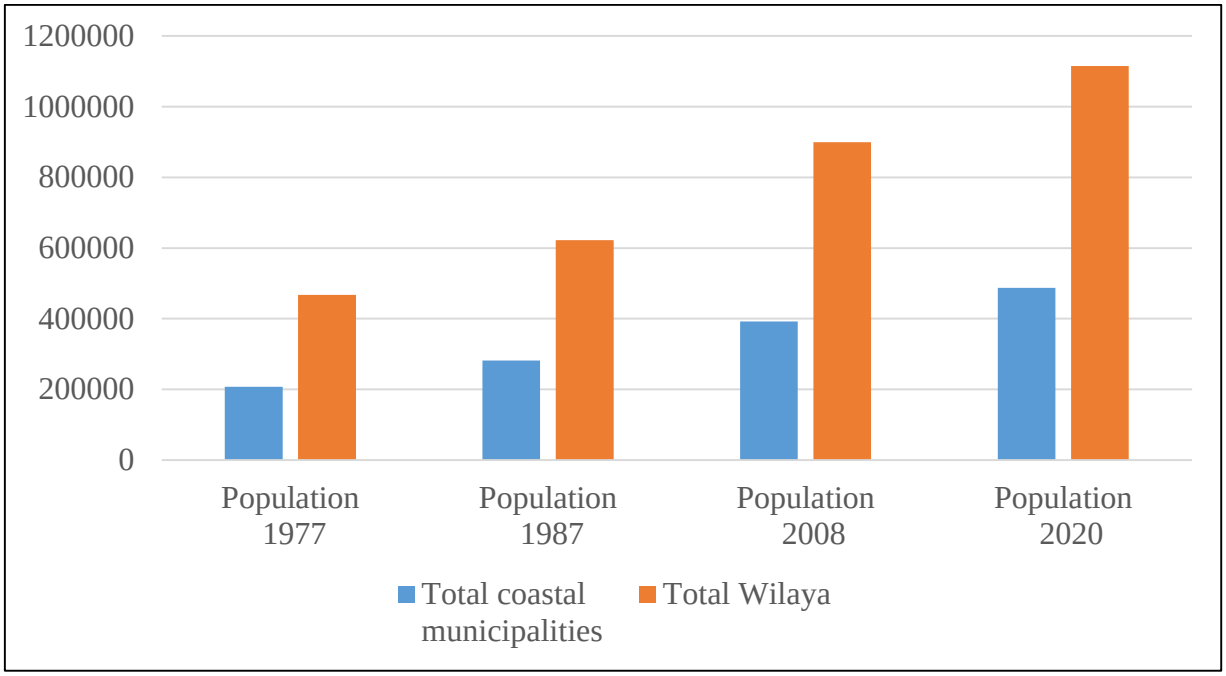

Figure 13: Total Demographic evolution of Skikda and it's coastal municipalies from 1977 until 2020.

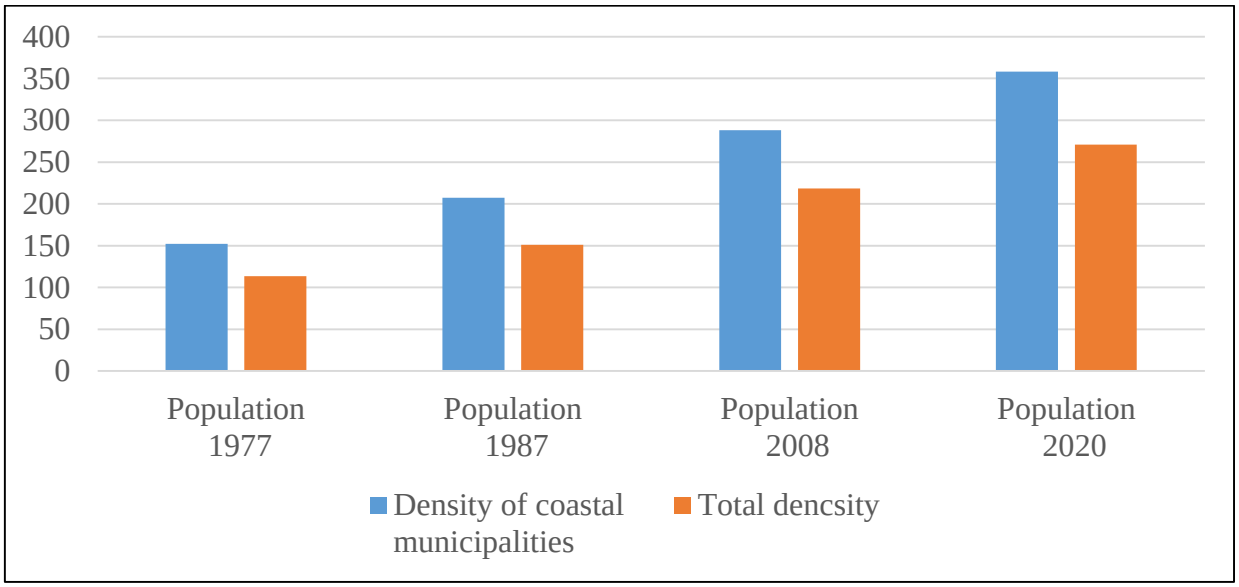

Figure 14: Total population density evolution of Skikda and its coastal municipalities from 1977 until 2020.

IV.1.2. Activities

IV.1.2.1. Unemployed population

The unemployed population of Skikda is 53,532 with an unemployment rate of 13.93%. This number represents individuals who are currently without employment in the specified context. This figure typically includes those actively seeking employment but unable to find suitable jobs.

The unemployed population of 53,532 represents the number of individuals who are currently without employment in the specified context.

This data offers valuable insights into the labor market conditions, indicating the challenges in finding employment opportunities and highlighting potential economic strains. Policymakers and economists can utilize this information to assess the state of the labor market, develop strategies to tackle unemployment, and create policies that promote job creation and overall economic growth.

IV.1.2.2. Labour force

The labour force existing in Skikda is 384,330 with an activity rate 34.46% (ANIREF. 2020). This labour forces is distributed by sector of activity 3**(figure 15).** Each slice of the pie corresponds to a specific sector, and the size of each slice represents the proportion of the labour force engaged in that particular sector.

The largest slice of the pie charts represents the sector of agriculture with a percentage of 28%, which indicates that a significant portion of the labour force is involved in these industries. Another slice is dedicated to the secondary sector, which encompasses administration activity with a percentage of 19%. A larger slice suggests a considerable presence of workers in this activity. A significant portion of the pie may be occupied by the tertiary sector, which comprises services such as retail, healthcare, education, finance, tourism, and hospitality with a proportion of 18%, which indicates a substantial presence of workers in the service sector. The quaternary sector represented by 14% in the pie chart encompasses the sector of business. The next sector of activity is industry with a percentage of 11%. Finally, the Building, Public Works, and Housing (BPH) sector, which is represented by 10% of the active population, this sector, has a real importance, which lies in its contribution to economic growth, infrastructure development, housing provision, urban planning, and the overall well-being of communities. It plays a vital role in shaping the physical, social, and economic landscapes of regions and countries.

The Examination of this pie chart is crucial for comprehending the economic framework of Skikda, identifying sectors that hold prominence, and assessing potential avenues for progress and advancement. Additionally, it aids in making informed decisions pertaining to workforce planning, policy formulation, and allocation of resources. This, in turn, facilitates the support and enhancement of specific sectors that play a significant role in the overall economy.

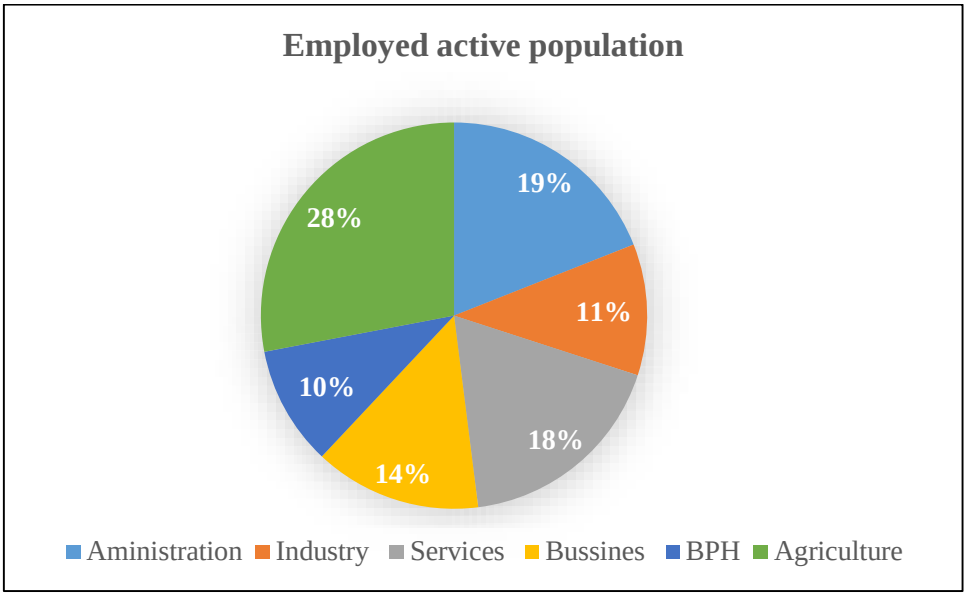

Figure 15: Distribution of the labour force employed by sector of activity (ANIREF. 2020).

IV.1.3. Tourism:

Skikda has a valuable tourism potential due to its unique location between the sea and mountains. The Mediterranean province offers numerous opportunities for beach tourism. The western part of the province is also rich in picturesque attractions such as mountains, varied vegetation, and forests in the hinterland and coastal regions.

Skikda contains also other tourist sites which are essentially composed of thermal springs and forest sites, which represent a vast potential for tourist attractions integrating a wide variety of products such as Mount El-Gouffi, Hadjar Mefrouche Forest, and Cape Bougaroune.

Additionally, the province boasts thermal springs in Ain Charchar and Azzaba. The coastal area, which includes ports, fishing, and leisure activities, spans from the outskirts of Skikda and El Marsa to Oued Z'hor and encompasses fourteen coastal municipalities.

Over eleven TEA are distributed on nine municipality **(figure 16)**. Six coastal municipalities has 11 TEA are illustrated in **(figure 17)** identified there:

- The El Marsa - Guerbes area;
- The Fil Fila area;
- The Western Skikda area;
- The Collo area;
- The Marsa Ezzitoune area.

Skikda contains also other tourist sites which are essentially composed of thermal springs and forest sites, which represent a vast potential for tourist attractions integrating a wide variety of products such as Mount El-Gouffi, Hadjar Mefrouche Forest, and Cape Bougaroune.

The consideration of TEA in the coastal vulnerability index highlights the need to strike a balance between tourism development and the protection of coastal ecosystems and natural resources. It encourages decision-makers to incorporate environmentally sustainable practices, coastal conservation, and responsible tourism management within the Tourism Expansion Zone to safeguard both the natural environment and the tourism industry.

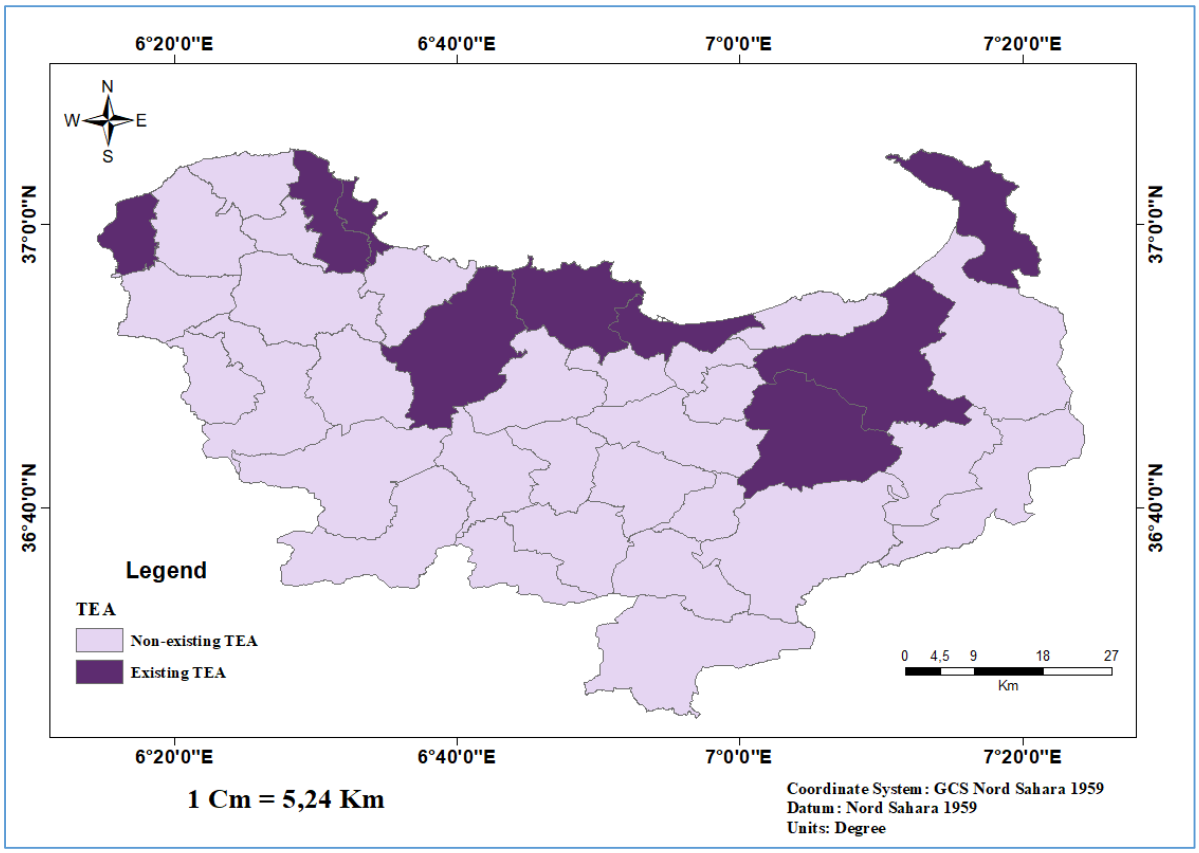

Figure 16: Map of the distribution of TEA in the Skikda's municipalities.

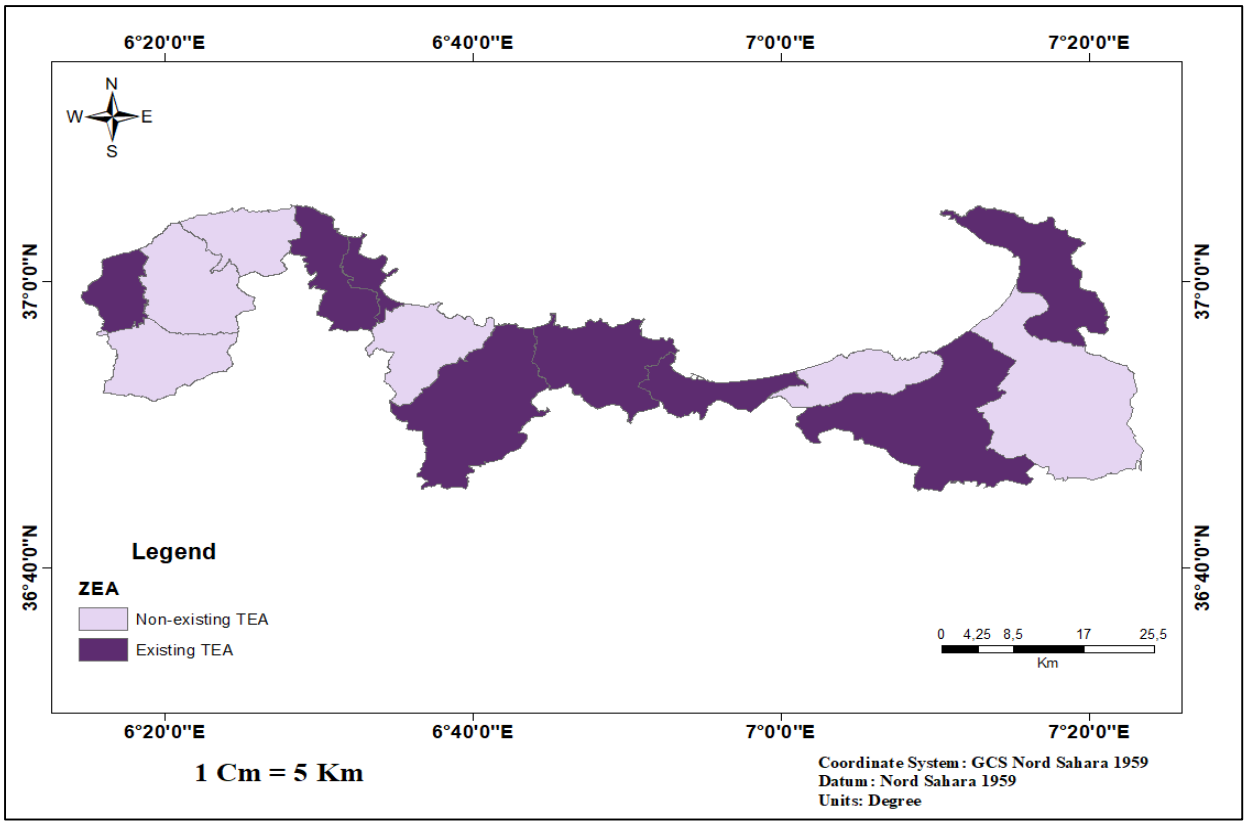

Figure 17: The distribution of TEA in The coastal municipalities Skikda.

IV.1.4. Cultural heritage

The map **(figure 18, 19)** indicates the locations of cultural heritage sites, including historical buildings, archaeological sites, monuments, museums, religious structures and other significant landmarks.

These landmarks are located on the level of 18 municipality. Three of Skikda municipalities have three historical landmarks that are Collo, ES Sebt and Ouled Hbbaba. Five of municipalities contain two landmarks that are Kerkera, Ain Zouit, Beni Ouelbane, Oum Toub and Sidi Mezghiche. Ten of municipalities have one landmark that are Ben Azzouz, Filfila, Ain Cherchar, Tamalous, Oued zhour, Ain Kechra, Zerdaza, Salah Bouchour, Ramdane Djamel and Emzedj Edchich.

Cultural heritage map provides us with a deeper understanding of the cultural richness, historical significance, and diversity within Skikda. It aids in appreciating and valuing the cultural heritage, promoting its preservation, and facilitating cultural tourism and education.

The inclusion of cultural heritage in this study acknowledges the vulnerability of these cultural sites and elements to the impacts of coastal hazards, climate change and socioeconomic changes.

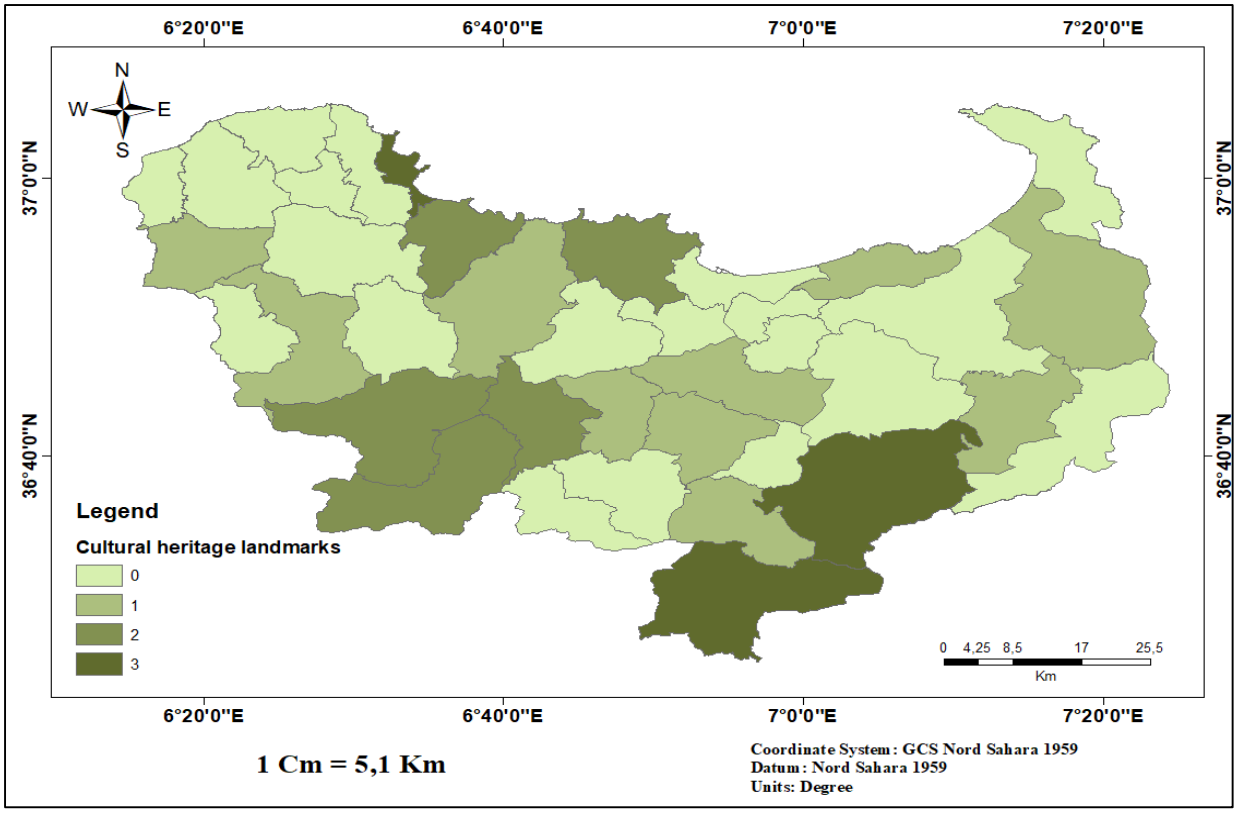

Figure 18: Map of the distribution of cultural heritage landmarks in Skikda in 2020.

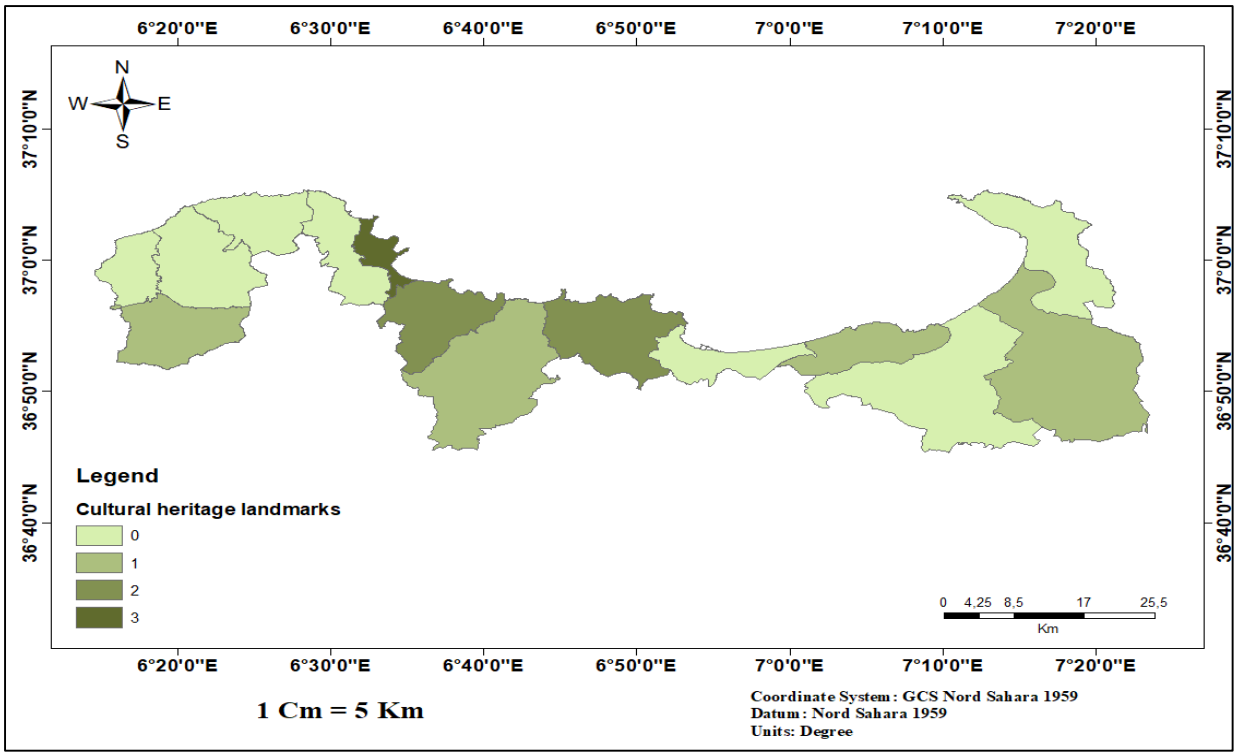

Figure 19: Map of the distribution of cultural heritage landmarks in Skikda's coastal municipalities in 2020.

IV.1.5. Industry

It should be noted that there is a significant industrial zone located along the coastline. One of the prominent areas within this zone is the Skikda petrochemical industrial zone. This national industrial hub is dominated by a complex dedicated to petrochemical production, equipped with various facilities for processing natural gas and oil. Spanning a considerable area of approximately 1195 hectares, it was established under the provisions of Decree 84/35 issued on March 3, 1984, governing the administration of industrial zones.

IV.1.5.1. Petroleum Industry Zone: refinery

The refinery is ine of the important zone for the economy of Algeria.

IV.1.5.1.1. Localization:

The refinery is located near the Mediterranean Sea (approximately 1.5 km north of the refinery). It is bordered by:

- To the north, the El Arbi Ben Mhidi city.

- To the west, an urban fabric.
- To the south, an urban fabric and other industrial sites.
- .To the east, the industrial zone.

The following image depicts the Skikda refinery in its surroundings.

IV.1.5.1.2. Purpose

The objective of refining is the transformation of crude oil into a range of finished products that can be used in various sectors such as transportation, energy, and petrochemicals. This operation concerns:

- Reception and storage of crude oil and products.
- Processing of crude oil in refining units (manufacturing of feedstocks).
- Blending of feedstocks and production of finished products.
- Quality control by the laboratory.
- Dispatch of finished products via trucks, pipelines, and ships.

IV.1.5.1.3. Storage Areas and Port Facilities

The Skikda refinery has three storage areas:

- The South Zone, which allows the storage of various products through 25 different tanks.
- The North Zone, also known as MELEX (Mixing and Shipping), which has a larger number of tanks for storing different products used on-site and for sending a portion of them, via pipelines, to the loading arms located at the port facilities.
- The East Zone, which stores various finished products.

To export a portion of its production, the refinery can transfer its products to two ports where they will be loaded onto ships using loading arms. The refinery is connected to the two ports of Skikda.

IV.1.5.2. Main industrial activities in skikda

In Addition to the petroleum industry, industrial units and quarries can also be found in the three municipalities of Skikda, Collo, and Ben Azzouz. However, it is worth mentioning that there are two quarries located outside the coastal region in the Djendel Saadi-Mohamed municipality. In the Filfila municipality, there is another quarry and a marble transformation

facility situated in Oued Ksob, both of which are also situated away from the coastal area **(figure 20).**

The following Figure depicts the main industrial activities in skikda.

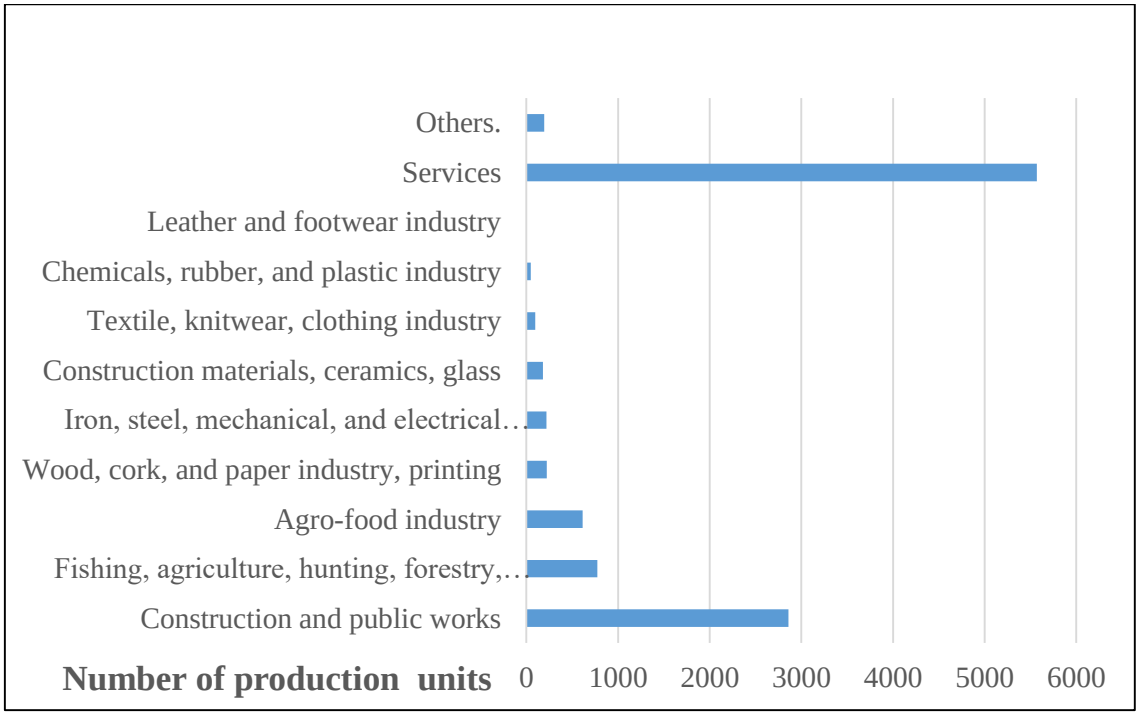

Figure 20: graph of main industrial activities in Skikda.

IV.1.5.3. Industrial zones

The only existing industrial zone in Skikda is the industrial zone of Hamrouch Hamoudi in municipality of Hamadi Krouma with a total are of 180 hectars. The number of created projects in the zone is 279 with 267 operational. It is specifically intended for industrial activities and accommodates various industrial facilities, including oil refineries, chemical plants, and other processing plants. This zone plays a crucial role in the regional economy, fostering job opportunities and economic development. However, the concentration of industrial activities also brings forth environmental concerns, such as air and water pollution. To address these issues and ensure sustainable industrial operations, measures are implemented to protect the environment and promote safety within the zone.

IV.1.5.4. Business/industrial Zones

Skikda has 23 Business/industrial Zones distributed among 23 municipalities. These infrastructures play a crucial role in economic development and the growth of industries.

Business/industrial zones attracts investments, generates employment, and foster regional development. They provide a supportive ecosystem for businesses to thrive and contribute to sustainable economic growth. The **(figure 21)** presents the designations of the zones and their area in the municipalities.

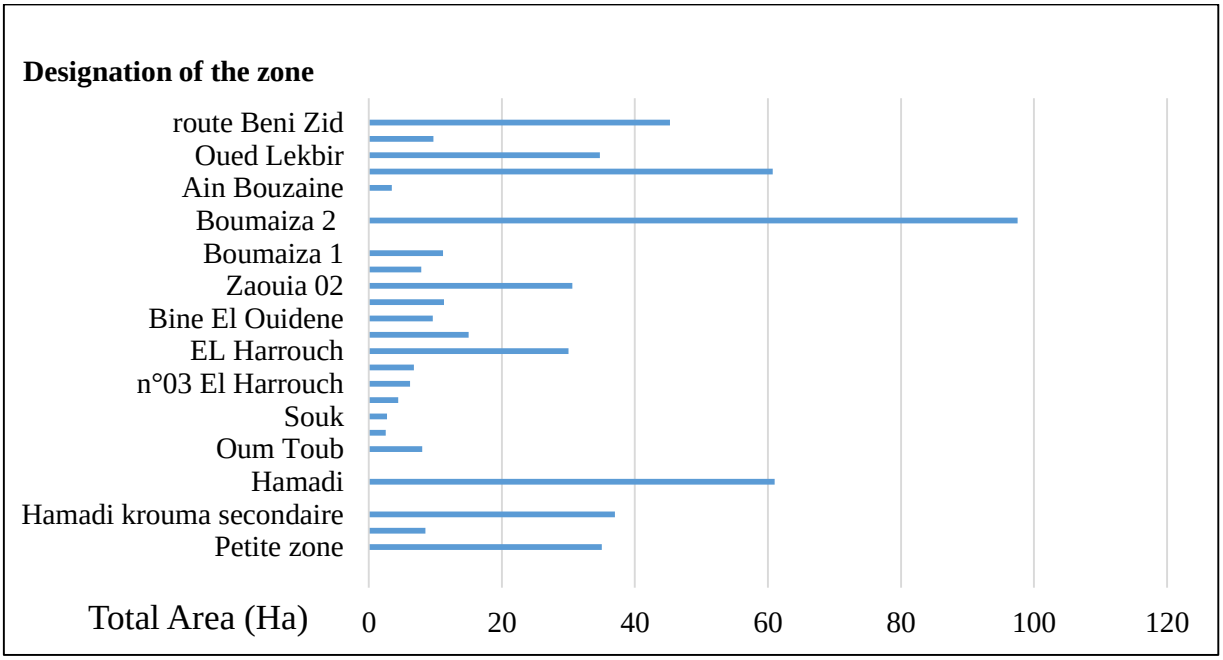

Figure 21: The business/industrial designation and their areas.

IV.1.6. Landuse

Skikda is a coastal province and a very important city for the Algerian economy. The landuse of the city increased from 1990 to 2020. Agglomerations are distributed on Collo's plain, Tamalous's plain, Saf Saf valley, Azzaba Bassan and Sanhaja plain **(figure 22).**

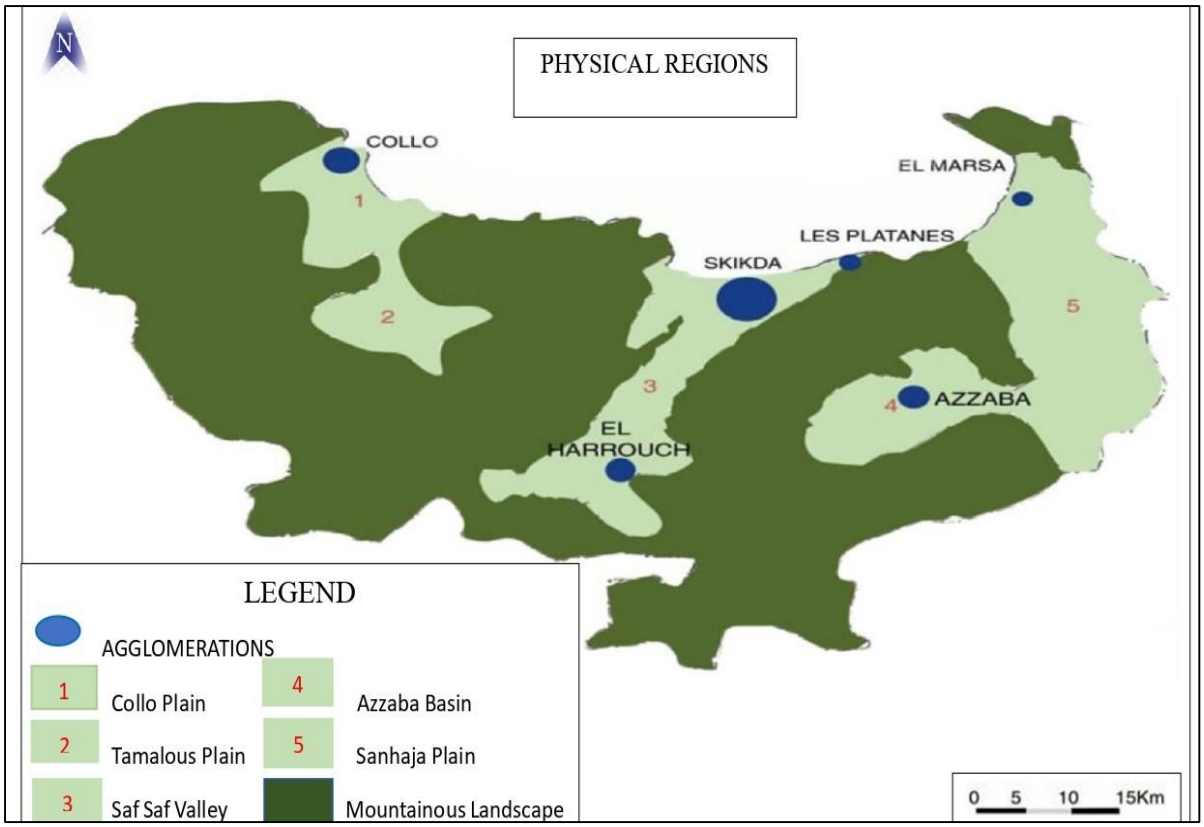

Figure 22: Localisation of physical regions.

From the given maps **(figure 23, figure 24, figure25, figure26),** we observe that the growth rate of urbanization is so important in specific municipalities. In 1990, it was concentrated in the center of the Province exactly in Skikda and Hammadi Krouma municipalities with a minimal coverage in Azzaba, Tamalous, Salah Bouchour, collo and El Harrouch. Then, in 2000, the rate stood the same except in Skikda where it rose and started to be observable in Filfila. In 2010 we notice that the rate rose in the given municipalities and started to be observable in Ramdane Djamel, Ain bouziane Ain Charchar, Ain Kechra, Oum toub, Kerkra, Es sebt, Bekouch Lakhdar, Emjez Edchiche, Sidi Mezghiche, Bouchetata, Beni ouelbane, El Ghedir. In 2020, we observe a peak in the urbanization rate in the last given municipalities and an observation of new urbanization areas the other municipalities of the province.

The Maps shows that bare lands are observable in 1990 in Ben Azzouz, El Marsa, Es sebt, Zrdaza, El Ghedir, Ouled Hbbeba, Skikda, Filfila, Djendel, Collo, Ain Kechera, Sidi Mezghiche and Oum Toub. In 2000, the rate rose in Ben Azzouz, Djendel, Oum Toub, Tamalous, Bein El Ouisene, Sidi Mezghiche, Bouchetata, Emjez Edchiche, Zerdaza, Azaba, Ouled Hbebba, Bekkouche Lakhdar and Es Sebt. In 2010, The Barelands were unobservable except in Ben

Azzouz, El Ghedir and Filfila. In 2020, barlands existed in the last municipalities and Ain Bouziane, El Marsa, Zerdaza, Djendel, Ain Cherchar, Bouchetata and Bekkouche Lakhdar.

The maps shows the localization of water bodies in the given time. In 1990, two water bodies existed in Zerdaza and Beni Ouelbane. In 2000, we observe Tree water bodies one between El Marsa and Ben Azzouz, the second in zerdaza and the th third in Oum Toub. In 2010, four water bodies are observable in Zerdaza, Bekkouche Lakhdar, Beni Zid, Beni Ouelbane. In 2020, theirwere Six water bodies in El marsa and Ben Azzouz which are barely observable, in Bekkouche Lakhdar, Beni Ouelbane, Oueldja Boulbalout and Bni Zid.

From the maps, we observe that there were changes in Forest coverage. In 1990, it was important in the coastal and few other municipalities and it rose in 2000. In 2010, we observe a decrease in Forests and kept decreasing to 2020. The maps shows that the majority of Skikda lands are covered with vegetation. The province's coverage changed through the given time because of the changes that happened in the other landuse areas such as urbanization, water bodies, bare lands and forests.

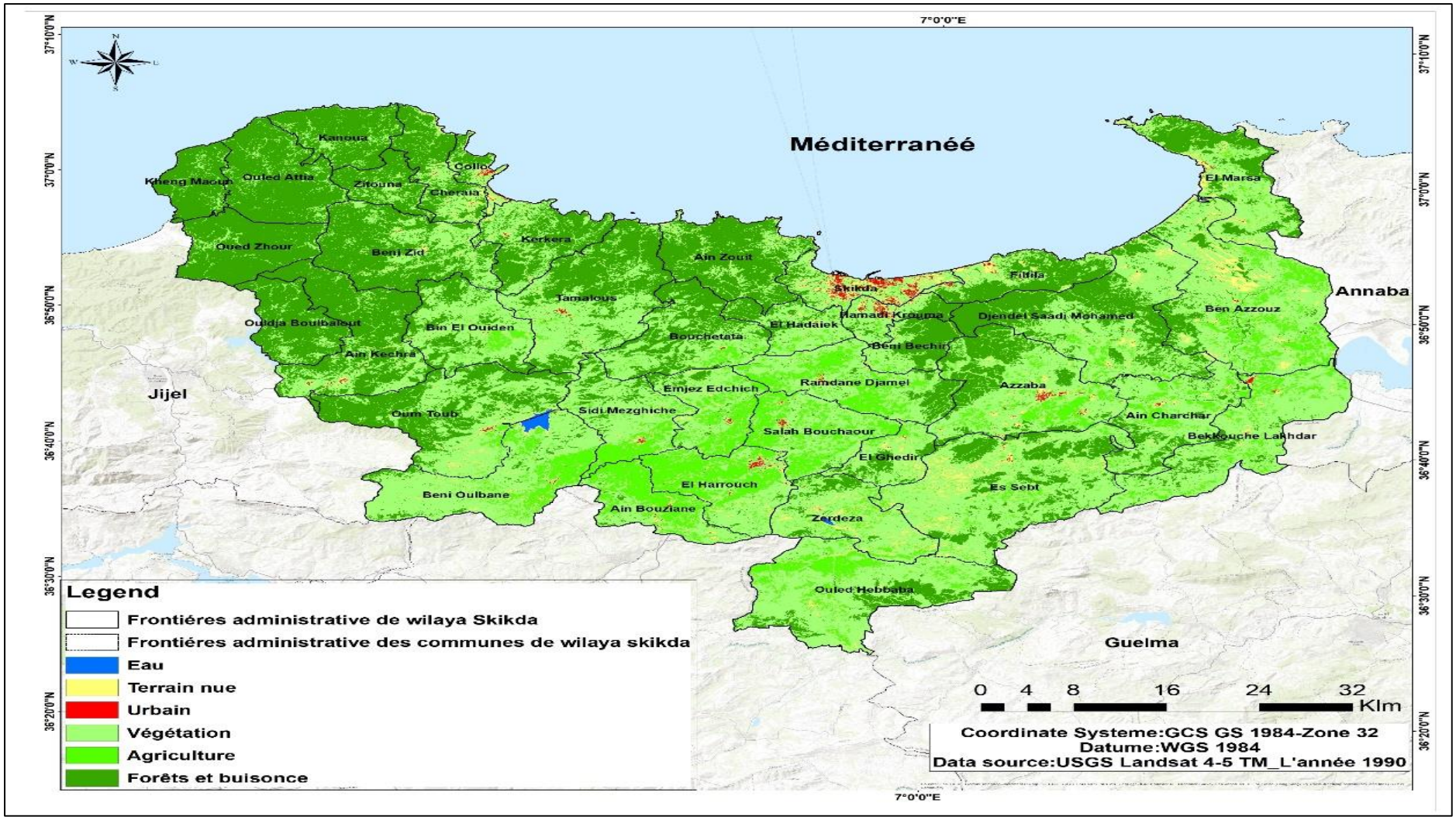

Figure 23: Map of the land use in 1990.

Figure:

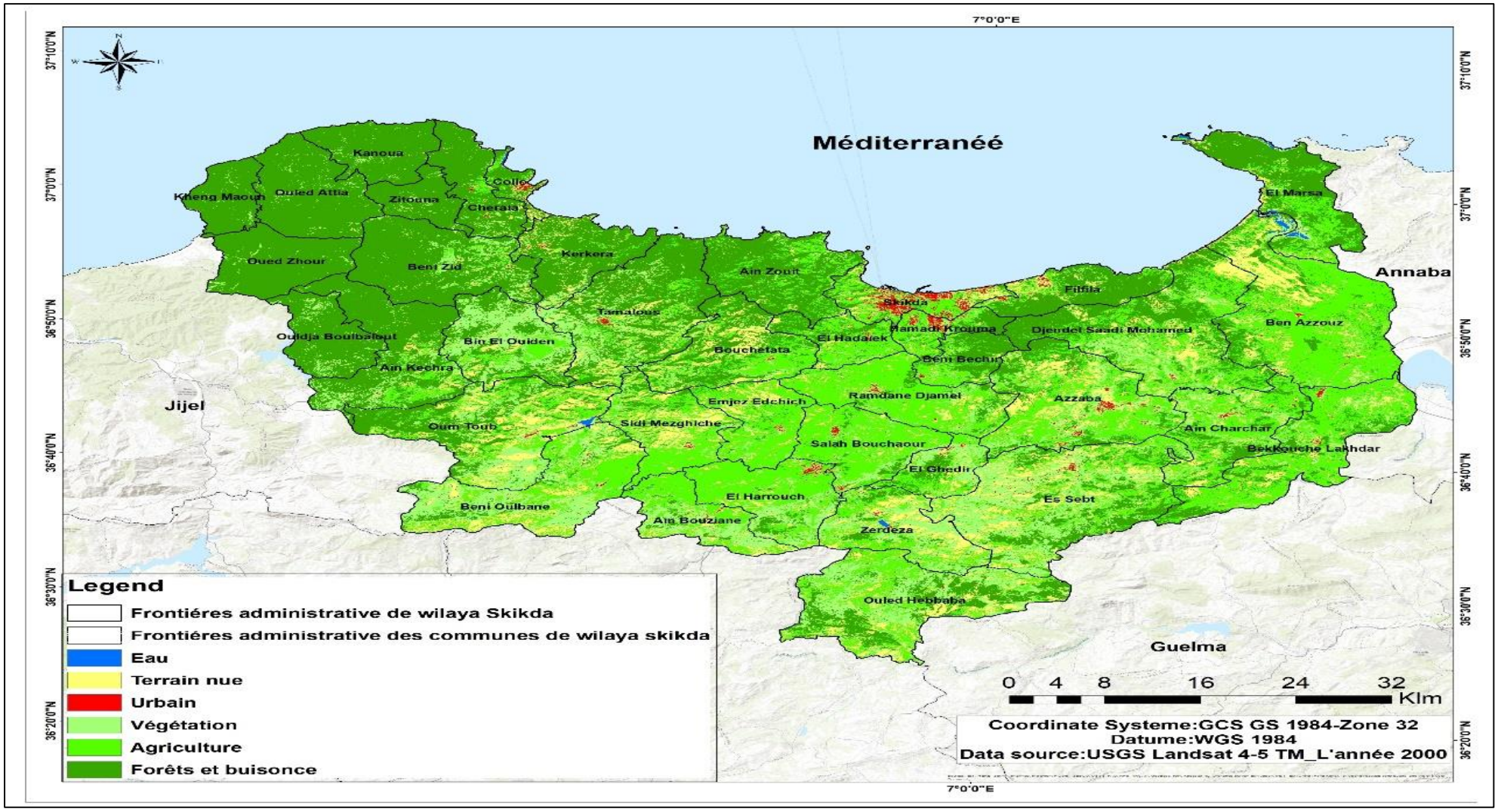

Figure 24: Map of the land use in 2000.

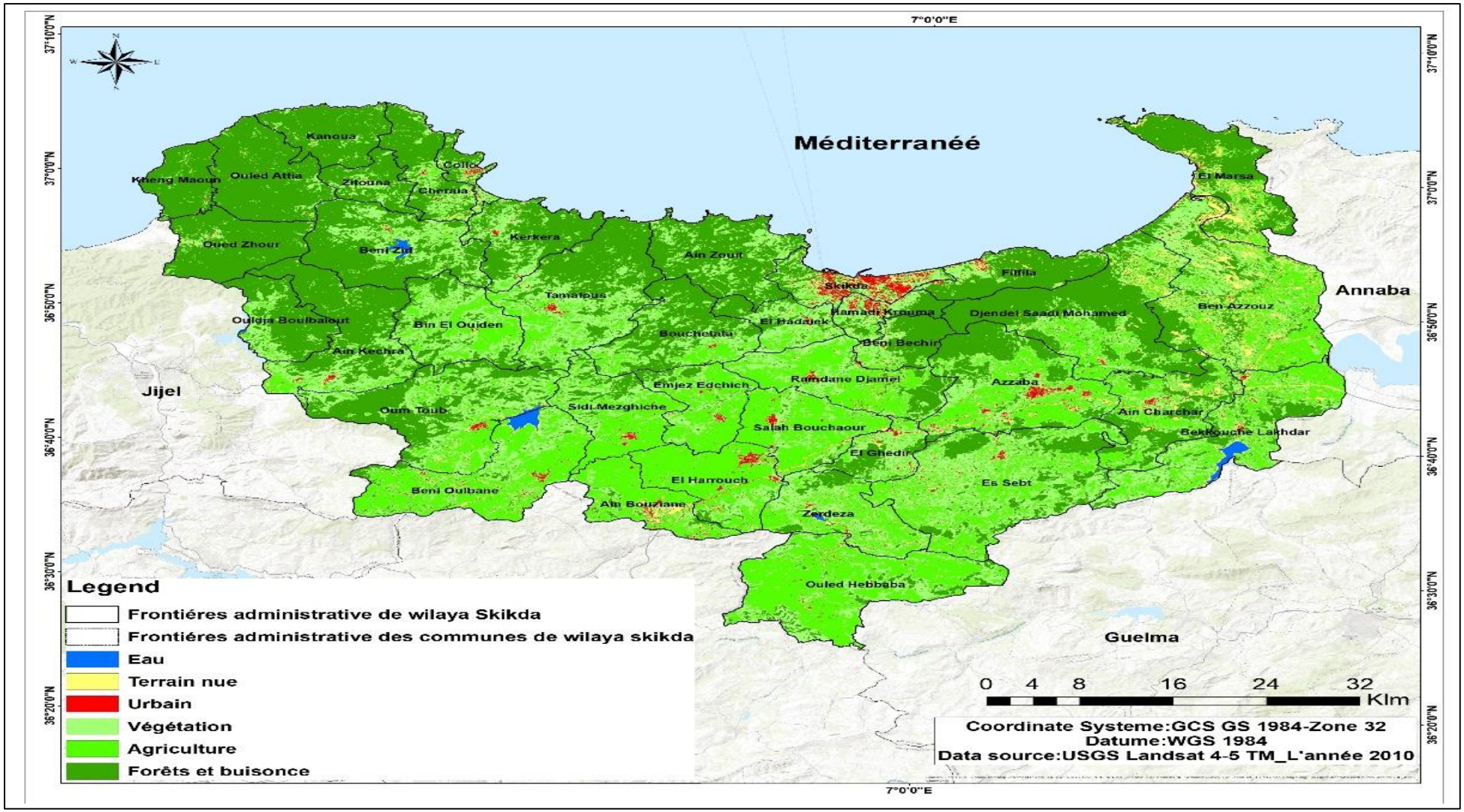

Figure 25: Map of land use in 2010.

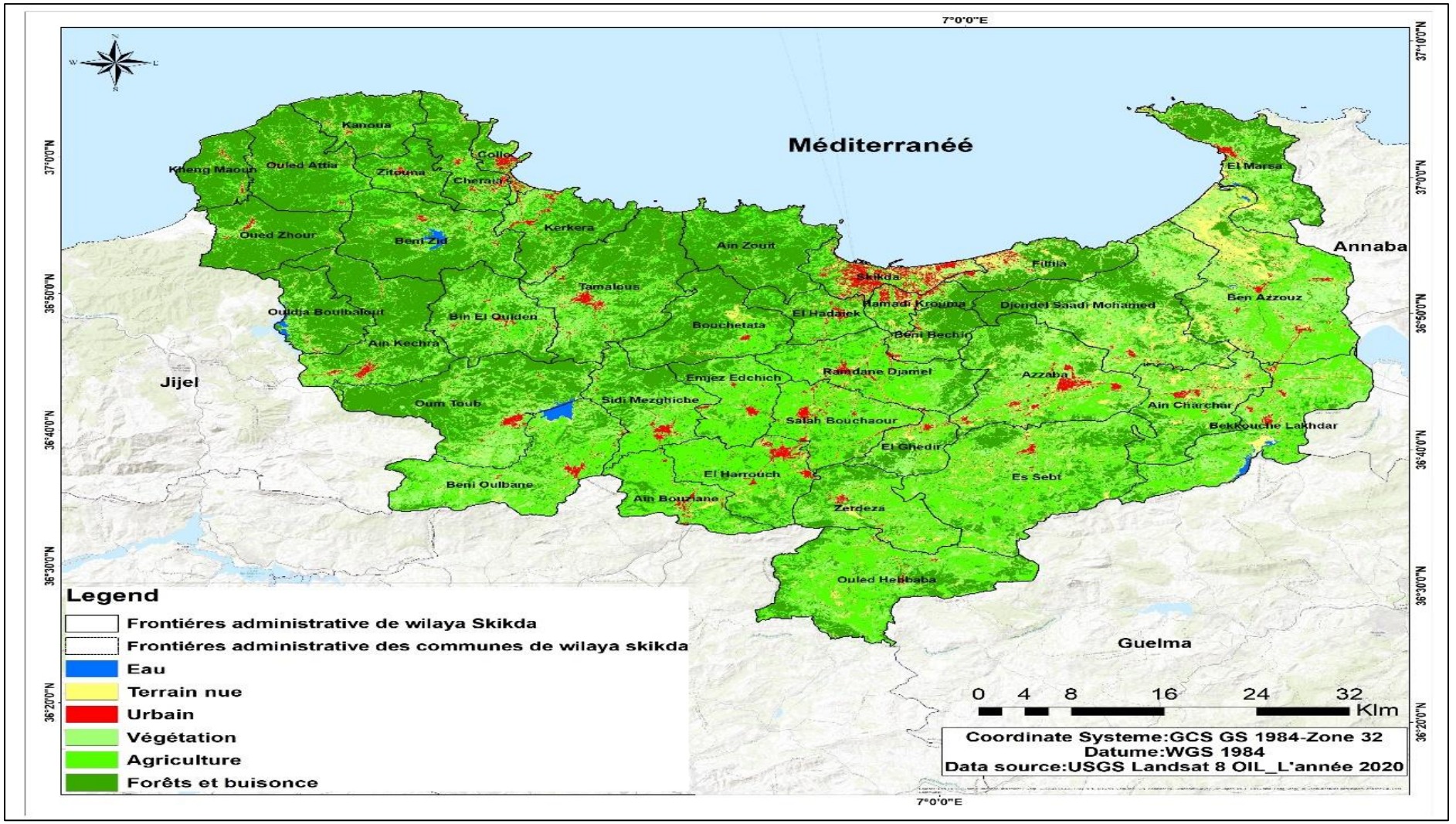

Figure 26: Map of land use in 2020.

IV.1.6.1. Agriculture lands

The graph **(figure 27)** evolution of agricultural areas in Skikda over a 32 year period from 1990 to 2022. The vertical axis represents the percentage of areas dedicated to agricultural activities, while the horizontal axis denotes the corresponding years.

According the graph **(figure27),** it is evident that there has been a decrease in agricultural areas over the given timeframe. The percentage of agricultural areas stood stable between 1990 and 2010 with approximately 31%. However, in 2022 there was a steady decline in agricultural areas, reaching a low point of 19, 8 %.

In 1990 the agriculture area in coastal municipalities was around 25000ha. However, in non-coastal municipalities it was more than 100000ha. In 2000, it rose to around 75000ha in coastal zones and decreased to around 90000ha. In 2010, the coastal municipalities presented decreased to around 25000 and around 80000 in non-coastal zones. In 2020, the areas decreased in coastal municipalities with around 10000 in coastal municipalities and 40000in non-coastal zones. This is because coastal zones have relatively smaller agriculture areas, which could be due to factors such as limited available land for agriculture along the coast.

Comparing to the total surface of the wilaya, the agriculture are is 1/4 of the total surface.

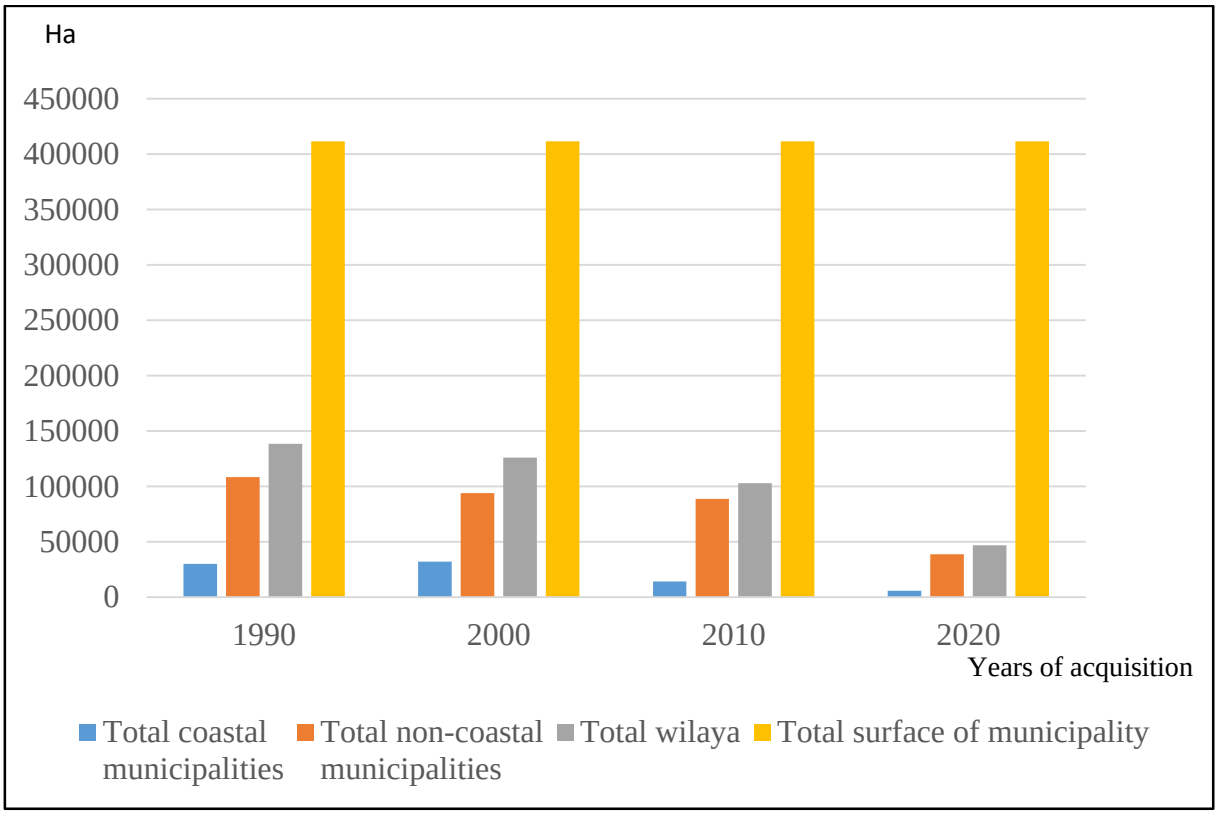

Figure 27: Distribution of Agriculture land in 1990, 2000, 2010 and 2020.

IV.1.6.2. Forests

The graph **(figure 28)** depicts the evolution of Forest lands in Skikda Province over 32 years period from 1990 to 2022. The vertical axis represents the percentage of land area covered by forest, while the horizontal axis denotes the corresponding years.

Over the course of three decades, the forest area declined from approximately 43,39% to 38,08%. In 2010, the percentage stood at a highest point of 47,98%. In 1990 and 2000, the areas had almost the same forest areas around 80000ha. In 2010, Forests rose in coastal municipalities to around 90000ha and decreased in non-coastal zones with around 65000ha. In 2020, the area decreased in coastal municipalities with around 65000ha and rose to around 80000ha in the non-coastal municipalities.

This decline can be attributed to various factors, including deforestation, the conversion of land for agriculture and urbanization, illegal logging, and natural disturbances like wildfires and diseases. The reduction in forest lands raises concerns about the loss of biodiversity, decreased carbon sequestration capacity, and disruptions to the ecological balance in Skikda.

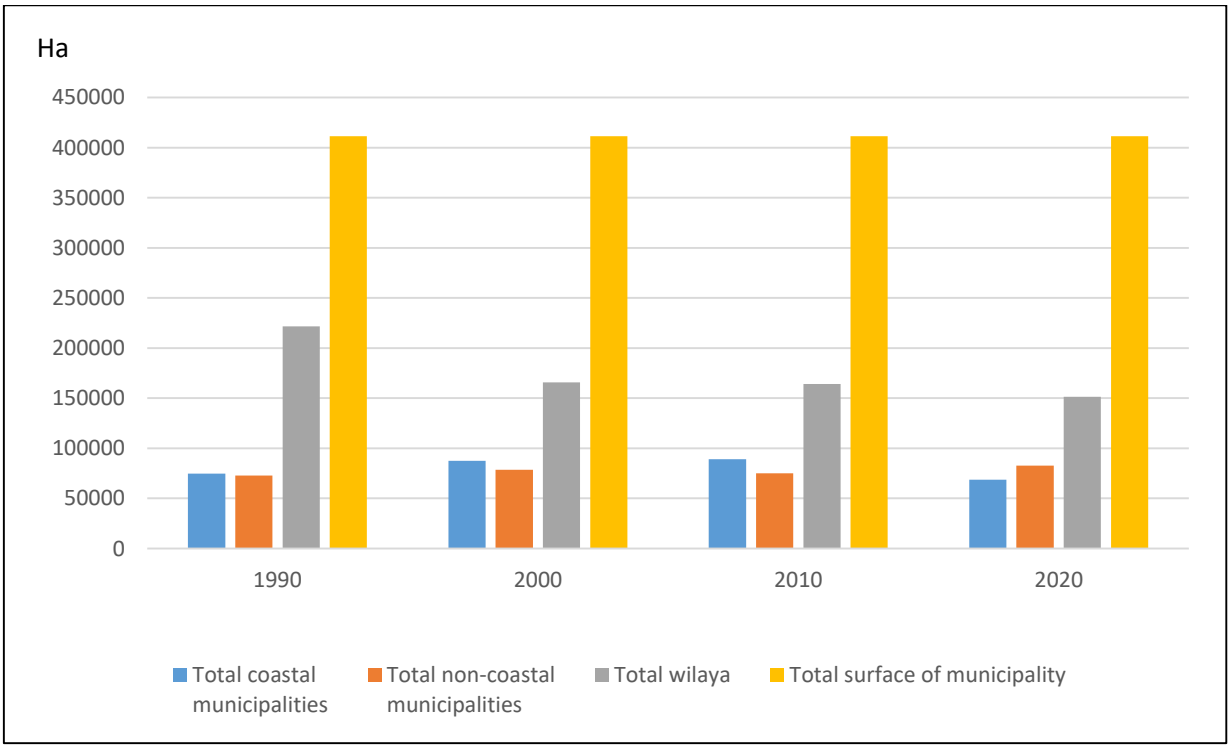

Figure 28: Distribution of Forests land in 1990, 2000, 2010 and 2020.

IV.1.6.3. Bare lands

The graph **(figure 29)** illustrates the changes in forest lands within Skikda from 1990 to 2022, revealing a decrease in their extent. In 1990, the percentage of bare lands stood at its highest point with 12, 35%. However, in 2000 and 2010 it stood approximately at 10%. In 2022, the percentage of bare lands rose to 11, 07%.

Bare lands rose from 1990 to 2020.In 1990 it was approximately

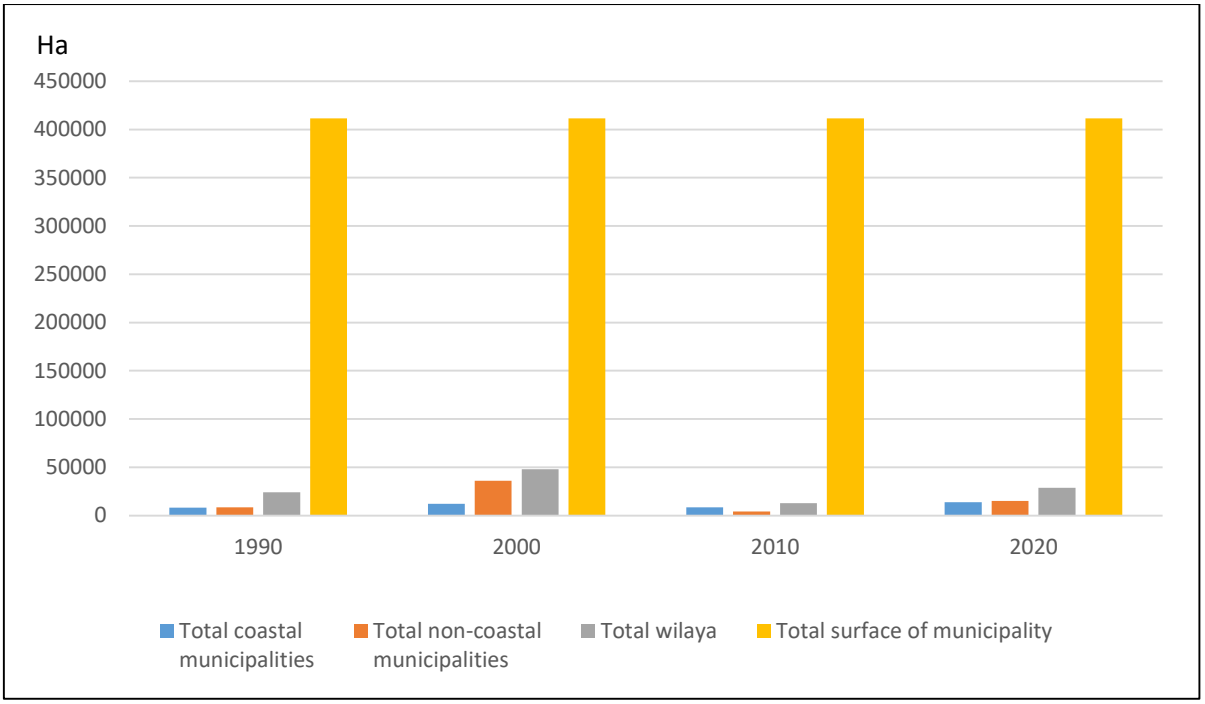

Figure 29: Distribution of bare lands in 1990, 2000, 2010 and 2020.

IV.1.6.4. Urban lands

The graph **(figure 30)** depicts the changes in urban land expansion in Skikda from 1990 to 2022, revealing a significant increase in urban coverage. Over the 32 year period, the urban land area grew from approximately 0, 74% to around 4, 67%.

This growth can be attributed to factors such as population growth, economic development, and urbanization trends. The city experienced substantial residential, commercial, and infrastructure development, resulting in the conversion of rural and undeveloped areas into urbanized zones.

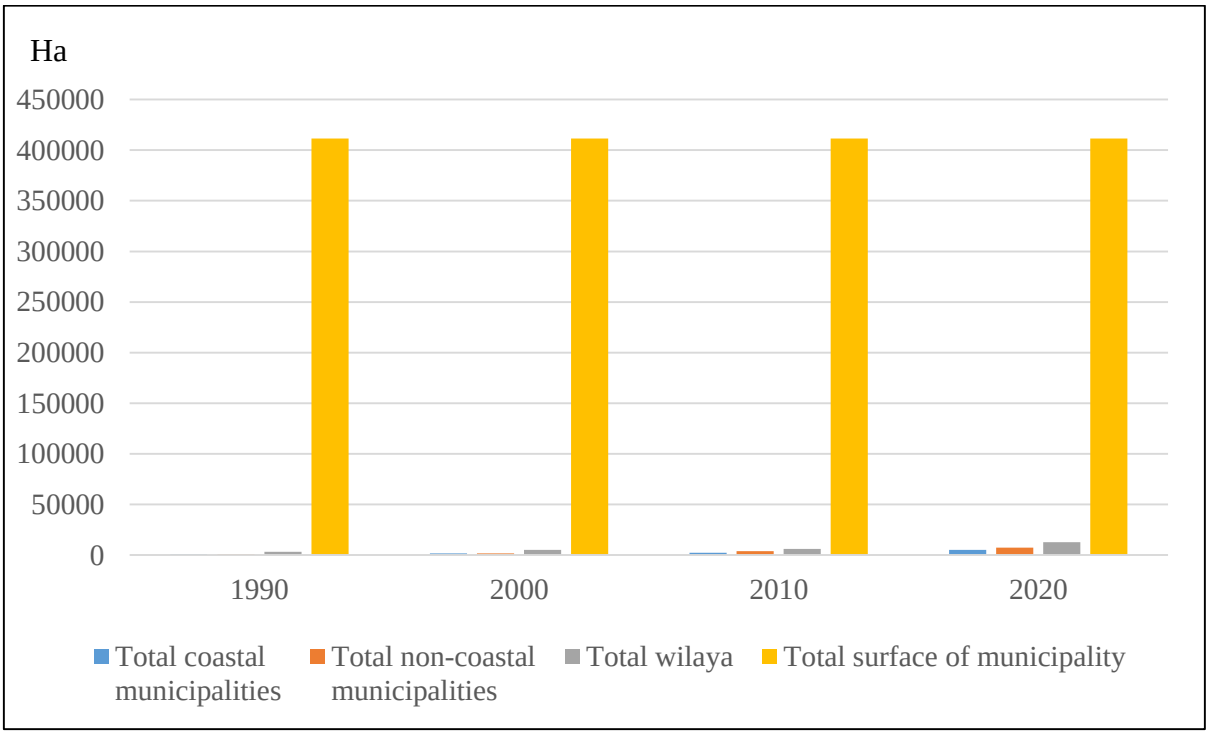

Figure 30: Distribution of urban lands in 1990, 2000, 2010 and 2020.

IV.1.6.5. Vegetation

The graph **(figure 31)** depicts the evolution of vegetation cover in Skikda province over 32 year period from 1990 to 2022. The vertical axis represents the percentage of land area covered by vegetation, while the horizontal axis denotes the corresponding years.

From the graph it is evident that there has been a decrease in vegetation cover over the given timeframe. In 1990 the vegetation cover was 28, 92% which is the highest point in the given timeframe, indicating a relatively healthy and plant presence in the area. Then, in 2000 the vegetation cover decreased to 20%. In 2010, there was a steady decrease in vegetation cover, reaching a low point of around 5%. However, the vegetation cover stood at approximately 26% in 2022.

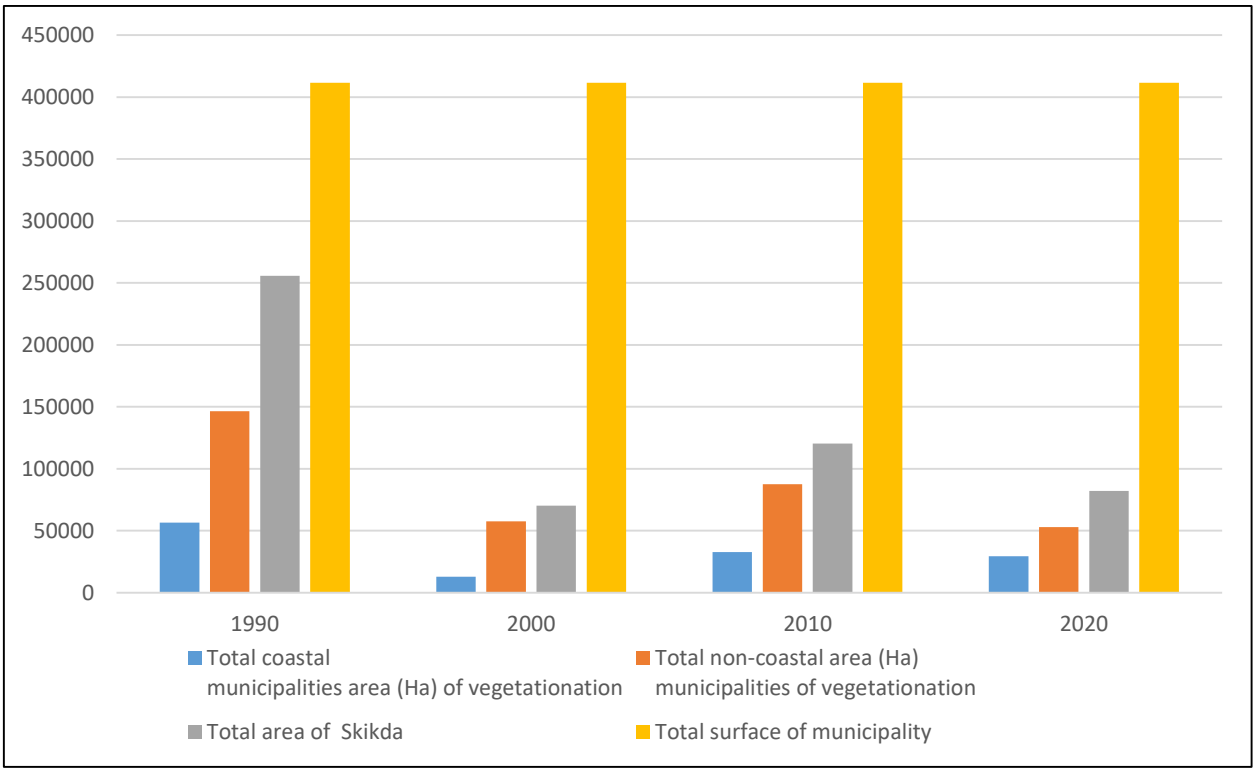

Figure 31: Distribution of vegetation land in 1990, 2000, 2010 and 2020.

IV.1.6.6. Water bodies

According to the graph **(figure 32)** showcasing the evolution of water bodies in Skikda over a 32 year period from 1990 to 2020. The vertical axis represents the surface area percentage of water bodies, while the horizontal axis denotes the corresponding years. It is evident that there has been a notable upward trend in the surface area of water bodies over the given timeframe. In 1990, the percentage of water bodies was 0, 1% and in 2000 it reached the low point with 0,03%. However, in 2010 the water bodies existing in the area reached the highest point with 0,32%. In 2022, the percentage stood at the point of 0, 22%

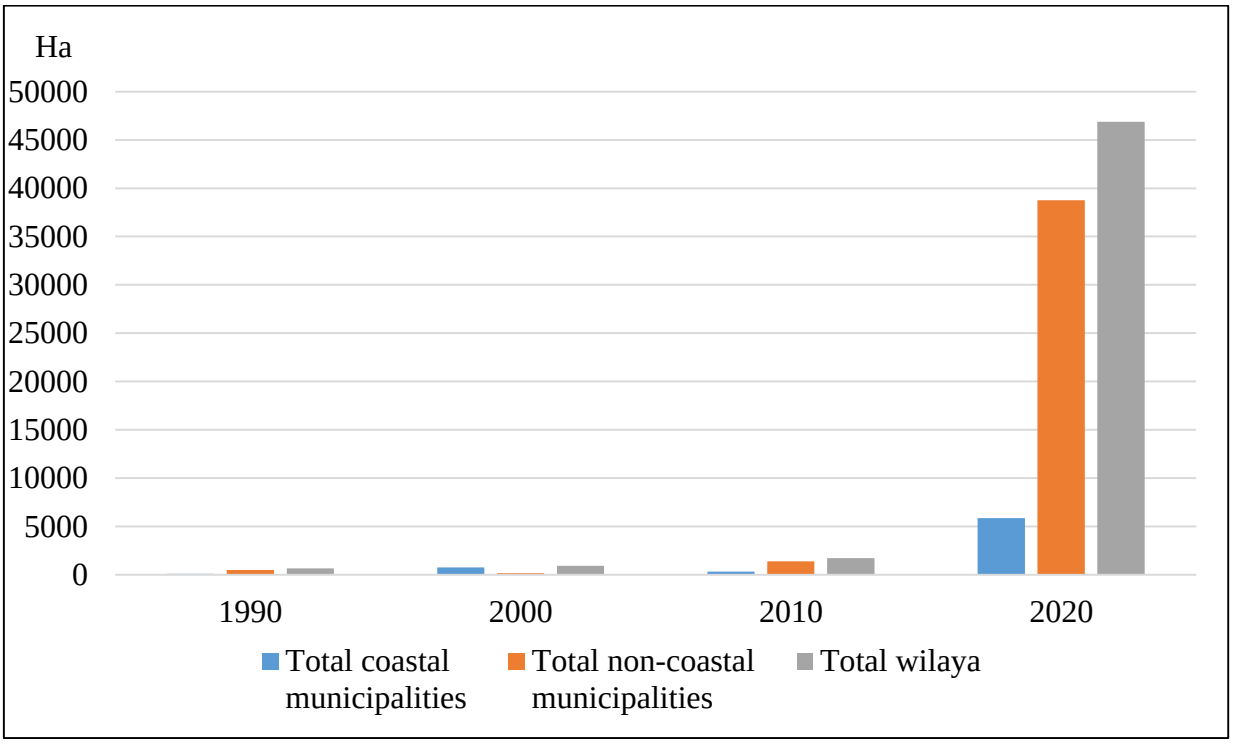

Figure 32: Distribution of water bodies in 1990, 2000, 2010 and 2020.

According to the graph **(figure 33)** we have the evolution of land use variables in the years 1990, 2000, 2010, 2010.

In the total surface of the wilaya agricultural lands, forest and vegetation areas show a gradual decrease over the last three decades; secondly, urban areas and bare lands show a gradual increase over the period. These trends imply that a considerable portion of agricultural land, forest and vegetation were occupied by urban and bare lands in the study area in the past 30 years. Another important cause of this remarkable decrease which present a threat on the environment of the municipality is the changes in precipitation patterns resulting from climate change led to increased rainfall in certain municipalities. This surplus of water contribute to the formation or expansion of natural or artificial water bodies within non-coastal areas.

What can be clearly seen in coastal municipalities in **(figure 33)** is the steady decline of agriculture area from 35000 Ha in 1990 to 5000 Ha in 2020. The area of forest experienced a slight increase between 2000 and 2010, followed by a continual decrease to 60000 Ha in 2020. In contrast, there was a sharp decrease in the area of vegetation lands in 2000 from 52000 Ha in 1990 to 10000 Ha in 2000. The area of urban lands experienced a slight increase in 2020.

Changes in land cover were also observed for all classes in non-coastal municipalities between 1990 and 2020. It is evident that the agriculture area, vegetation lands area, and forest area have undergone a significant decline, with nearly half of their previous total areas being lost over the course of the last three decades.

The urbanization of agricultural areas and the deforestation leads to decry the agricultural capacity and loss of forests and their biodiversity. As cities expand, they encroach upon fertile agricultural regions, reducing the available land for food production. This conversion disrupts the agricultural supply chain, leading to a decrease in agricultural capacity. The loss of biodiversity can disrupt natural processes, such as pollination and seed dispersal, which are crucial for the functioning of ecosystems.

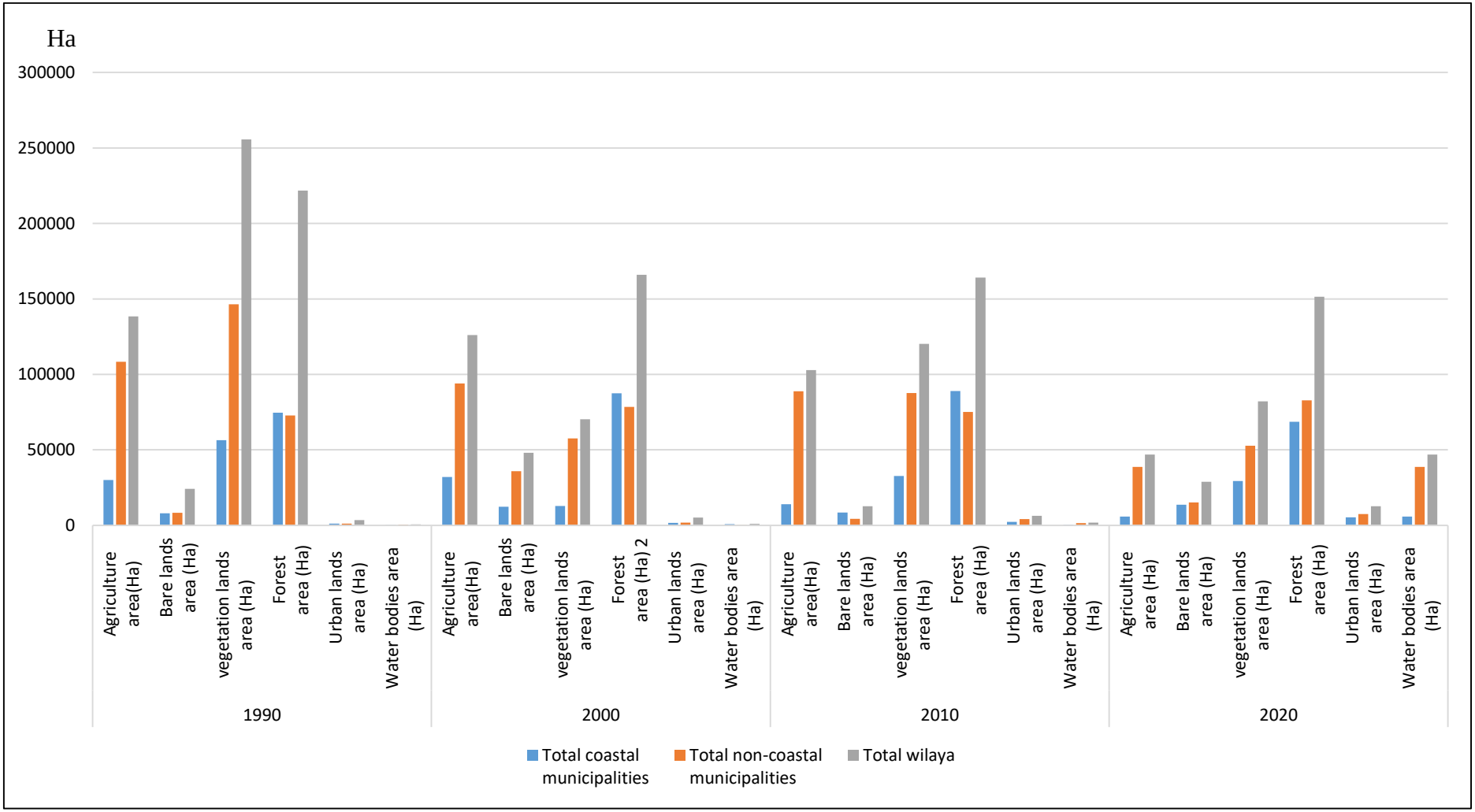

Figure 33: Total Land use in 1990, 2000, 2010 and 2020.

IV.1.7. Synthesis on pressure

The **(figure 34)** illustrates the socioeconomic natural and anthropogenic pressure on the coastal municipalities of Skikda. The presence of several pressures on the coast al zone contributes to coastal vulnerability.

The presence of industrial zones which often release pollutants, such as chemicals, heavy metals, and wastewater, into coastal. These discharges can degrade water quality, harm marine life, and disrupt the ecological balance of coastal ecosystems. Besides, industrial zones release pollutants in soil which leads to soil pollution and destruction of agriculture lands.

The Development of commercial activity zones, such as factories and coastal infrastructures has a crucial importance in the economic development of the province. However, it can cause habitat destruction, alter natural sedimentation processes, and contribute to erosion and habitat fragmentation.

Desalination facilities produce concentrated brine as a byproduct, which is often discharged into coastal waters. The release of this brine can modify the salinity of the water, influence marine organisms, and disrupt local ecosystems. Additionally, the intake and outflow of water for desalination and purification processes can have consequences for coastal water quality, including shifts in temperature, salinity, and nutrient levels, potentially affecting marine life and coastal ecosystems.

Aquaculture farms located in coastal zones can pose risks of disease outbreaks among the farmed species. The use of antibiotics, chemicals, and excessive feed in these farms can contribute to the pollution of coastal waters, potentially causing harm to both wild populations and coastal ecosystems. Additionally, escaped or released farmed species have the potential to interbreed with wild populations, leading to changes in the genetic diversity and ecological dynamics of coastal ecosystems.

Agricultural activities, which involve the application of fertilizers and pesticides, have the potential to contribute to the runoff of nutrients and the pollution of coastal waters. The presence of excessive nutrients can give rise to harmful algal blooms, oxygen depletion, and the degradation of marine ecosystems. Furthermore, agricultural practices may necessitate the conversion of natural coastal habitats, resulting in the loss and fragmentation of these habitats.

Ports Dredging and Channelization have the potential to disturb the natural movement of sediment and modify the shape of the coastal area, resulting in shifts in water currents, erosion, and patterns of sediment deposition.

The growth and development of tourism areas in coastal regions present a risk to the well-being of the coastal environment such as coastal habitats like dunes, mangroves, and coral reefs. This habitat loss not only results in the decline of biodiversity but also disrupts vital ecological processes.

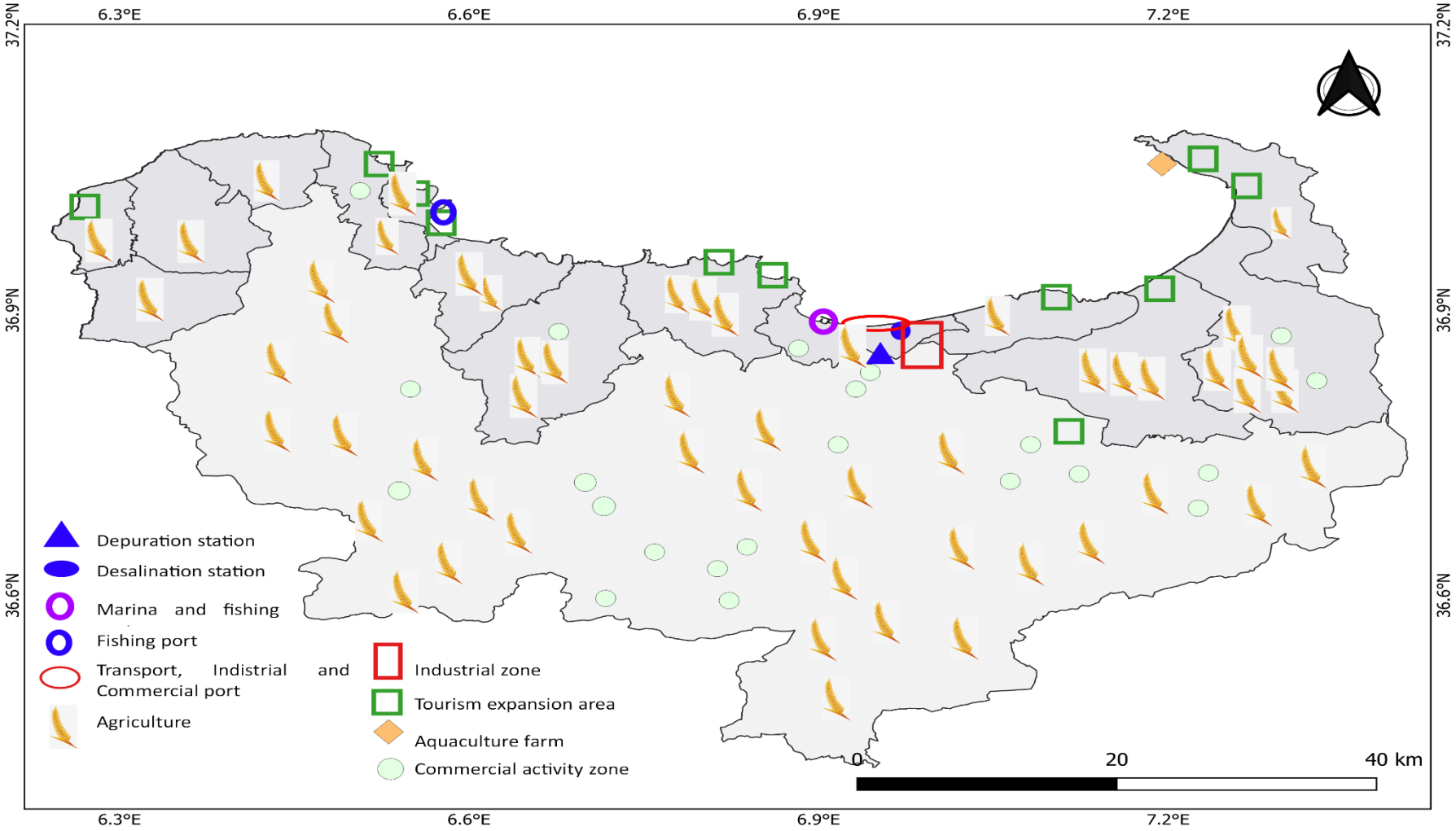

Figure 34: Map of natural and anthropogenic pressures on the coastal zone of Skikda

IV.2. Assessment of coastal vulnerability to erosion

A ranking of coastal vulnerability to erosion has been conducted on a scale of 5. In this study we chose the ranking of coastal erosion vulnerability of (McLaughling et al. 2010). Include Non-Vulnerable Areas (1), Low-Vulnerable Areas (2), Moderately Vulnerable Areas (3), Vulnerable Areas (4) Highly vulnerable Areas (5). Five vulnerability classes account for the entire coast of Skikda, as shown in **(figure 35).**

According to the mapS **(figure 35, 36, 37, 38)** there is more highly vulnerable areas on the east coast, especially in Djendel Saadi Mohamed, Benazouz and El Marsa in addition to Kerkera in the west coast. All remaining municipalities are generally considered to be in the moderate class.

The differences of vulnerability classes are described as follows:

1. Non-Vulnerable Areas presented in green: They represent coastal regions that are relatively resilient to erosion and coastal hazards. These areas have natural protective features such as stable beaches and dunes that mitigate erosion risks, non-vulnerable areas are less likely to experience significant coastal erosion.
2. Low-Vulnerable Areas presented in light green: Low-vulnerable areas exhibit a slightly higher degree of vulnerability compared to non-vulnerable areas. While erosion and coastal hazards are not as severe as in more vulnerable zones, there might be occasional localized erosion or vulnerability during extreme weather events, the overall risk level is still relatively low, and the impacts are generally manageable.
3. Moderately Vulnerable Areas presented in yellow: Moderately Vulnerable Areas may experience more frequent erosion events, higher erosion rates. Coastal management strategies and mitigation measures are often required to reduce the risks associated with erosion and coastal hazards. The majority of the coastal zone of Skikda is moseratly vunerable.
4. Vulnerable Areas presented in orange: Vulnerable areas are characterized by a high degree of susceptibility to coastal erosion and hazards. They face significant erosion rates. They are characterized by densely populated areas, critical infrastructure, making them more vulnerable to the impacts of erosion.
5. Highly Vulnerable areas presented in red: experience significant erosion rates, resulting in the loss of coastal land over a relatively short period. The erosion and degradation of these habitats not only impact their biodiversity and ecological functions but can also result in the

loss of important natural buffers that provide protection against erosion and storm events. The coast with a high vulnerabilities are exposed natural pressures such as wind, water (waves, currents, and rainfall), and gravity can contribute to erosion. According to the map, the municipalities which presents a high vulnerability to erosion are E Marsa, Skika and Kheneg El Mayoun. These factors can wear away soil and rock surfaces over time. Besides the human activity.

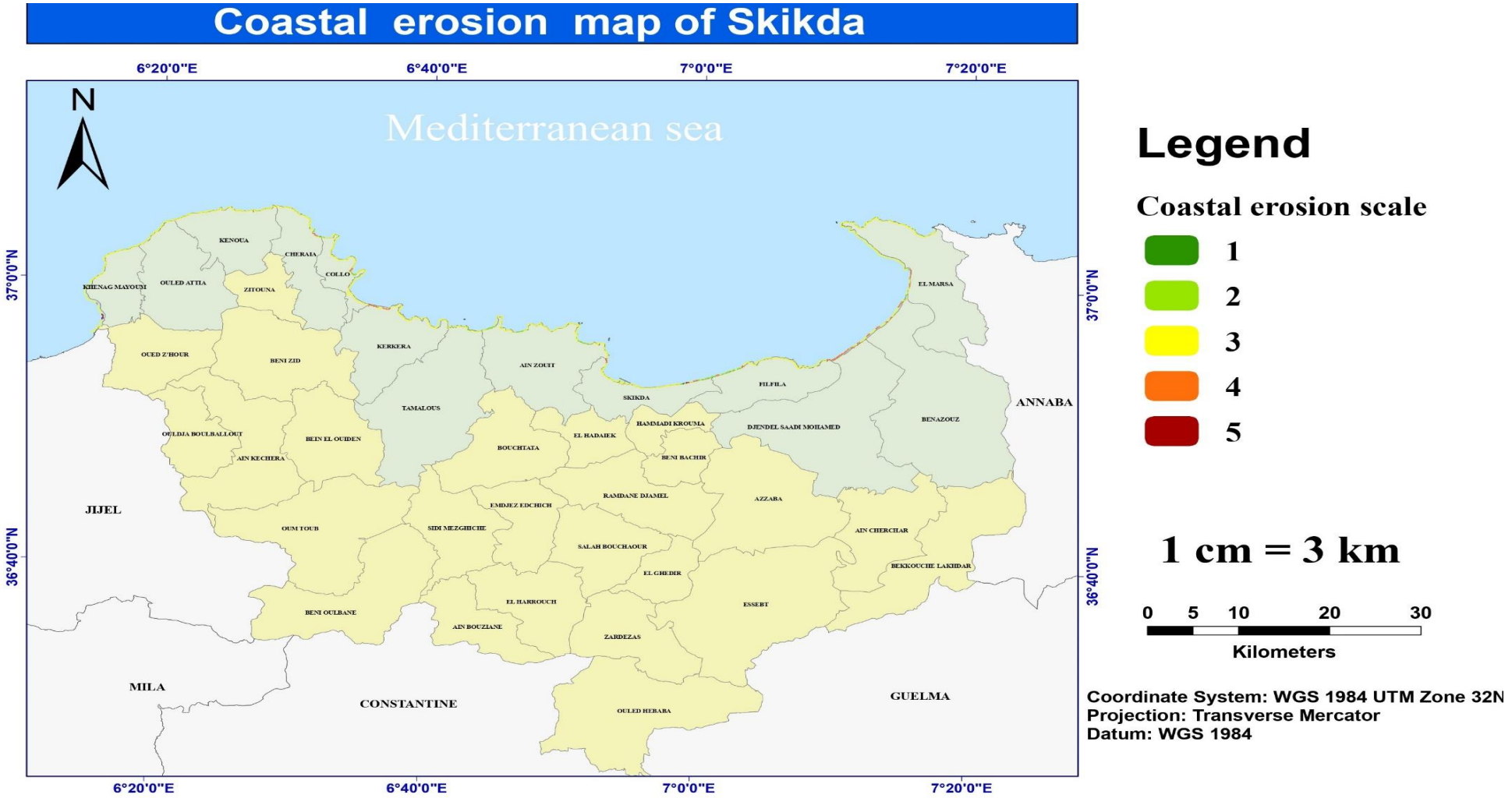

Figure 35: Coastal erosion map of Skikda.

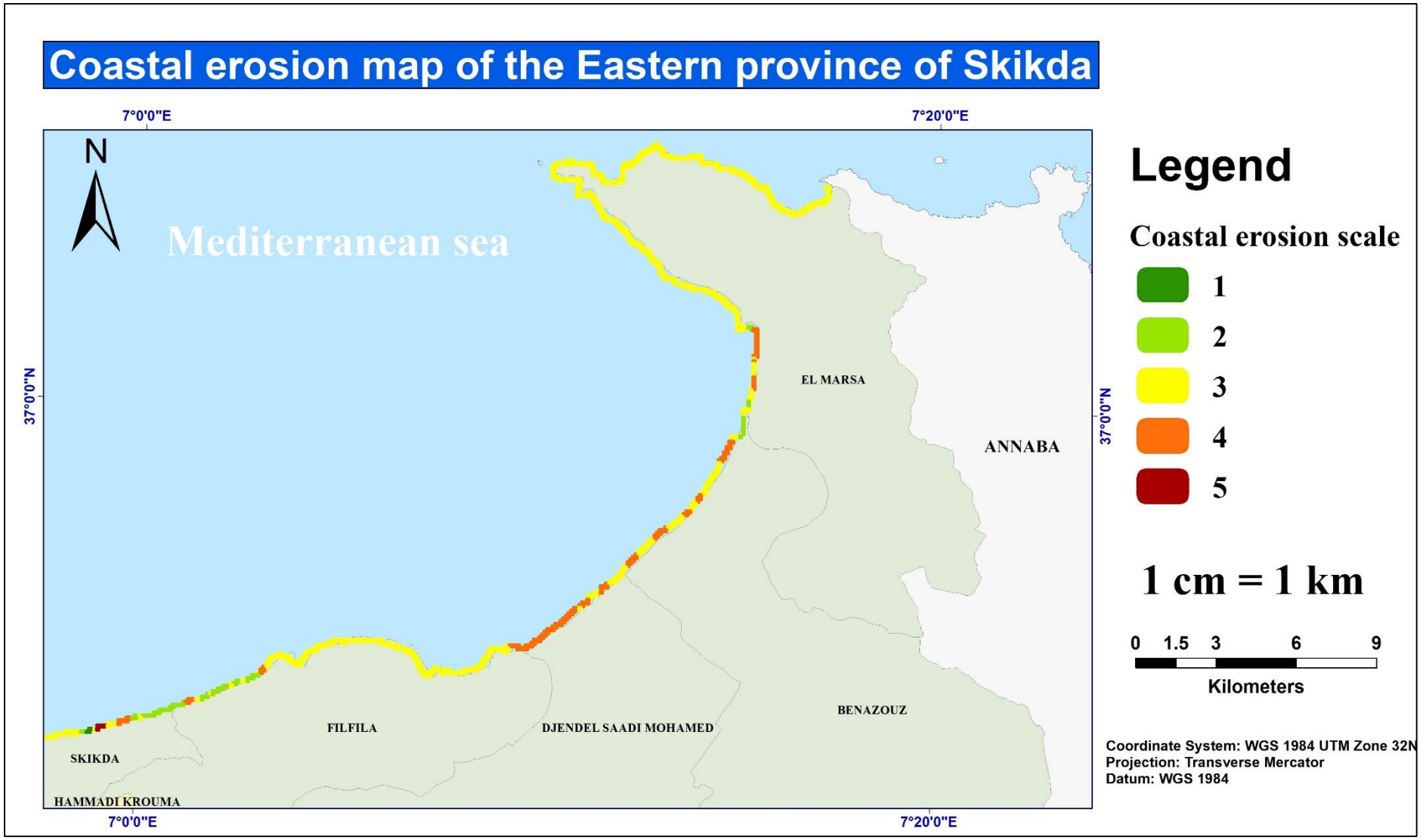

Figure 36: Coastal erosion map of the eastern province of Skikda (Kamel, 2023).

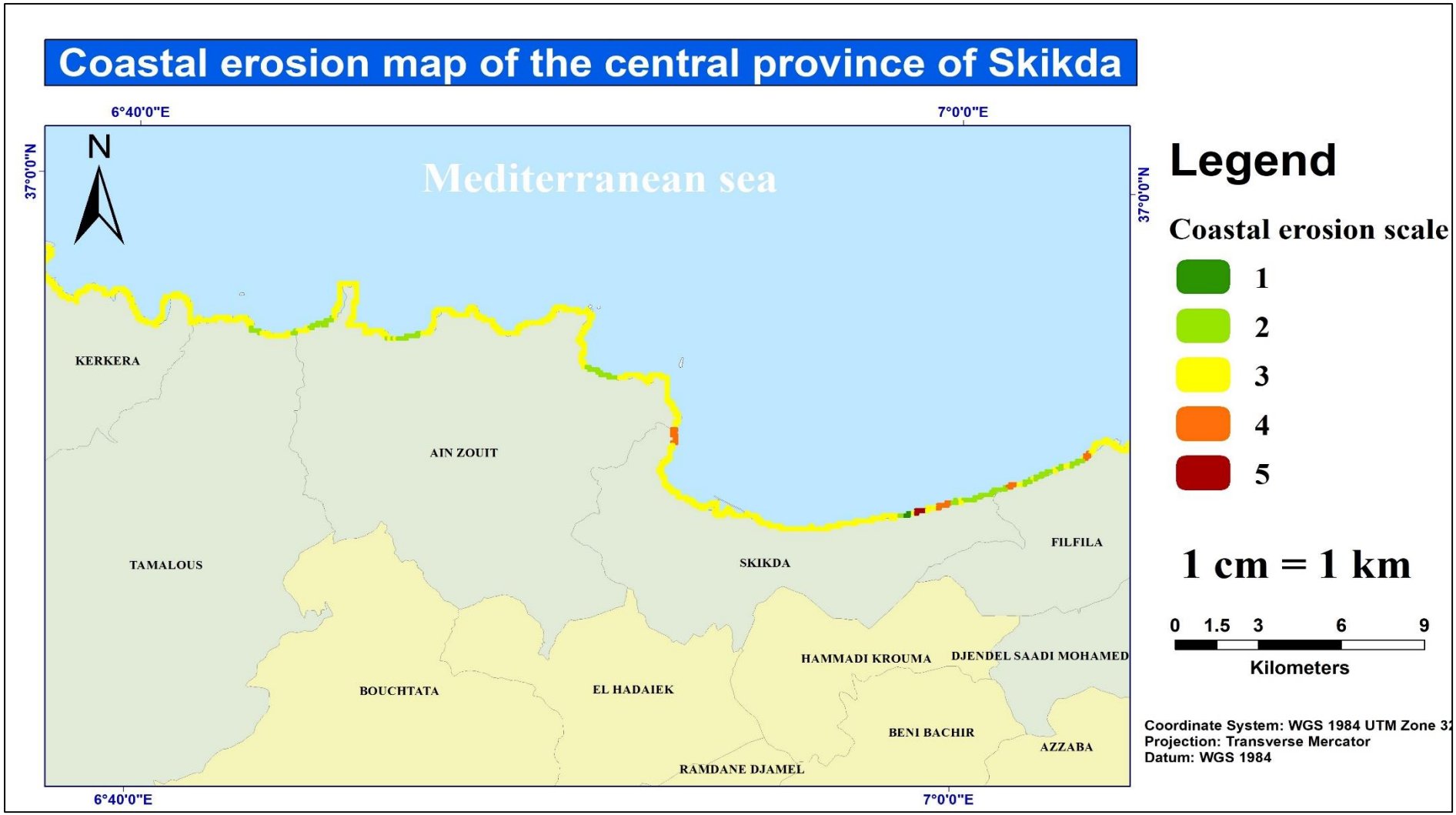

Figure 37: Coastal erosion map of the central province of Skikda **(Kamel, 2023)**

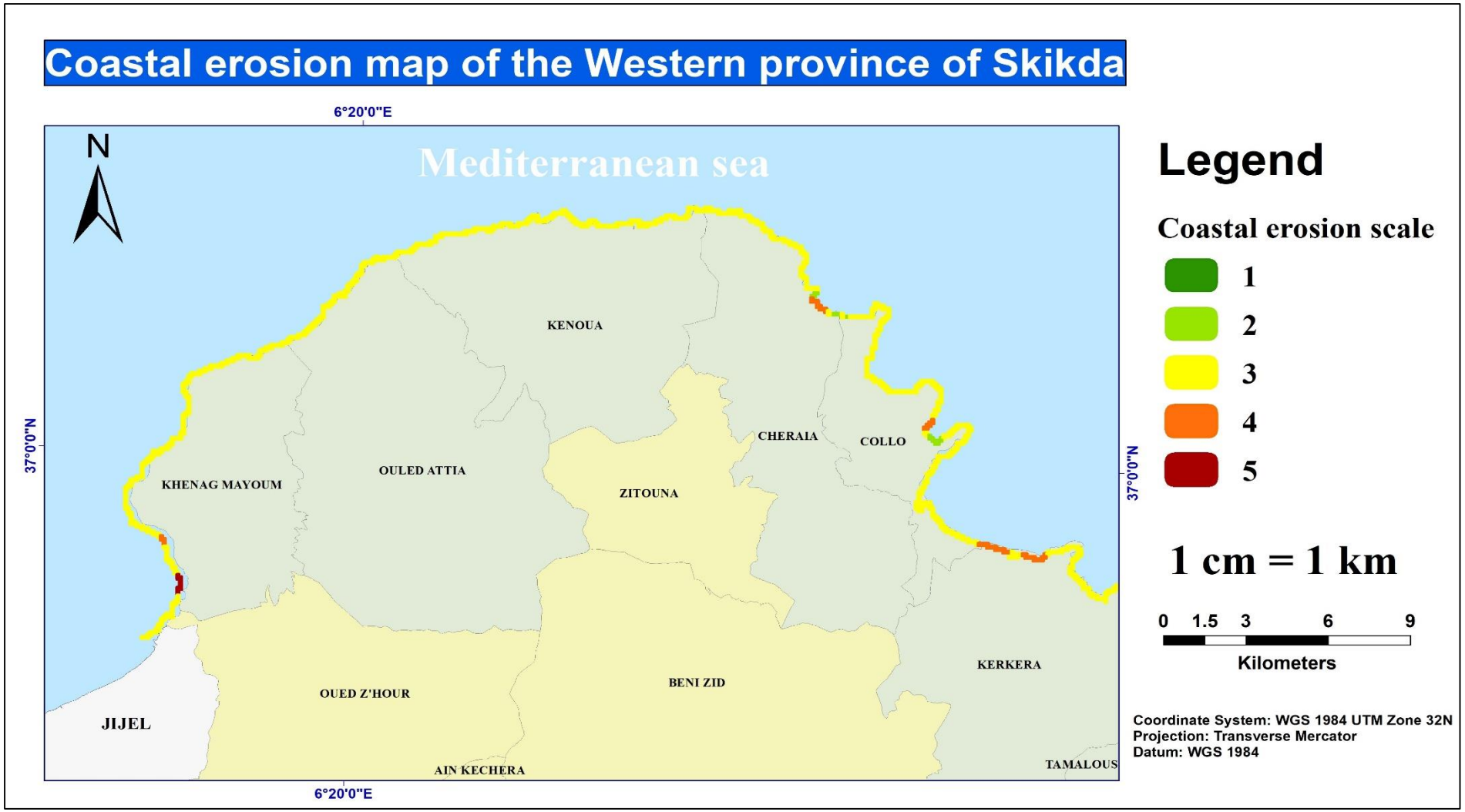

Figure 38: Coastal erosion map of the western province of Skikda (Kamel, 2023).

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IV.3. Assessment of environmental sub-vulnerability

IV.3.1. Water resources

The hydraulic network of the Skikda province is characterized by its dense structure, which can be attributed to the area's humid climate, slopes, and low permeability terrain. As a result, there is a greater propensity for runoff rather than infiltration. Skikda's hydraulic potentials consist of three (03) main types of water resources, namely surface, underground, and spring water. Understanding the importance resources and how they interact with the local environment is critical to the sustainable management and utilization of Skikda's water resources. By doing so, it is possible to ensure the continued availability and accessibility of these resources for the benefit of the province's communities and economy.

- **The underground resources:** The volume of groundwater resources (from wells and boreholes) is estimated to be 87,115 Hm3 and is located in the alluvial aquifers of the rivers in the province, namely El Kébir, Saf-Saf, Guebli, Bibi côtier, Fil-Fila, and the coastal river of Bougaroun (ANIREF).
- **The surface resources:** The Province benefits from abundant rainfall and a mountainous terrain that contribute significantly to its hydrology. Despite having a dense hydrological network with several watersheds, a considerable amount of water is lost every year due to the lack of adequate mobilization means. The mobilization infrastructure represented by the Zerdazas, Bekkouche Lakhdar, Oum Toub, and Beni Zid dams, with a total capacity of 290,667 hm3, along with the two desalination stations, allowed for the exploitation of 93,177 hm3 of water in 2020. However, the capacity of the 13 hill reservoirs in the area is only 01.41 hm3, which is insufficient to meet the increasing water demands of the province (ANIREF).

IV.3.1.1. Drinking Water Supply

The drinking water supply are:

- Network length: 2,082,802 meters;
- Connection rate: 94.34%;
- Existence of two (02) desalination units;
- Demineralization of brackish waters.

IV.3.1.2. Sanitation

The sanitation system is supported by a network that has a total length of 1298935m.This indicates that a significant portion of the population has access to sanitation services, although it is possible that some people may still lack access. Providing adequate sanitation services is important for maintaining public health (ANIREF).

IV.3.1.3. Dams

The province has four (04) dams: Zerdazas, Bekkouche Lakhdar, Oum Toub, and Béni Zid, with a total capacity of 290.667 hm^3. In addition, there are twelve (12) hillside reservoirs with a capacity of approximately 1.25 hm^3. Furthermore, to address the water resource deficiency due to the important agricultural and industrial needs of the province, various processes have been initiated to make water more available, including:

- Desalination: there are two (02) desalination units, one located in Larbi Ben M'hidi and the other in the industrial zone. These two stations produce 103,500 m3/day and currently supply Skikda and its surroundings with drinking water;
- Demineralization of brackish water used for the industrial area's water supply. These waters are produced by demineralization stations at a rate of 4,000 m^3/day;
- Wastewater treatment, exclusively intended for agriculture in the Saf-Saf plain (ANIREF)

IV.3.2. Agricultural potential

The national strategy for agricultural development has designated Skikda as a region for intensive cultivation of various crops including horticultural, fruit, industrial, and fodder crops. Indeed, these crops are capable of ensuring local production needs and generating a potential surplus for other Provinces since they correspond with the levels of irrigation and natural potentialities identified in the region.

The diverse natural and cultivated vegetation layers that constitute the region of province support the agro-sylvo-pastoral triptych. As such, the agricultural sector, along with industry, is a major area of activity in the province.

The distribution of agricultural lands in the region (**table 5)** is dominated by herbaceous crops, which occupy 61.86% of the total agricultural land, while perennial crops cover 17.07% of the land. The remaining 21.06% of the land is left fallow. The majority of the agricultural land is

concentrated along the two main dynamic axes of the region, which include the Azzaba and El-harrouche regions. Approximately 71% of the agricultural land in the region is located in these areas, which produce the majority of the agricultural output. Agriculture remains one of the primary sectors of economic activity in the region, along with industry (ANIREF 2020).

Table 5: The agricultural area by municipality (ANIREF 2020).

Municipalities	Agriculture area (Ha)
Total coastal municipalities	50006,85
Total Wilaya	193024

According to the map **(figure 39, 40)** the municipality of Ben Azzouz has the largest agriculture land with 15135 ha, Tamalous has about 8351ha. Djendel in the third position with 7056, 54. La Marsa, kanoua, cheraia and Skikda are more than 2000 Ha. The others FiFila, Collo, Ouled Attia, Khenak Mayoune and Kerkera are less than 2000.

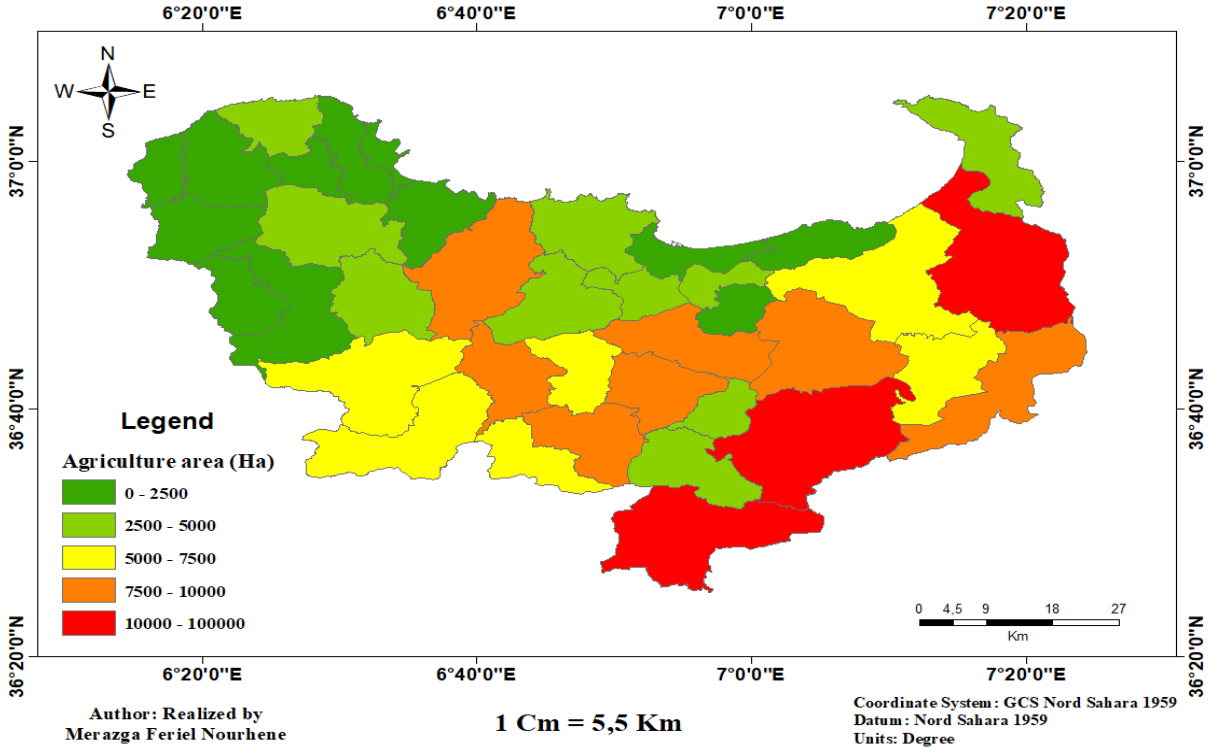

Figure 39: Agriculture area in Skikda in 2020.

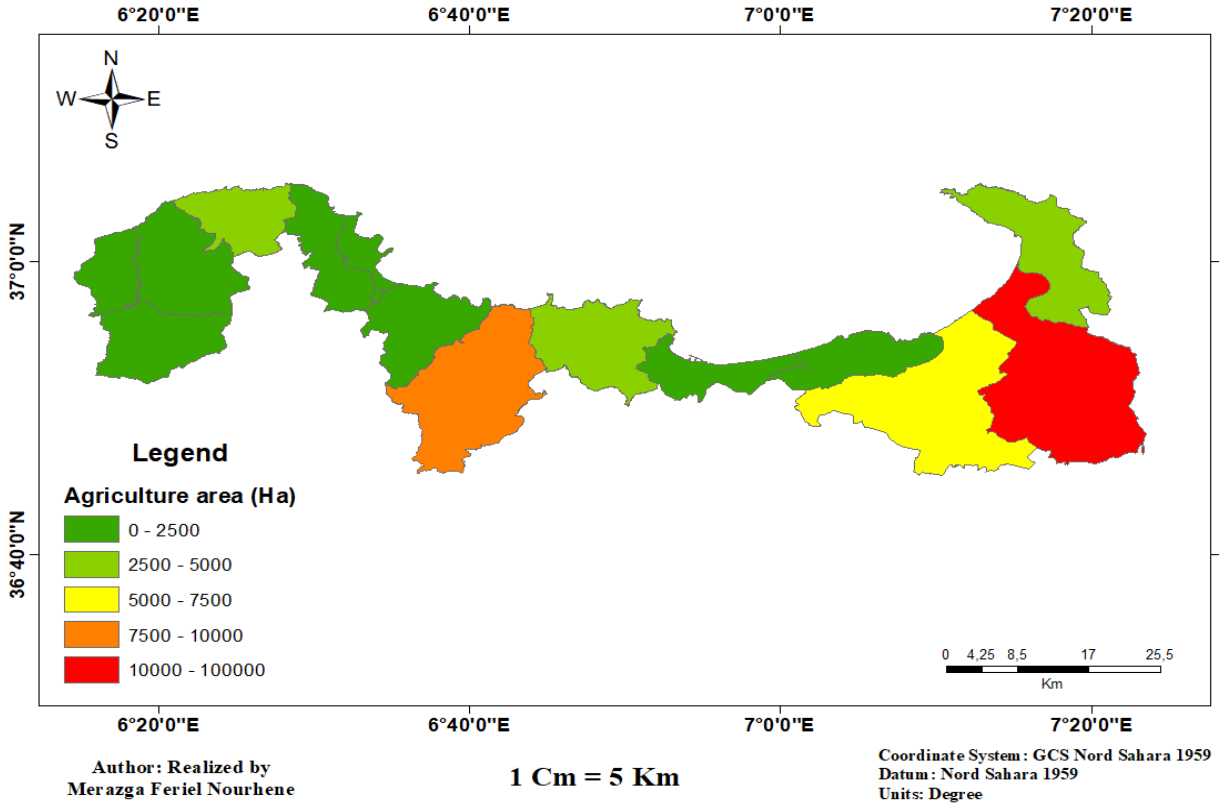

Figure 40: Agriculture area in coastal municipalities of Skikda.

The agriculture area of the total coastal municipalities is 50006, 85 hectars about 21 % of the total area of the Wilaya of Skikda and 193024 hectars in the whole wilaya **(figure 41).** In Skikda coastal municipalities has less agriculture area than non-coastal mucipalities this is due to:

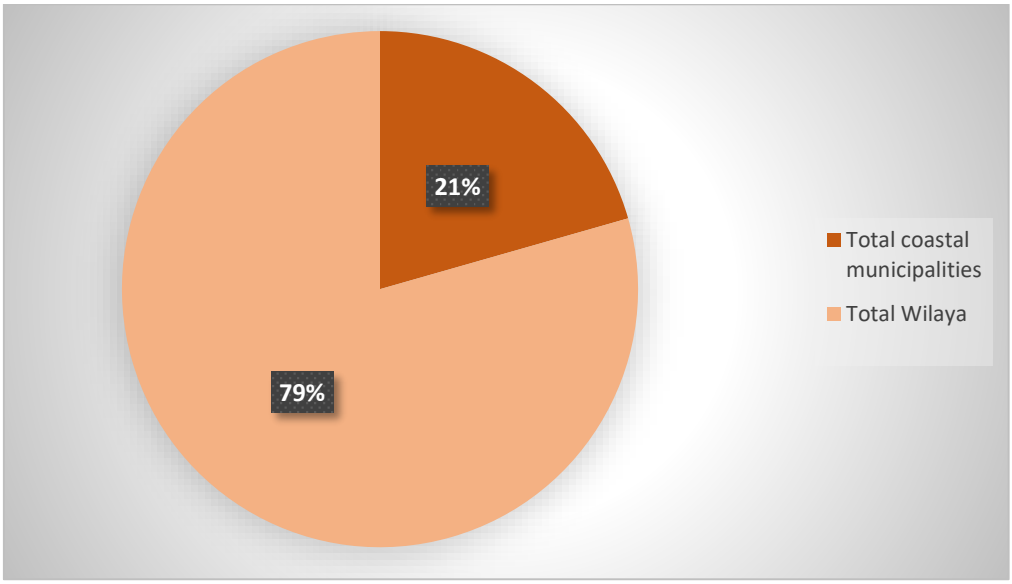

Figure 41: Pie chart representing the agriculture area of the total coastal municipalities in regards to the total Wilaya.

From graph **(figure 42)** of representation of the agriculture area (Ha) of the coastal municipalities. The Ben Azzouz the most municipalitie, which has the largest agriculture land with 15135.Tamalous, is about 8351. Djendel in the third position with 7056, 54. La Marsa, kanoua, cheraia and Skikda are more than 2000 Ha. The others FiFila, Collo, Ouled Attia,Khenak Mayoune and Kerkera are less than 2000.

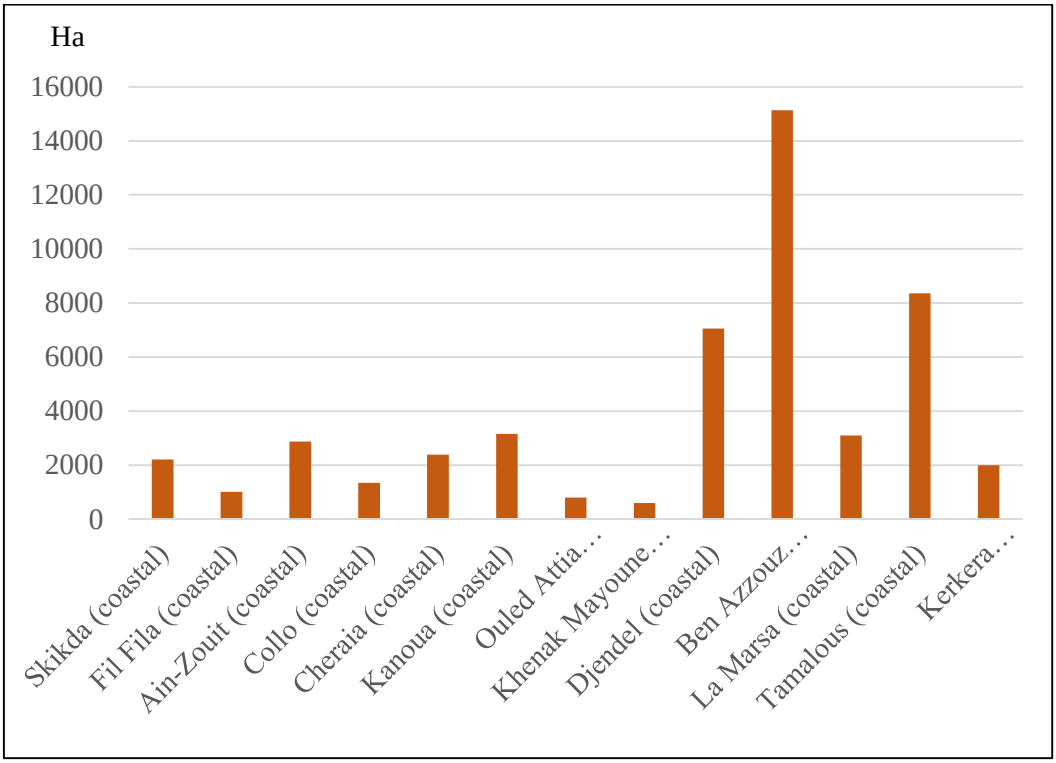

Figure 42: Bar graph representing the agriculture area (Ha) of the coastal municipalities.

IV.3.3. Forests

According to the **(table 6)** woodland rate of the Skikda province is about 48.18%, with forests covering roughly 198,420 hectares of its total area of 411,800 hectares (ANIREF).

Table 6: Forest areas in hectare by municipalities (ANIREF).

Municipalities	**Forests (Ha)**
Total coastal municipalities	**79601,77**
Total province	**198420**

The map **(figure 43)** illustrates the distribution of the forests areas in the wilaya of Skikda. And the **(figure 44)** demonstrates their distribution in the coastal municipalities of the region .

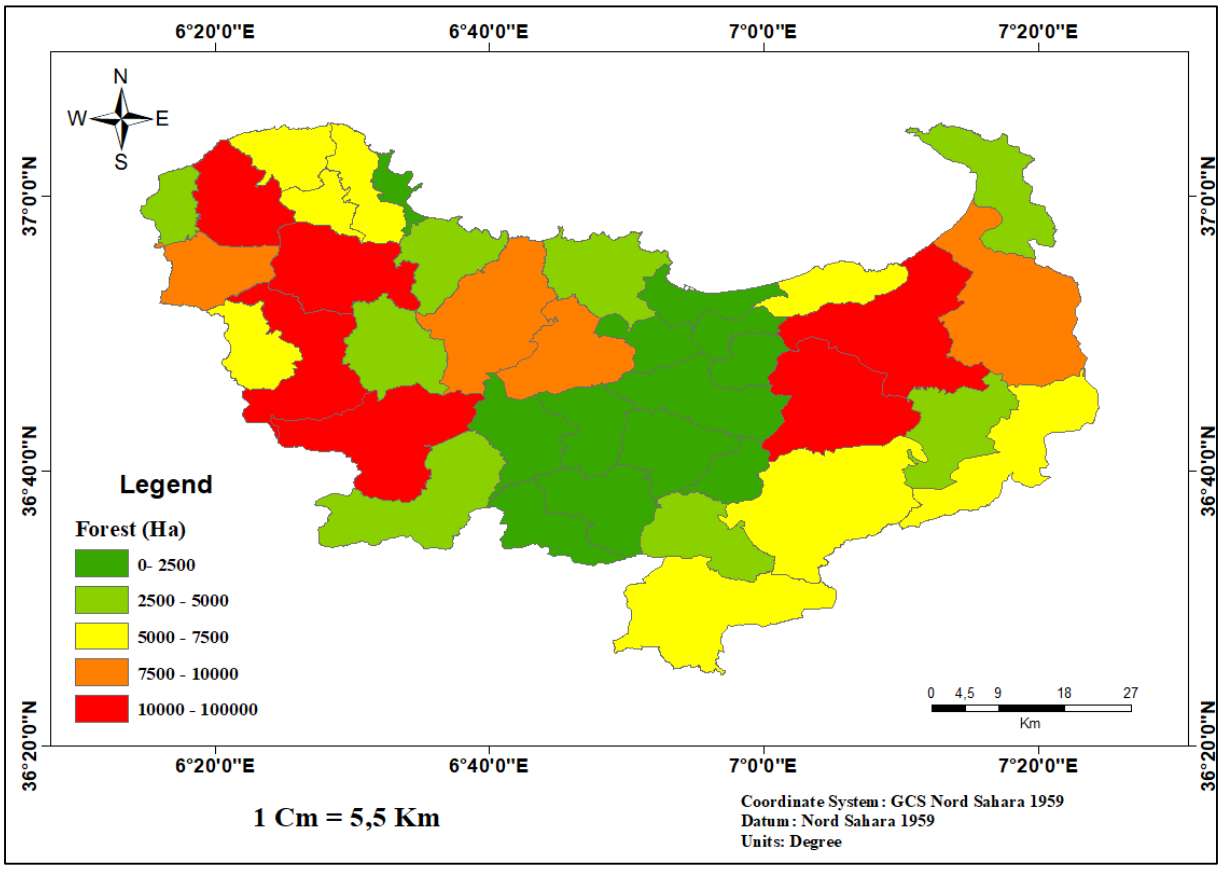

Figure 43: Map of the forest area in Skikda in 2020.

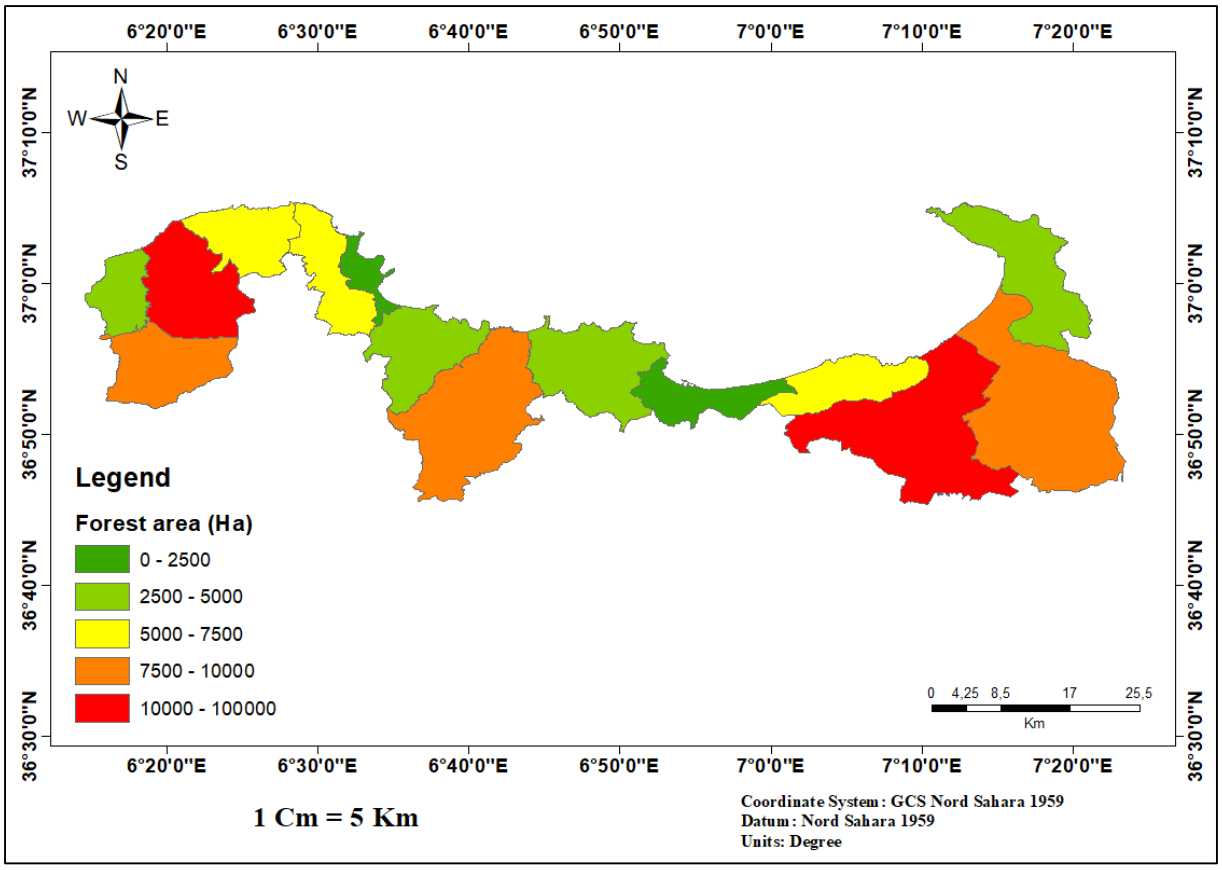

Figure 44: Map of forests area in coastal municipalities in Skikda in 2020.

Here in this graph **(figure 4()**, we notice that the forests areas (Ha) of the coastal municipalities is about 40% of the total province.

Knowing that there are many causes of deforestation in the coastal municipalities like:

- Urbanization and Infrastructure Development.
- Logging and Timber Industries.
- Fuelwood Collection and Charcoal Production.
- Climate Change and Natural Disasters.
- Illegal Logging and Land Encroachment.
- Unsustainable Practices and Poor Forest Management.

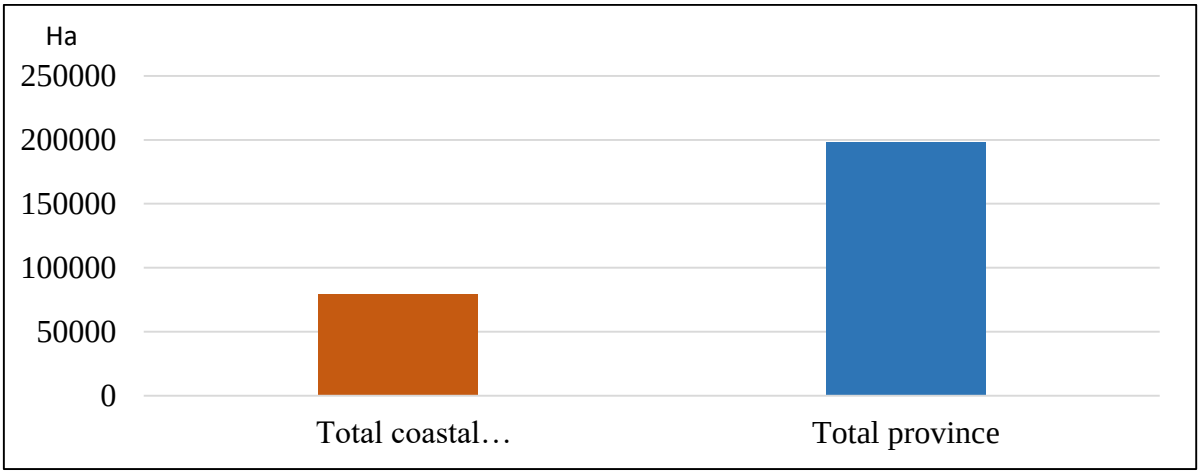

Figure 45: Bar graph representing forests area of the total coastal municipalities in regards to the total province.

The pic in the graph **(figure 46)** is the municipality of Djendal with 16059, 73 and the largest forest area. Then Ouled Attia 10255, 2 and Tamalous 8667,34. Oued Zhour 8176, 5 and Ben Azzouz 7949.Kanoua with 6721.Beside Fil Fila 5537, 68. Cheraia,and Karkra with 5146, 4 820,76 .La Marsa and Khenak Mayoune more than 4000 Ha.Ain-Zouit approximatively 4000 Ha.In the end Skikda and Collo 995,56;1102.

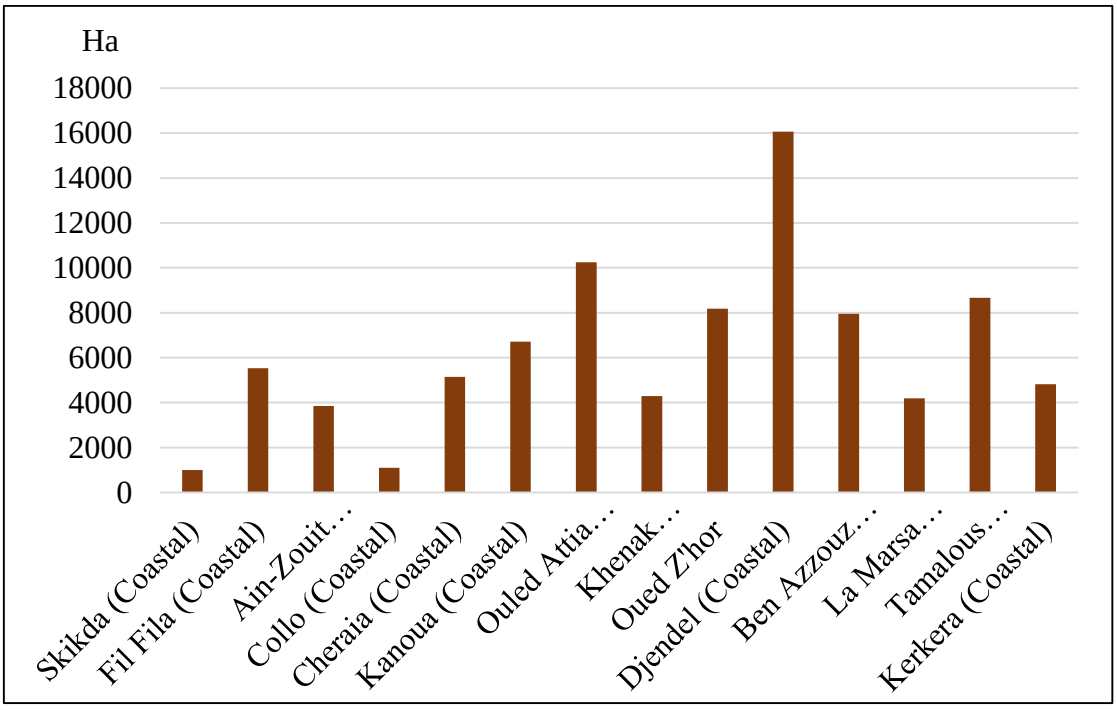

Figure 46: Bar graph representing the forests area (Ha) in the coastal municipalities of the province.

IV.3.4. Fishing potential

IV.3.4.1. Fishing

The Skikda province has a coastal stretch of 140 km (which represents 11% of the Algerian coast) with a fishing zone which covers an area of 3,068 km². The fish stocks in the coastal area, as well as the potential for fishing in continental aquaculture sites, are assets that could foster a fishing industry that is just as important as agriculture (ANIREF).

Maritime fishing is practiced in accordance with the regulations in force in the following areas:

- The coastal fishing zone: located within six (6) nautical miles from the reference lines;
- The offshore fishing zone: located beyond six (6) nautical miles and within twenty (20) nautical miles;
- The high seas fishing zone: located beyond the offshore fishing zone, beyond twenty (20) nautical miles.

On average, the annual catch in the Eastern region is between 5,000 to 5,400 tonnes, of which 90% consists of blue fish. This represents a mere 14.21% of the potential fishery in the area, which is estimated to be 38,000 tonnes. The primary fishing locations are the ports of Stora, Collo, La Marsa, and Oued Z'hor, which became operational in 2017

The presence of 4 fishing ports **(Table 7)** suggests that there are specific areas or infrastructures dedicated to supporting fishing activities. These ports serve as important hubs for the fishing industry, facilitating the operations of fishing vessels, fishermen, and seafood-related businesses. This helps in assessing the infrastructure and support available to the fishing sector, planning for resource management, identifying areas for potential growth or improvement, and developing strategies to ensure the sustainable and efficient operation of the fishing ports. These available ports gives also the opportunity of job postings and the development of the economy of Skikda.

The information **(Table 7)** indicates also that there are no fishing shelters available in the specified context or region. Fishing shelters are structures or facilities designed to provide protection and shelter for fishing vessels and fishermen during adverse weather conditions or when they are not actively engaged in fishing activities.

The fact that there are no fishing shelters implies that there is a scarcity of specific structures or designated areas where fishermen can find safety or temporarily moor their boats. This

situation has potential consequences for the security and welfare of the fishermen, as well as for safeguarding their fishing equipment and vessels during harsh weather conditions.

Table 7: Existing fishing infrastructure (ANIREF).

The nature of the infrastructure	Number
Fishing ports	4
Fishing shelters	0

The Composition of the fleet:

The given information **(Table 8)** presents the composition of the fleet with a total number of 552 designations categorized into different types of vessels. The fleet includes 35 trawlers which are fishing vessels equipped with large nets (trawls) that are dragged along the seabed or through the water to catch fish or other marine species. The fleet comprises 151 sardine fishing boats focusing on sardine fishing. The fleet is not composed of tuna fishing boats and shellfish gatherers. The "Others" category comprises 366 vessels that do not fall into the specified categories. These may include various types of fishing boats or vessels engaged in different fishing activities not specifically mentioned.

This information provides insights into the composition of the fleet, highlighting the prominence of trawlers and sardine fishing boats. The absence of tuna fishing boats and shellfish gatherers suggests a potential focus on other types of fishing or a lack of emphasis on these specific activities within the fleet.

Table 8: Composition of the fleet.

Designation	Number
Trawlers	35
Sardine fishing boats	151
Tuna fishing boats	0
Shellfish gatherers	0
Others	366
Total	**552**

IV.3.4.2. Aquaculture

The table provides an overview of the existing sites for aquaculture, specifying the types of locations where aquaculture activities are being conducted.

Aquaculture activities are conducted at 10 sea sites and 4 dam sites, making a total of 14 locations. This indicates that aquaculture practices are being carried out in both marine and freshwater environments. The **(Table 9)** demonstrates the diversity of aquaculture practices, involving the cultivation of aquatic organisms in different natural or constructed habitats. These data ensure sustainable practices and making informed decisions regarding resource allocation and regulatory measures.

Table 9: The existing sites for aquaculture.

Breeding sites	**Number**
Sea	10
Dams	4
Total	**14**

According to the map **(figure 47),** there are sites of Experimental shrimp farming and fish farming in the region of Cap de Fer, Sidi Akkacha and el marsa in the municipality of El Marsa. The number of Experimental shrimp farming sites is 4 with only one operational site. The number of fish farming sites is one which is operational.

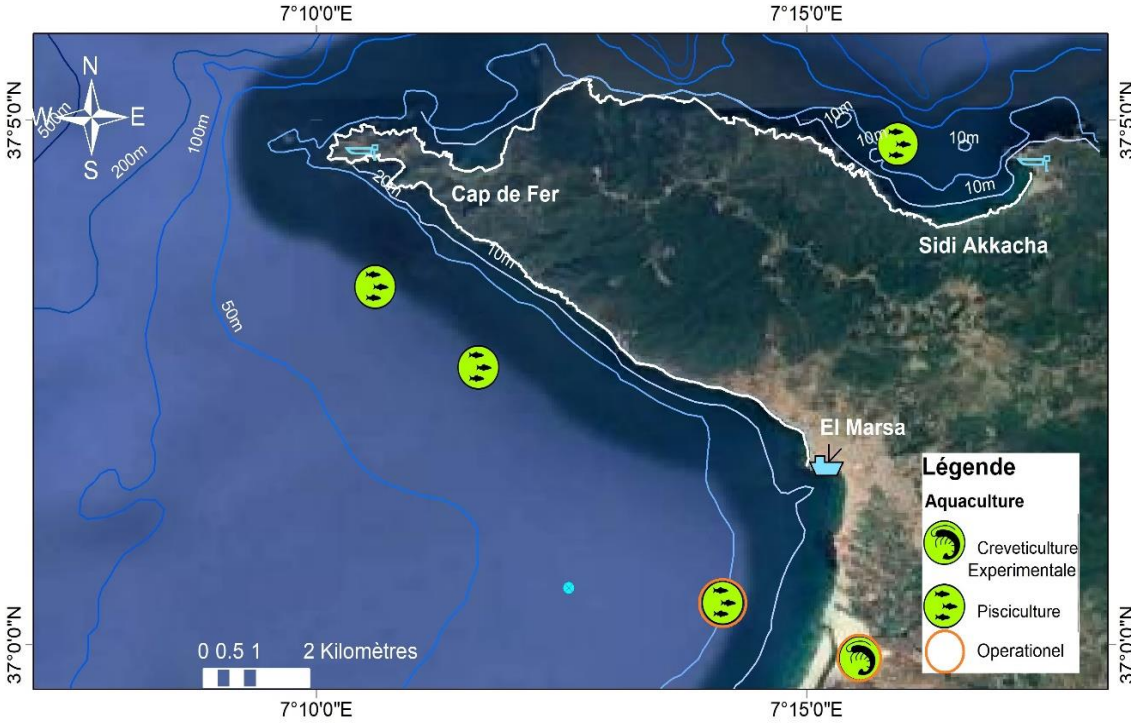

Figure 47: Location of marine aquaculture projects in the region of Cap de Fer (El Marsa).

IV.3.5. Ecological assessment

Skikda's marine biodiversity is equally impressive. The coastal waters are teeming with a wide array of marine life, including fish, crustaceans, mollusks, and marine mammals. The area is also known for its rich coral reefs and seagrass meadows, which provide essential habitats for a variety of marine species. These marine ecosystems support local fishing communities and contribute to the overall health and resilience of the marine environment.

The loss of marine biodiversity is a matter of great concern, as it disrupts vital ecological processes, reduces the resilience of marine ecosystems, and threatens the stability of the planet. It also has significant implications for human well-being, as we depend on healthy oceans for food security, livelihoods, and cultural experiences.

Skikda has a wetland localisated in Benazzouz.

IV.3.5.1. The rocky coasts :

The rocky cliffs can be found primarily in the western area, spanning from the mouth of Oued Z'hour in the west to Stora in the east. They extend along the coast of the Filfila municipality and the eastern section of Cap de Fer in El-Marsa. These cliffs are characterized by their steepness, with vertical variations exceeding 100 meters. Their total length is estimated to be approximately 70 kilometers (MATE. 2005).

Table 10: The Skikda's rocky coasts (MATE. 2005)..

Cliffs	Municipalities	Main Characteristics
Oued Z'hor	Oued Z'hor	It takes shape at the western edge of Oued Z'hor Beach over a length of 2500 m.
Terhane	Khenag Mayoun	It is located to the west of Marset Zitoune Beach.
Rocky coast of Tamanart	Collo	With a length of 100m, it separates between the two beaches of Tamanart.
Marset zitoune	Khenag Mayoun	With a length of 920m, this cliff is located between Marset Ezitoune Beach to the east and Oued Z'hor Beach to the west.
Zribet El habalet	Collo	This rocky coast takes shape to the west of Tamanart Beach over a length of 4400m.
Sidi Yahia	Collo	It takes shape to the west of the Bay of Young Girls over a length of 3260m.

El djerda	Collo	It takes shape to the west of the port of Collo over a length of 3600m.
Kef el hmar	Skikda	Located to the west of the 7 Brothers islets, it extends over a length of 6000m.

Approximately 70% of Skikda's shoreline consists of rocky coasts. The greatest diversity of algae species, forming a dense blanket that typically obscures the seabed, can be found at depths ranging from 5 to 10 meters.

IV.3.5.2. The fauna

Table 11: The Skikda's fauna (MATE. 2005).

The fauna	
The ascidian (*Halocynthia papillosa*).	The red coral (*Corallium rubrum*), is present from about 20 meters depth almost everywhere, forming dense carpets in certain caves, while the colonies appear in a much more scattered pattern.
The Dalmatian dorid (*Peltodoris atromaculata*).	The stone sponge (*Petrosia dura*)
The crater sponge (*Hemimycale columella*).	The green clione (*Cliona viridis*).
The spiny sponge (*Clathrina clathrus*)	The orange agelas (*Agelas oroides*).
The Mediterranean slipper lobster (*Scyllarides latus*), the squid.	The bluish encrusting sponge (*Anchinoe tenacior*).
The squat lobster (*Galathea strigosa*).	The small slipper lobster (*Scyllarus arctus*)
The false coral (*Myriapora truncata*).	The serpulid worm (*Serpula vermicularis*).
The kidney sponge (*Chondrosia reniformi*).	The plate axinellid sponge (*Axinella damicornis*).
The plate axinellid sponge (*Axinella damicornis*)	The common axinellid sponge (*Axinella polypoides*)
The yellow encrusting anemone (*Parazoanthus axinellae*).	The gorgonian (*Paramuricea clavata; P. chamaeleon*).
The European squid (*Loligo vulgaris*).	The John Dory (*Zeus faber*).
The two-spot wrasse (*Labrus bimaculatus*).	The brown meagre (*Sciaena umbra*)
The forkbeard (*Phycis phycis*)	The big-scale cardinalfish (*Apogon apogon*)

Table 12: The Skikda's Flora (MATE. 2005).

The flora	
The Halimede (*Halimeda tuna*).	The udotée (*Udotea petiolata*)
The hooked algae (*Asparagopsis armata*)	The spherococcus. (*Sphaerococcus coronopifolius*).
The dictyote (*Dictyota dichotoma, Dictyopteris membranacea*).	

IV.3.5.3. The dunes

Skikda boasts one of Algeria's most significant and harmonious coastal dune complexes. Extending for about ten kilometers along the coastline, it encompasses the Sanhadja and Ben-Azouz plains and spills over into Guerbes. The dune ridges align parallel to the prevailing northwest to southeast winds. With certain dunes reaching heights of up to 30 meters, they exhibit a predominantly shrub-like vegetation colonization, while some dunes remain fixed in place.

Table 13: The Dunes of Skikda (MATE. 2005).

The dunes	Municipalites	Main Characteristics
Dunes El Marsa	EL-Marsa	The dunes of El Marsa beach reach a maximum height of 7 meters and are stabilized by a maquis of Cistus vegetation. Illegal sand extraction from these dunes has been reported.
Dunes les platanes	Fil Fila	Despite the disruption caused by the road cutting through, the dunes of Platanes beach have thrived and grown extensively. Towards the eastern part of the beach, the dunes soar to impressive heights of up to 30 meters, gradually decreasing to 5 meters as you move westward. The dunes are anchored by resilient halonitrophilous plants, with the eastern section dominated by beach grasses, creating a lush Euphobe vegetation. On the western side, the dunes are secured by a combination of Cistus shrubs and Alpine pines, adding to the diverse landscape.

Dune Kef Fatma	Ben Azzouz	Despite experiencing excessive extraction in previous years, the dunes of Kef Fatma beach have remarkably flourished. These dunes reach an impressive height of 20 meters and are firmly held in place by a resilient maquis vegetation dominated by Cistus shrubs.

IV.3.5.4. The coastal bodies of water and their proximity

IV.3.5.3.1. Guerbes-Sanhadja wetland complex (Source:ASAL).

- **Localization**

The Guerbes-Sanhadja is a large coastal plain in Benazzouz municipality occupying an area of 42,100 hectares, bordered to the west by the coastal hills of Skikda and to the east by the coastal forest massif of Chetaibi (ASAL).

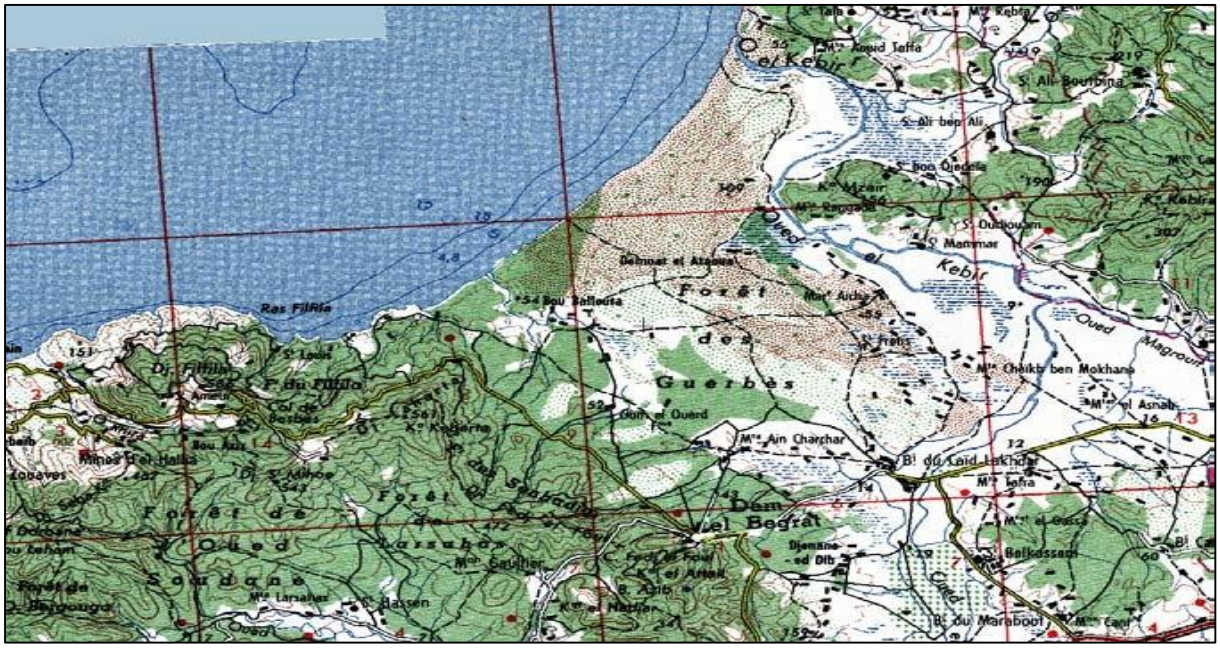

Figure 48: Localization of Guerbes-Sanhadja wetland in Skikda (ASAL).

- **Importance of the site:**

The Guerbes plain encompasses internationally significant "sites" that offer distinctive and exceptional examples of natural wetland ecosystems. These sites are not only noteworthy within the Maghreb, North Africa, and the North Africa-Central Africa sub-region, but they also hold importance for the broader Mediterranean region. The Guerbes plain, with its bioclimatic diversity, features a continental dune massif that creates a unique environment. The undulating morphology, oriented NW-SE, along with the formation of depressions and dune valleys, contributes to a refreshing atmosphere during winter, thanks to prevailing winds, and a humid heat during the summer. Moreover, the reduction of vegetation in the dune areas results in rapid temperature drops in specific wetland and aquatic habitats during winter. As a result, these sites exhibit a simultaneous presence of plant species (and consequently animal species) from both tropical (5% of the 234 flora species associated directly with wetlands) and northern (28%) biogeographic origins. This region showcases a significant representation of species from Sub-Saharan Africa and Europe, alongside the Mediterranean region, accounting for 34% of the overall biodiversity. (Samraoui & de Belair, 1997).

- **Criteria :**

- **Biodiversity:** The Guerbes-Sanhadja plain possesses significant importance in maintaining biological diversity, thanks to its abundant and diverse fauna and flora. Spanning over 28,000 hectares, it hosts approximately 234 plant species, originating from various biogeographic regions, including 145 taxa specifically adapted to aquatic habitats. Additionally, the plain supports 50 bird species and 27 Odonate species. Among the documented plant species, 19 are classified as rare, while 23 are exceptionally rare, further emphasizing the region's biodiversity value;
- The Guerbes-Sanhadja plain wetland complex serves as both a migratory destination and a food source for eels and other marine species that have not yet been identified (mullets, barbels, etc.).
- Rare species and threatened ecological communities.
- >1% of the waterbird population.

- **Ecological characteristics**

Few habitats represented by examples of plant communities with rare species:

- Ponds with *Salvina natans* (pteridophytes), *Lemna gibba* or *Wolffia arrhiza*, and *Persicaria senegalensis*.
- Dune water bodies with *Nymphaea alba*, *Myriophyllum alterniflorum*, *Potamogeton lucens, Rorippa amphibia*, and *Ricciocarpus natans* (bryophytes).
- Alder groves with *Alnus glutinosa, Carex elata, Cladium mariscus, Ranunculus flammula*, *Campanula alata*, *Eleocharis multicaulis*, *Rhynchospora glauca*, and various orchids (*Dactylorhiza elata*, *Serapias parviflora*, or *Serapias lingua*).
- Water bodies in alluvial plains with *Rumex algeriensis* and *Persicaria amphibia*, accompanied by a sedge community.
- Ponds with *Isoetes velata* and *Coleostephus paludosus*.
- Marshes with *Salicornia arabica* and *Lepidium coronopus*.
- Riparian forests with *Populus alba*, *Ulmus campestris*, *Salix alba*, and *Vitex agnus-castus.*

- **Physical elements**

➢ **Climate**

Region: Humid middle-latitude climate with mild winters.

Subregional climate: Mediterranean (Mild, scorching summers).

➢ **Soil:**

The soils in the area are a mix of less developed aeolian deposits and less evolved alluvial soils. There are also some brown soils, occasionally leached. Most of the soils are found in relatively flat zones, with varying textures that allow for intensive or semi-intensive land use. However, they do pose challenges due to the generally unstable and chemically poor nature of the aeolian deposits.

➢ **Hydrological regime:**

The hydrological network primarily comprises two main rivers: Oued El Kebir and Oued Magroune. Oued El Kebir is one of the largest rivers in terms of length and volume, with a width ranging from 20 to 50 meters. It flows into the Marsa beach in the Mediterranean Sea. The network is further complemented by eight smaller rivers in the plain. The area is divided

into three watersheds: 1) Skikda East (4,927 hectares), 2) Western Oued El Kebir (23,046 hectares), and 3) Annaba West (704 hectares). A comprehensive table with further details can be found in the additional documents (ASAL).

IV.3.5.3.2. The protected marine areas to protect

- **Ras El Moghreb à Ras Bougaroun**

This protected marine area is situated in the western region of Skikda province. The coastline, with its steep rocky cliffs, offers limited natural shelters. Notably, between Kef Lekhal and Ras El Kmakem, the rocky formations are home to thriving populations of barnacles (Lepas anatifera). With a variety of marine species, including both fauna and flora. 1026 species.

- **Ras Frao à Ras Kalaa**

This region encompasses a variety of coastal features, including bays, coves, and sandy beaches nestled within them. Notably, there are barrier reefs formed by Posidonia oceanica, which serve as protective barriers for the seagrass meadows of Zostera marina. Moreover, the marine sections of these beaches host thriving populations of edible shellfish, specifically Donax trunculus and Donax semistriatus. A marine fauna and flora of 607 species are recorded.

At the bottom of the coves, in areas protected from the swell, algae such as Liagora viscida and Padina pavonica thrive. The Cystoseira genus of algae, which is found in more turbulent conditions, plays an important ecological role and is highly sensitive to chemical pollutants, highlighting the water quality in this region.

- **El Marsa à la Pointe Akkecha**

This region boasts a rich array of marine ecosystems, characterized by its eastern coastline adorned with islands, islets, coves, bays, and pebble beaches. Along the pebble beaches of El Marsa, archaeological sites provide a glimpse into the area's historical significance.

The marine flora and fauna in this region are exceptionally abundant and diverse, encompassing a remarkable 809 species.

IV.3.5.3.3. Continental shelf

The Skikda's continental shelf receives water from multiple rivers, including Oued El Kebir and Oued Saf Saf. It is a well-developed continental shelf, with a width of 12 km facing Oued Kebir and 10 km in the Gulf of Stora. Even in front of Cape Est, the width remains considerable, and it reduces to 1.8 km near Cape de Fer.

The sedimentology of the area exhibits distinct characteristics. Coarse sands dominate the region between 0 and 15 meters deep, while fine to medium sands are prevalent in the 15 to 25-meter depth range. Beyond that, the seabed is covered with muddy deposits.

IV.3.5.3.4. The beaches

Table 14: Beaches of Skikda (MATE. 2005).

Beach	Municipalities	Main caracteristics
Sidi Akacha	El Marsa	It is a straight beach composed exclusively of pebbles, with a length of 5000 meters and an average width of 5 meters. It is bordered at the back by the road.
Boumerouane	El Marsa	The Boumerouane beach is rocky in nature and extends for a length of 100 meters.
Marsa	El Marsa	It is a sandy beach located to the east of Port El Marsa, which has a cross-sectional profile over a length of 500 meters and a width of 20 meters.
Marsadelle	El Marsa	This beach extends for a length of 500 meters. Its fine sand is mixed with very fine golden particles. Constructions are reported in the back of the beach. This beach is characterized by small-scale fishing activities, which constitute the main source of income for the

		locality. Fishing is practiced using flat-bottomed boats hauled directly onto the beach by manpower.
Cheikh Rabah	El Marsa	It is a sandy beach with a length of 500 meters and a width of 10 meters.
Kef Fatma	Ben Azzouz	Kef Fatma beach extends for a length of 500 meters. Its fine sand is mixed with debris and solid waste, forming a thin layer. This is due to the excessive extraction of sand from the beach.
Guerbes	Djendel	Guerbes beach has a more or less concave profile. It extends for a length of 1000 meters and a width of 20 meters. It is a beach composed solely of sand and bordered at the back by dunes. It is limited to the west by the cliff of the holy ruins.
Oued Saboune	Fil Fila	It is a sandy beach that extends for a length of 350 meters and a width of 15 meters. It is limited to the east by the cliff of Ras Dzira ed Dib.
Oued Righa	Fil Fila	This sandy beach extends for a length of 500 meters and a width to the west of the beach Les Platanes.
Les Platanes	Fil Fila	Les Platanes beach forms a cross-sectional profile and extends for a length of 400 meters with an average width of 8 meters. It is composed of fine sand with the presence of a few scattered pebbles to the east of the beach. The beach is bordered by dunes that are interrupted by the road.
Guigue	Skikda	Guigue beach has a straight profile over a length of 400 meters and a width of 15 meters. It is composed of medium-sized sand with a few pebbles accumulated in the upper part of the foreshore.
Militaire 1	Skikda	The Militaire 1 beach has a transversal profile and has a length of 300 meters and a width of 10 meters. It is exclusively composed of fine sand.
Ben M'hidi	Skikda	It is a sandy beach that extends for a length of 800 meters and a width of 10 meters. The road has been constructed right at the edge of the shore, significantly reducing the width of the foreshore.

Sirène	Skikda	The Sirène beach has a length of 500 meters and a width of 20 meters, with a transversal profile. It is composed of coarse sand. Seafront promenades have been built on the upper part of the beach.
Embouchure Oued Saf-Saf	Skikda	This beach is located to the west of the Saf-Saf port, where the Saf-Saf river directly flows into it. It is mainly composed of medium sand and extends for a length of 200 meters with an average width of 30 meters. Tree debris is washed up on the beach.
Ilot des Chèvres	Skikda	The Ilot des Chèvres beach is shaped like a cove, composed exclusively of sand, and stretches for a length of 600 meters with a reduced width of 5 meters.
Château Vert	Skikda	The Château beach is a beach with medium sand. It extends for a length of 300 meters and has an average width of 15 meters. It is located to the west of the port of Skikda.
Casino	Skikda	It is a beach with medium sand that extends for a length of 200 meters and has an average width of 15 meters.
Militaire 2	Skikda	This coastline with fine sand is straight and extends for a length of 100 meters with an average width of 10 meters.
Paradis	Skikda	It is a beach with medium sand that extends for a length of 300 meters and has an average width of 7 meters.
Biquini	Skikda	It is a beach with medium sand that extends for a length of 200 meters.
Stora	Skikda	Stora Beach is located to the east of the Stora port and is bordered to the east by rock blocks. This beach, with medium sand, extends for a length of 150 meters and has a width of 6 meters.
Molo	Skikda	The Molo beach extends for a length of 150 meters and has a width that does not exceed 5 meters. Its sediment is primarily composed of fine sand with the presence of scattered pebbles.
Large Beach (Grande plage)	Ain-Zouit	The large beach is shaped like an open cove towards the north and stretches for a length of 1000 meters. It is exclusively composed of medium sand. The coastline becomes rocky in front of the cliffs at both ends of the beach.

Oued Tanger	Ain-Zouit	The Oued Tanger beach is straight and has a regular slope from south to north. It is composed of fine sand and extends for a length of 2000 meters.
Ben Zouit	Tamalous	Ben Zouit beach is shaped like an open cove towards the north, with a length of 2200 meters and a width of 50 meters. Its sediment is primarily composed of fine sand. Sparse vegetation, such as sea purslane and wild cucumber, helps stabilize the sand on this beach.
Taleza	Collo	Taléza beach has a more or less concave transversal profile. It extends for a very significant length of 3000 meters and has a width of 50 meters. It is composed exclusively of fine sand. The back of the beach has a fairly flat aspect, allowing for the installation of a concrete plant for the production of tetrapods and artificial blocks in the eastern part of the beach.
R'mimla	Collo	It is a sandy beach that extends for a length of 100 meters and has a width of 10 meters.
Baie des Jeunes Filles	Collo	It is a sandy beach shaped like a cove. It extends for a length of 1030 meters and has a width of 20 meters. Two discharges are reported: the first one represents the discharge of domestic water from the Bougaroun hotel, and the second discharge is through the Sial River.
Tamanart	Cheraia	Tamanart beach consists of two arc-shaped beaches with a length of 1000 meters and an average width of 30 meters, separated by a rocky coastline that stretches for 300 meters. It is characterized by the predominance of coarse sand with the presence of pebbles at the mouth of the Tamanart River.
Zeroual	Cheraia	This coastline with fine sand is characterized by the presence of several scattered rocks. It extends for a length of 150 meters with a maximum width of 5 meters.
Marset Zitoune	Khenak Mayoun	It is a sandy beach that extends for a length of 1000 meters. It is bordered to the east by the Oulad Atia cliff and to the west by the Terhane cliff.
Oued Z'hour	Khenak Mayoun	Oued Z'hour beach is shaped like a cove and bordered to the west by the Oued Z'hour. It is composed of medium sand and extends for a length of 500 meters with a width of 40 meters.

IV.3.5.3.5. Islands and islets

Table 15: Islands of Skikda (MATE. 2005).

Islands	Municipalities	Main Characteristics
Serjina Island	Skikda	With an area of 6 hectares.
phare Djerda	Collo	With an area of 0.4 hectares.
Pigeon Island	Skikda	Located 2020 meters away from the shoreline, with a length of 350 meters and a width of 140 meters.
Iron Cape (Cap de Fer)	El-Marsa	Located 600 meters away from the shoreline, with a length of 220 meters, a width of 80 meters, and a height of 90 meters.
Zoubia Island		Located 100 meters away from the shoreline, with a length of 110 meters and a height of 100 meters.
Lion Island	Ain zoui	Located 210 meters away from the shoreline, with a length of 130 meters and a width of 100 meters.

IV.3.5.5. The underwater seagrass beds and coastal underwater formations:

The Posidonia seagrass meadows along the coast of Skikda province are widespread, particularly between Hadjra Sidi Mahchich and Monkey Islet, the cliffs of Filfila, and between El Marsa and Akkecha Islet. The extent of the Posidonia seagrass is limited in depth, where it reaches a sparse formation down to 40 meters deep (MATE. 2005).

The seagrass meadow is grazed by the salema (Boops salpa) and the striped seabream (Spicara maena). Other fish species benefit from the advantages of the seagrass meadow as a spawning area: the painted comber (Serranus scriba), the seahorse (Hippocampus ramulosus), the spider crab (Maja squinado), and the noble pen shell (Pinna nobilis) take refuge at the base of the seagrass meadows.

IV.3.6. Coastal vulnerability to Landfills

IV.3.6.1. Landfills

The classification of controlled/ uncontrolled landfills and their stock capacity leads us to determine a region's vulnerability to them. Skikda munisipalities vulnerability to landfills deffers from one to another. The maps **(figure 49, 50)** illustrates the municipalities which have or not uncontrolled wastes.

The municipalities classified as non-vulnerable are Djendal,FilFila,Kerkira,Es-Sebt,Ramdane-Djamal,Beni-Bechir,El-Ghedir,HamadiKrouma,Bouchetata,Ain kechra, Ouldja Boulballout without either uncontrollable landfills or non-vulnerable controlled landfills.

The municipality of Skikda without uncontrollable landfills + the controlled one closed since 2015 that's leads us to classify it as non-vulnerable.

Azzaba with controlled landfills with 2 trenchs one is saturated, and the other still not, without any uncontrollable landfills, so weakly vulnerable.

El Hadaiek controlled landfills with 2 trenchs saturated, weakly vulnerable.

El Harouch controlled landfills with 2 trenchs still not saturated and uncontrollable landfills, moderately Vulnerable.

Ben Azzouz with a controlled landfill with 1 trench (12 Ha) and uncontrollable landfills, moderately vulnerable.

Tamalous with a controlled landfill with 3 trenchs (20 Ha) and uncontrollable landfills, vulnerable.

Kanoua, Ouled Attia, Khenak Mayoune, Zerdaza, Ouled hbaba, Salah Bouchaour, Collo, La Marss, Ain-Zouit, Ain Cherchar, Oum Toub, Bekkouche Lakhdar, Zitouna,Beni Oulbane,Ain Bouziane,Sidi Mazghich,Bin El ouiden, Cheraia, Beni Zid, Emdjez Edchich with uncontrollable landfill so it is excessively vulnerable.

This information can lead us to the identification of Potential Pollution Sources because landfills contain waste materials that can potentially pose environmental risks, especially if

located near the coast. It can also impact local ecosystems and wildlife habitats and contribute to water pollution, particularly through leachate discharge. Landfills may be susceptible to coastal hazards such as erosion, flooding, and storm surge.

This information is crucial for sustainable coastal planning, management, and protection of vulnerable coastal environments.

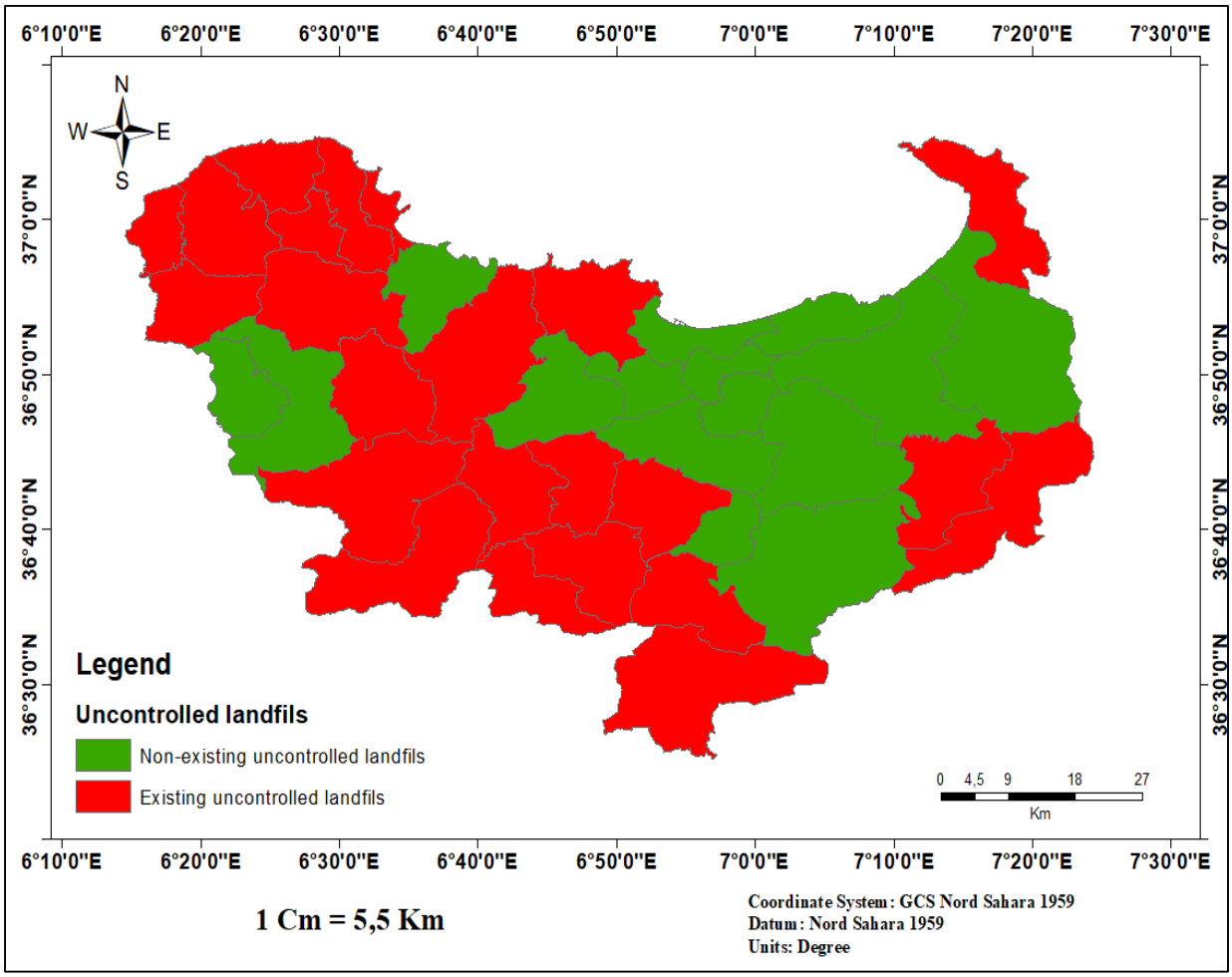

Figure 49: Localization of uncontrolled landfills in Skikda.

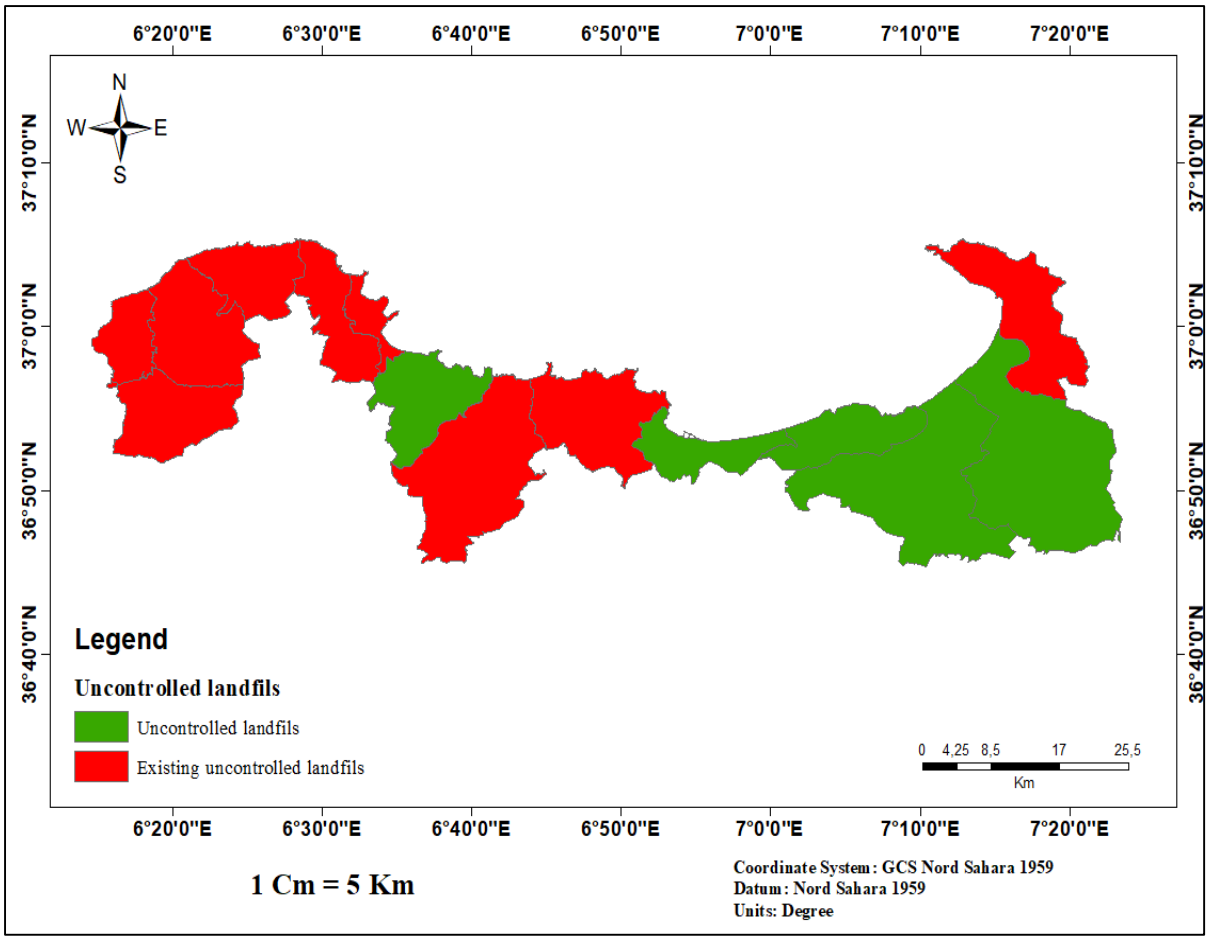

Figure 50: Localization of uncontrolled landfills in coastal municipalities of Skikda.

IV.3.6.2. Coastal vulnerability to landfills

The determination of coastal vulnerability to landfills according to the **(figure 51)** which illustrates the skikda's municipalities vulnerability to uncontrolled wastes and **(figure 52**) which illustrates only the coastal municipalities vulnerability to uncontrolled landfills. The classification of these regions is:

- The municipalities classified as non-vulnerable are Djendal,FilFila,Kerkira,Es-Sebt,Ramdane-Djamal,Beni-Bechir,El-Ghedir,HamadiKrouma,Bouchetata,Ain kechra, Ouldja Boulballout without either uncontrollable landfills or non-vulnerable controlled landfills.
- The municipality of Skikda without uncontrollable landfills + the controlled one closed since 2015 that's leads us to classify it as non-vulnerable.
- Azzaba with controlled landfills with 2 trenchs one is saturated, and the other still not, without any uncontrollable landfills, so weakly vulnerable.
- El Hadaiek controlled landfills with 2 trenchs saturated, weakly vulnerable.

- El Harouch controlled landfills with 2 trenchs still not saturated and uncontrollable landfills, moderately Vulnerable.
- Ben Azzouz with a controlled landfill with 1 trench (12 Ha) and uncontrollable landfills, moderately vulnerable.
- Tamalous with a controlled landfill with 3 trenchs (20 Ha) and uncontrollable landfills, vulnerable.
- Kanoua, Ouled Attia, Khenak Mayoune, Zerdaza, Ouled hbaba, Salah Bouchaour, Collo, La Marss, Ain-Zouit, Ain Cherchar, Oum Toub, Bekkouche Lakhdar, Zitouna,Beni Oulbane,Ain Bouziane,Sidi Mazghich,Bin El ouiden, Cheraia, Beni Zid, Emdjez Edchich with uncontrollable landfill so it is excessively vulnerable.

This information can lead us to the identification of Potential Pollution Sources because landfills contain waste materials that can potentially pose environmental risks, especially if located near the coast. It can also impact local ecosystems and wildlife habitats and contribute to water pollution, particularly through leachate discharge. Landfills may be susceptible to coastal hazards such as erosion, flooding, and storm surge.

This information is crucial for sustainable coastal planning, management, and protection of vulnerable coastal environments.

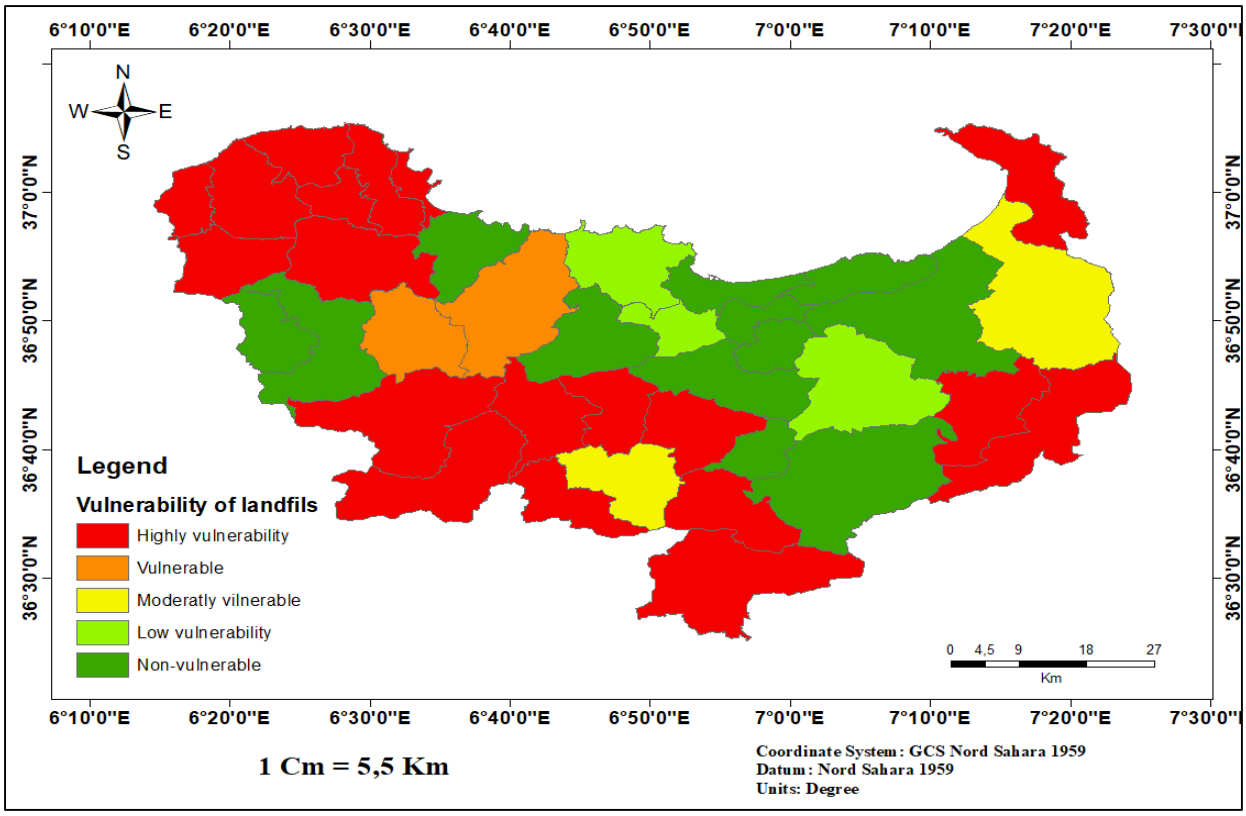

Figure 51: Map of Skikda's municipalities vulnerability of landfills.

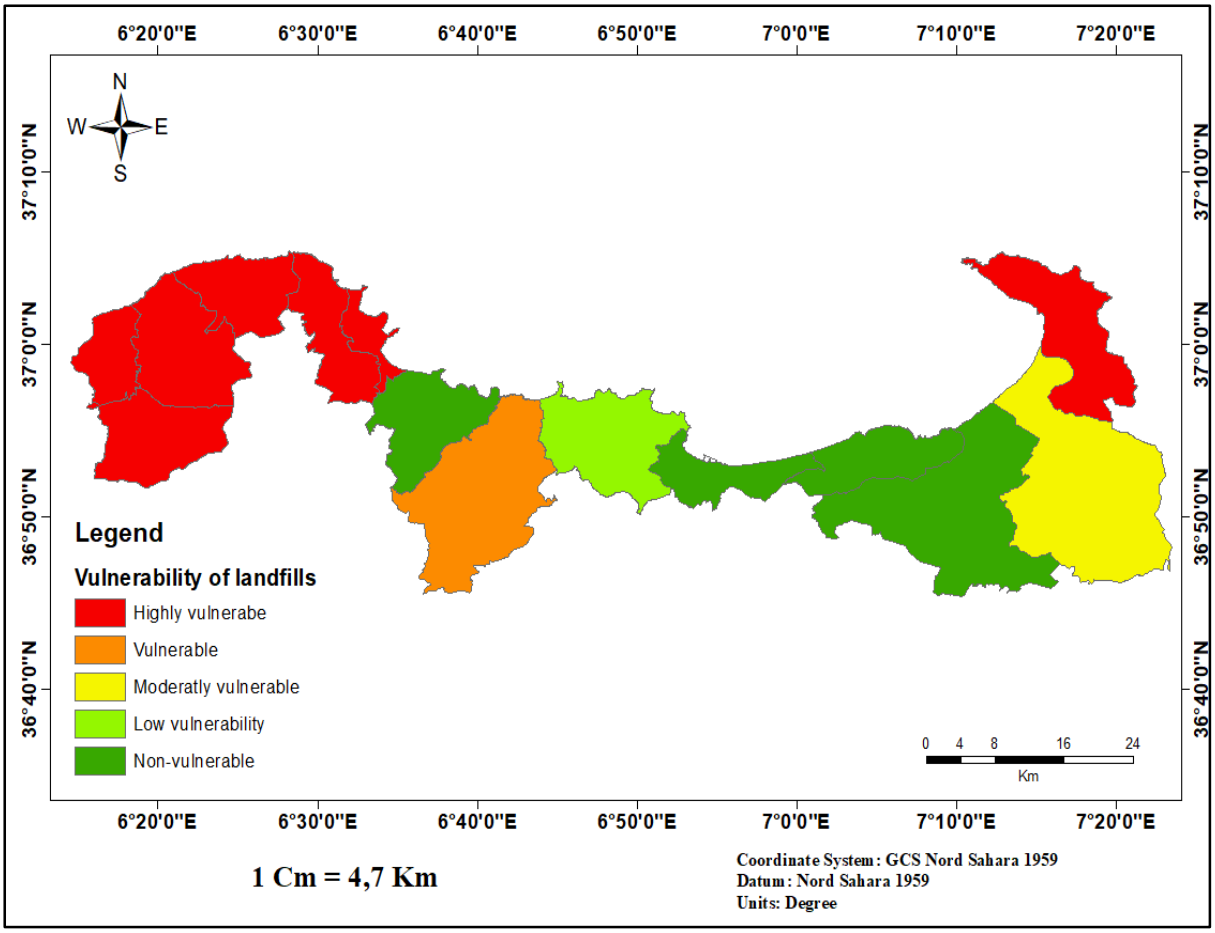

Figure 52: Map of Skikda's coastal municipalities vulnerability of landfills.

IV.3.7. Ecological sensitivity

According to the map **(figure 53)** of ecological sensitivity we notice that the wilaya of Skikda has:

- 3 marines protected areas in different coastal municipalities.
- 5 Islands.
- Important habitat at Serijina Island and some remarkable species
- The wilaya of Skikda contain also 3 dunes, and some cliffs are distributed at several municipalities.
- It is characterized by the presence of Posidonia in El Marsa and Fil Fila, and coral reefs.
- All municipalities have forests with different surface area (Ha).

Skikda is classified with riche and marine and tersest biodiversity. The important ecological values present in the region's ecosystem increases its vulnerability. This is because of the ecological values which may be more sensitive to disturbances and environmental changes, making them more likely to experience negative impacts. Knowing that vulnerable ecosystems often face pressures that result in the disappearance or reduction of certain species, and in consequence, disrupt the ecological interactions, destabilize food chains, and lead to a decrease in biological diversity. In addition, vulnerable ecosystems are more likely to experience habitat degradation due to factors such as the urbanization which is increasing in the region, the remarkable deforestation, and the development of intensive agriculture and climate change. This degradation reduces the availability of resources necessary for species survival, which can result in population decline and eventually local extinction. Thus, the presence of industrial, commercial and tourism zones in the coast of Skikda makes it more vulnerable to biodiversity decline and habitats loss. Furthermore, this vulnerability can undermine the region's ability to provide vital ecosystem services, such as clean water, air purification, or soil fertility. This loss of ecosystem services can have detrimental effects on human well-being and disrupt the balance of ecological systems.

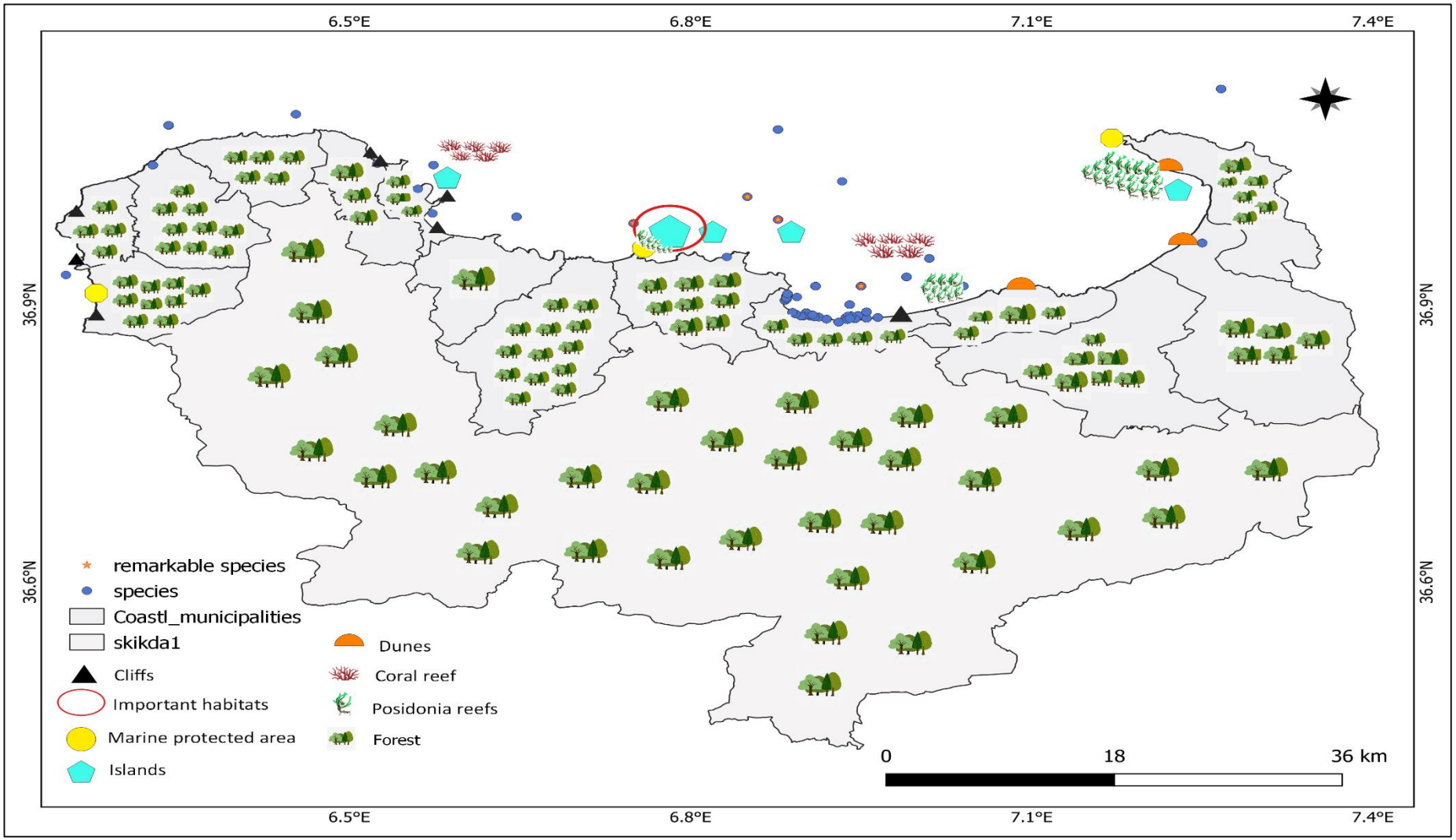

Figure 53: Ecological sensitivity.

IV.4. Coastal vulnerability of Skikda

The analysis of the socio-environmental vulnerability map **(figure 54)** of the Skikda province is a combination of marine and coastal ecological values with pressures from degradation and pollution sources.

This analysis shows that the entire coastal area of the Skikda province is vulnerable on a socio-environmental level. The level of vulnerability varies from one area to another, depending on the level of risk and the existence of marine and coastal ecological heritage in the zone. In fact, eight major vulnerability zones can be distinguished, including three red zones on the map. The first one is located near Collo, exposed to fishing port activities as well as other ecological risks in the area characterized by coral and species presence. This zone has different sources of pollution such as agriculture and uncontrolled waste.

The second zone is located in the center and includes Skikda and Ain Zouit, which are exposed to pollution caused by human activities such as industry, petrochemical plants, desalination plants, and fishing, pleasure, industrial, and commercial ports. Its ecological value is significant due to remarkable species and important habitats, as well as a large marine protected area (Serigina).

The third zone is El Marsa, in the extreme east, bordering the Skikda and Annaba provinces. This zone has a very high ecological value with the presence of Posidonia and red coral, as well as other species considered as heritage by the Barcelona Convention. This zone is exposed to intense fishing activity, particularly optimized fishing, as well as pollution generated in the east of the province and reaching this area through the NNW/SSE currents.

Regarding the zones showing orange vulnerability on the vulnerability map, they are located in three areas. The first one is in the communes of Ben Azzouz and Djendel, which are exposed to ZAC (Coastal Development Zones) and TEA (Agricultural Development Territories). This zone is exposed to pollution sources such as current patterns and agriculture. The second and third zones are the communes of Tamalous and Cheraia. These zones are characterized by similar natural and anthropogenic pressures, including coastal erosion, agriculture, a significant population size, controlled and uncontrolled waste, and ZAC.

The zone characterized by medium vulnerability, indicated in yellow on the vulnerability map, is located in the far west of the province, in the communes of Oued Zhour, Kheneg Mayoun, Kenoua, and Ouled Attia. This zone has a small population size but is exposed to coastal erosion and uncontrolled waste.

The last zones characterized by low vulnerability are Kerkera and Filfila, which are only exposed to population pressure and coastal erosion.

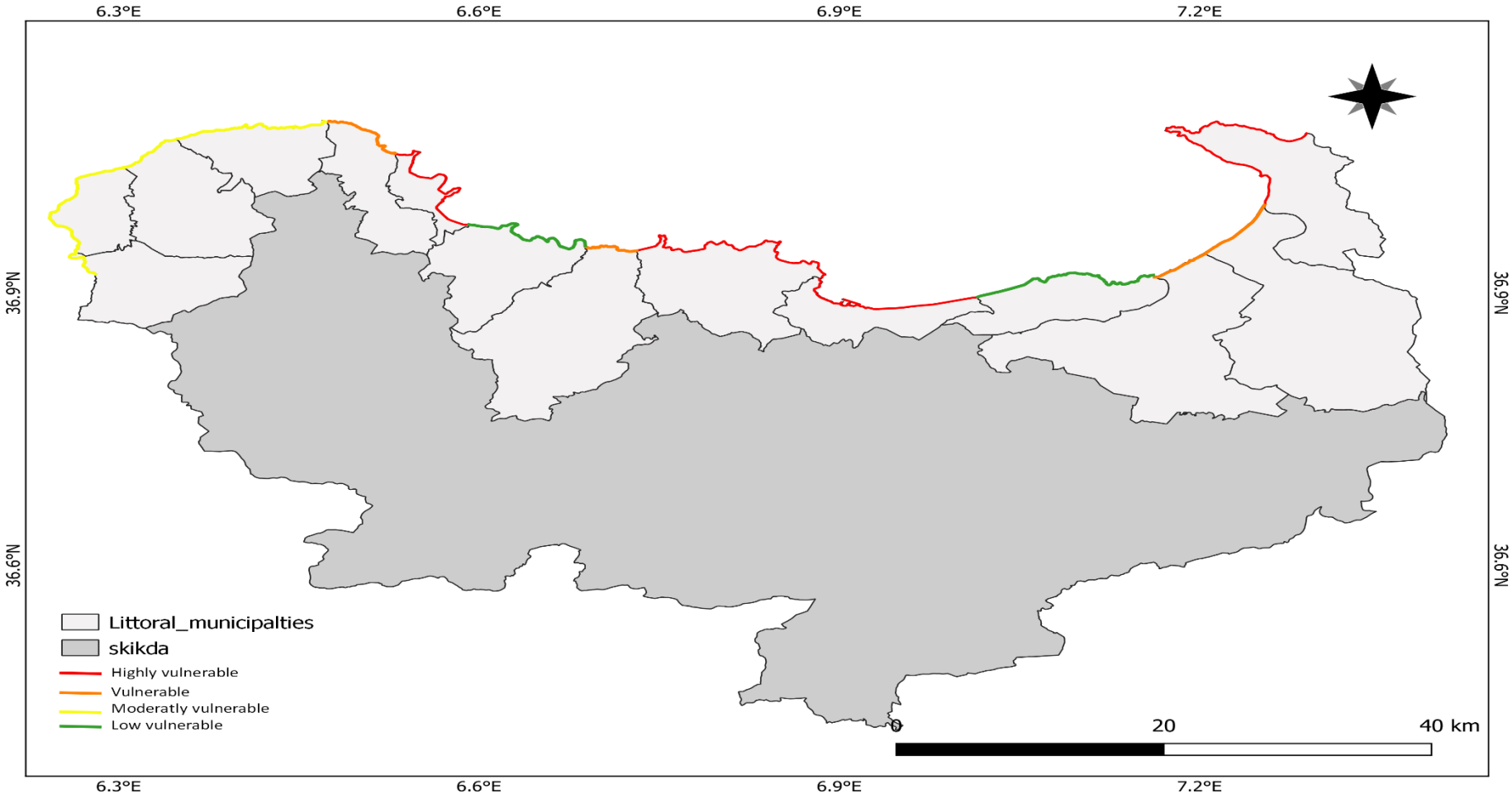

Figure 54: Map of the vulnerability of Skikda.

Conclusion

The work we have accomplished in the coastal area of the province is a pilot project that allowed for the first-ever analysis of the socio-environmental vulnerability of this coastal zone. This exercise was not easy because it required a significant amount of data and covered various sectors.

In order to achieve our objective, we had to make a choice regarding the vulnerability segments we considered. Based on the data context, we focused on the dimensions of coastal erosion, pollution, ecology (including species and habitats of remarkable or high ecological value), socio-economic aspects (including tourism, agriculture, industry), as well as urbanization and population. The combination of all these parameters allowed us to create an initial assessment of the socio-environmental vulnerability of the coastal area in the province of Skikda.

Among the major results obtained from this final research project, we identified the risks posed by anthropogenic activities, particularly those related to industrial and petrochemical zones. Additionally, the combination of these risks with overexploitation or fishing activities in habitats of significant ecological value became evident. It is clear that areas with high ecological value, such as El Marsa and the Collo Peninsula, both in marine and terrestrial aspects, face increasing risks. Urgent and concrete measures need to be implemented to prevent the potential loss of species and habitats.

In this regard, the establishment of a marine protected area in L'Edough, covering a large part of the western region of Annaba, the eastern part of El Marsa, as well as the coastal and marine protected area in the Collo Peninsula, form part of the response to reduce the vulnerability of the coastal zone in the Skikda province. These marine and coastal protected areas will help establish the necessary conditions and regulations to manage human activities, particularly fishing and various sources of marine pollution.

Another important element for reducing this vulnerability is the implementation of measures to control urbanization, which is accompanied by the discharge of industrial and domestic wastewater. Furthermore, the artificialization and change in land use in coastal municipalities will impact the ecological balance in the coastal zone of the province. This work provided us with a comprehensive overview, but we believe that further refinement is necessary, especially to better understand the overall vulnerability by integrating the dimensions of climate change, marine submersion, and sea-level rise. Another research project focusing on these aspects is currently underway at the school.

Combining the results of our work with existing studies on geological forcing factors (coastal erosion, marine submersion, sea-level rise) will yield a vulnerability map of the Skikda province. This map will serve as a decision-making tool at the local level for coastal urbanization, human activities, and adaptation to climate change. It is our recommendation that this work be organized around a comprehensive database for the Skikda province, enabling regular updates of the vulnerability assessment for decision-making and coastal zone planning purposes.

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Annexes

Annexe I

Table: Administrative organisation of the Skikda province **(ANIREF)**

Districts	Municipalities	Area (Km²)
Skikda	- Skikda - Filfila - Hamadi Krouma	148
Azzaba	- Azzaba - Es Sebt - Ain Charchar - El Ghedir - Djendel	782
Ben Azzouz	- Ben Azzouz - El Marsa - Bekkouche Lakhdar	510
El Harrouch	- El Harrouch - Emjez Edchiche - Zerdazas - Ouled Habbeba - Salah Boucahour	570
Sidi Mezghiche	- Sidi Mezghiche - Beni Ouelbene - Ain Bouziane	333
Tamalous	- Tamalous - Kerkera - Bin el Ouisdene	368
Ain Kechera	- Ain Kechera - Ouldja Boulbalout	213
Oum Toub	- Oum Toub	179
Collo	- Collo - Beni Zid - Cheraia	229
Zitouna	- Zitouna - Kanoua	102
Ouled Attia	- Ouled Attia - Khenak Mayoune - Oued Zhour	239
Ramdane Djamel	- RAmdane djamel - Beni Bechir	186
El Hadaiek	- El Hadaiek - Bouchetata - Ain Zouit	286
13	**38**	**4118**

ANNEXES

Table: Average temperature of Skikda from 1991 to 2020 **(web site: https://www.climatsetvoyages.com/climat/algerie/skikda)**

Skikda - Températures moyennes (1991-2020)			
Mois	**Min (°C)**	**Max (°C)**	**Moyenne (°C)**
Janvier	9,2	16,6	12,9
Février	9,2	16,6	12,9
Mars	10,8	18,4	14,6
Avril	12,6	20,1	16,4
Mai	15,7	22,9	19,3
Juin	19,1	26	22,5
Juillet	21,9	28,6	25,3
Août	23	29,7	26,3
Septembre	20,6	27,4	24
Octobre	17,4	25,1	21,2
Novembre	13,3	20,7	17
Décembre	10,3	17,8	14,1
An	15,3	22,5	18,85

ANNEXES

Annexes II

Table: Distribution of population and population density by coastal municipalities and Total province since 1977 until 2020

Municipalities	Population 1977	Population 1987	Population 2008	Population 2020	Area Km²
Skikda (coastal)	102 800	130 880	162 349	202 567	52
Hamadi Krouma	8 300	12 599	29 892	37 637	31
Fil Fila (coastal)	5 200	14 032	28 575	35 901	65
El Hadaiek	6 100	8 607	18 091	22 288	48
Bouchtata	6 700	8 115	9 290	11 415	112
Ain-Zouit (coastal)	2 000	2 170	1 997	2 444	108
Ramdane Djamel	13 100	17 511	26 991	36 466	144
Beni Bechir	5 700	6 474	9 734	11 932	42
Collo (coastal)	16 500	24 450	34 045	44 178	24
Beni Zid	11 400	15 836	21 327	25 622	139
Cheraia	8 000	10 557	20 425	23 225	66
Zitouna	5 800	7 821	8 390	10 342	34
Kanoua (coastal)	5 400	7 181	6 967	8 658	68
Ouled Attia (coastal)	7 500	9 688	10 780	13 437	104
Khenak Mayoune (coastal)	2 900	3 629	4 532	5 676	47
Oued Z'hor	5 800	6 946	6 739	8 351	88
Azzaba	25 100	36 031	57 128	70 468	178
Djendel (coastal)	5 000	6 648	8 726	10 714	212
Ain Charchar	7 900	10 593	15 887	19 463	102
Es-Sebt	13 200	14 911	15 080	18 902	244
El Ghedir	4 800	5 402	6 493	7 989	46
Ben Azzouz (coastal)	14 900	19 949	29 858	36 102	239
Bekkouche Lakhdar	9 800	11 909	15 348	18 791	150
La Marsa (coastal)	3 800	4 917	6 118	7 422	112
El Harrouch	21 900	29 688	49 929	60 654	96
Salah Bouchaour	13 900	19 252	29 989	36 851	96
Emjez Edchich	9 800	12 932	20 309	24 855	77
Zardezas	7 600	8 174	8 469	15 546	102
Ouled Habeba	8 900	10 478	12 647	10 363	199
Sidi Mezghiche	11 900	15 677	25 649	31 686	95
Beni Ouelbene	12 700	16 730	25 304	31 039	162
Ain Bouziane	5 300	6 951	9 668	11 872	76139
Tamalous (coastal)	19 900	28 910	50 546	63 467	178
Bin El Ouidene	11 600	14 484	20 893	26 775	104

Kerkera (coastal)	13 300	18 909	27 409	33 648	86
Ain Kechera	11 600	16 730	25 042	30 423	143
Ouldja Boulbalout	4 100	4 252	4 510	5 553	70
Oum Toub	17 400	23 486	34 690	42 658	176
Total coastal municipalities	**207 200**	**281 920**	**392 327**	**487 439**	1 361
Total Wilaya	**467 600**	**622 510**	**899 816**	**1 115 380**	**4 118**
Density of coastal municipalities	**152,2409993**	**207,1418075**	**288,2637766**	**358,1476855**	
Total density	**113,5502671**	**151,1680427**	**218,5080136**	**270,8547839**	

Table: Distribution of tourism expansion zones.

TEA Designation	Municipalities	Area (Ha)
Sidi Akkacha	La Marsa	110
La Marsa	La Marsa	112
Les Ruines Saintes	Djendel	180
Ben M'hidi (platanes)	Skikda - Filfila	206
Grande plage	Ain Zouit	140
Oued Bibi	Tamalous - Ain Zouit	820
Baie de Collo	Collo - Kerkera	400
Tamanart	Cheraia	67
Marsa Ezitoune	Khenak Mayoune	65
Beni said	Collo	600
Hammam Essalhine	Azzaba - Ain Charchar	318
Total		**3018**

Table: Districutio of cultural landmarks in Skikda.

Number	Sites & Landmarks	legal nature	municipalities
1	Dolmen tombs	property of the state	Oued zhour
2	military barracks	property of the Ministry of Culture	Sid Mazeghich
3	Zaouia of Sidi Ali Ben Zouit	endowmen	kerkara
4	Church of Saint Andrew	municipal property	collo

5	Akhmakhem	property of the state	Ouled hbbaba
6	Ain Selamat	private ownership	Ouled hbbaba
7	Dolmen tombs	property of the state	Tamalous
8	Archaeological Site of Oued Bébé (men of the castle)	property of the state	Ain zouit
9	Archaeological Site of Oued Tangier	property of the state	Ain zouit
10	water collection point	property of the state	Skikda
11	the Roman bridge	property of the state	Skikda
12	tunnel dedicated to water conveyance channels	property of the state	Skikda
13	Charles Montaland Urban Complex	privileges	Skikda
14	the ancient mosque	property of Ministry of Religious Affairs	Sid Mazeghich
15	Dolmen tombs	property of the state	Collo
16	Dolmen tombs	property of the state	Kerkera
17	the municipal museum	property of the state	Skikda
18	Al-Qubbah neighborhood	property of the state	Skikda
19	city walls	property of the state	Skikda
20	Ain Am Sadi	property of the state	Bin ouleban
21	Kerara	property of the state	Bin ouleban
22	EL rajouhia	property of the state	Salah Bouchaour
23	Ain Gherab	property of the state	Ramdane Djamel

24	Roman cisterns in Bouiâla	property of the state	Skikda
25	Roman cisterns in Stora	property of the state	Skikda
26	EL Kherba	property of the state	Zerdaza
27	Kermat Ahmed	property of the state	Oum Toub
28	Ouled Djamaa	property of the state	Oum Toub
29	Ain Oum Nahel	property of the state	Es Sebt
30	Lmssad	property of the state	Es Sebt
31	Farfour	property of the state	Es Sebt
32	the Roman dome	property of the state	Skikda
33	Al-Farabi School"	property of the state	Skikda
34	Sidi Nasser Torture Center	property of the state	Ain chachar
35	Al Hamma	property of the state	Ben Azzouz
36	Settaiha Fort	property of the state	Emdjez Edchich
37	Lakssar	property of the state	Ain Kechra
38	Qalaat al-Qala"	property of the state	Ouled hbbaba
39	Lemsadjed	property of the state	Fil Fila

Table: Main industrial activities at the province level.

Existing industrial zones							created projects	
Muncicipality	Total Area (ha)	Available for transfer/	Number	Awarde	Awarded	Available	Total	Operational

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		Lease surfaces (ha)	of lots	d lots	surfaces (ha)	surfaces (ha)	project s	projects
Industrial zone of Hamrouch Hamoudi Municipality of **Hamadi Krouma**	180	141	279	279	141	0	279	267

Table: table of existing industrial zones.

Existing industrial zones							created projects	
Muncicipality	Total Area (ha)	Available for transfer/ Lease surfaces (ha)	Number of lots	Awarded lots	Awarded surfaces (ha)	Available surfaces (ha)	Total projects	Operational projects
Industrial zone of Hamrouch Hamoudi Municipality of **Hamadi Krouma**	180	141	279	279	141	0	279	267

Table: table of existing business/industrial Zones

Communes	Designation of the zone	Total Area (ha)	Available surfaces for transfer/ Lease (M²)	Number of of lots	Awarded Lots	Awarded surfaces (ha)	Available surfaces (ha)		Numb
Skikda	Petite zone	35	24	39	39	24	0		39
	Zef Zef	8,48	3,25	38	38	3,25	0		38
Hamadi krouma	Hamadi krouma secondaire n°6	37	21	10	10	21	0		10
	Hamadi krouma côté ouest	61	40	36	36	40	0		36
Oum Toub	Oum Toub	8	5,35	61	19	1,27	4,08		19
Sidi Mezghiche	Kantalia	2,5404	1,99	19	19	1,99	0		19
	Souk	2,73	7,1	21	21	7,1	0		21
El Harrouch	n° 01 EL Harrouch	4,4	1,52	28	28	1,52	0		28

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	n°03 El Harrouch	6,2	2,31	41	36	2,31	0		36
	n° 02 EL Harrouch	6,78	3,92	30	27	3,64	0,28		27
	EL Harrouch	30	23,79	60	55	20,94	2,85		55
Tamalous	Tamalous	15	6,78	108	76	5,02	1,76		76
Bine el Ouidene	Bine El Ouidene	9,59	2,12	28	22	1,54	0,58		22
Azzaba	Zaouia 01	11,28	9,02	67	67	9,02	0		67
	Zaouia 02	30,58	27,55	35	35	27,55	0		35
	Diar Zitoune	7,9	7,9	7	5	6,65	1,25		5
Ben Azzouz	Boumaiza 1	11,15	9,25	39	39	9,25	0		39
	Boumaiza 2	97,54	78,85	212	24	10,55	68,3		24
Ain Bouziane	Ain Bouzaine	3,44	1,62	16	13	1,38	0,24		13
Ain Charchr	Al Attassa	60,73	32,74	98	96	31,73	10,1		96
	Oued Lekbir	34,75	25,44	66	8	3,03	22,41		8
Ramdane Djamel	Remdan Djemal	9,72	6,44	35	8	1,63	4,81		8
Cheraia	route Beni Zid Cheraia	45,25	22,96	59	0	0	22,96		0

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Table: Landuse data of 2020

	Water		Bare lands		Urban lands		vegetation		Agriculture		Forest lands	
Municipalities	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**
Ain Bouzine	**/**	**/**	**3,98**	**299,79**	**3,45**	**260,56**	**13,87**	**1045,32**	**63,37**	**4773,6**	**15,3**	**1152,57**
Ain charchar	**0,02**	**2,24**	**13,97**	**1564,033**	**3,37**	**377,44**	**29,96**	**3354,13**	**37,09**	**4152,31**	**15,58**	**1744,74**
Ain kechra	**/**	**/**	**2,75**	**396,43**	**2,37**	**342,96**	**10,91**	**1575,44**	**18,42**	**2658,17**	**65,53**	**9456,45**
Ain zouit	**0,06**	**7,1**	**3,18**	**356,75**	**0,47**	**53,46**	**3,19**	**358,82**	**21,65**	**2429,21**	**71,42**	**8011,32**
Azzaba	**0,006**	**1,17**	**10,47**	**1807,73**	**5,14**	**888,25**	**30,02**	**5182,7**	**33,42**	**5770,16**	**20,92**	**3611,32**
Bekkouche lakhdar	**1,63**	**250,13**	**10,02**	**1532,49**	**2,07**	**317,1**	**30,35**	**4638,62**	**47,8**	**7304,07**	**8,09**	**1237,177**
Beni Azouz	**0,25**	**59,3**	**21,94**	**5240,39**	**2,54**	**607,44**	**35,51**	**8482,71**	**31,78**	**7592,69**	**7,96**	**1902,24**
Beni oulbane	**2,56**	**415,07**	**3,64**	**589,31**	**2,11**	**342,8**	**31,26**	**5058,47**	**45,97**	**7440,11**	**14,4**	**2335,7**
Beni zid	**1,82**	**253,96**	**2,83**	**395,16**	**1,54**	**214,99**	**10,07**	**1404,19**	**20,54**	**2864,27**	**63,18**	**8810,42**
Bin el ouiden	**/**	**/**	**2,26**	**240,47**	**2,27**	**241,65**	**26,12**	**2769,45**	**27,64**	**2930,82**	**41,69**	**4421,11**
Bouchetata	**/**	**/**	**3,91**	**444,88**	**1,17**	**133,2**	**8,23**	**934,85**	**29,81**	**3386,25**	**56,86**	**6457,67**
Cheraia	**0,13**	**8,55**	**4,13**	**277,48**	**3,96**	**266,32**	**10,94**	**735,6**	**24,41**	**1641,31**	**56,42**	**3793,11**

Djendel saadi mohamed	**0,013**	**2,88**	**11,41**	**2438,74**	**1,21**	**258,59**	**38,99**	**8331,78**	**15,97**	**3413,16**	**32,4**	**6923,53**
El ghedir	**/**	**/**	**10,15**	**484,74**	**3,92**	**187,32**	**26,18**	**1249,38**	**36,88**	**1759,95**	**22,85**	**1090,14**
El hadaiek	**0,0017**	**0,089**	**4,06**	**207,43**	**5,5**	**281,05**	**11,74**	**599,08**	**41,84**	**2135,55**	**36,84**	**1880,24**
El harrouch	**/**	**/**	**5,23**	**533,02**	**5,85**	**596,65**	**9,17**	**936,07**	**64,52**	**6580,05**	**15,22**	**1552,17**
El marsa	**0,17**	**20,6**	**10,04**	**1166,82**	**2,98**	**346,5**	**29,62**	**3441,97**	**14,35**	**1668,07**	**42,82**	**4976,97**
Emjez edchich	**0,009**	**0,72**	**3,74**	**290,69**	**2,64**	**205,37**	**12,71**	**986,55**	**62,24**	**4831,6**	**18,64**	**1447,07**
Es sebt	**/**	**/**	**7,17**	**1748,47**	**1,41**	**345,14**	**22,97**	**5603,69**	**48,98**	**11949,85**	**19,46**	**4747,27**
Filfila	**/**	**/**	**13,09**	**905,28**	**6,18**	**427,71**	**22,007**	**1520,83**	**5,76**	**398,45**	**52,93**	**3658,29**
Hamadi krouna	**/**	**/**	**12,5**	**457,8**	**13,48**	**493,7**	**15,89**	**581,97**	**25,77**	**943,86**	**32,35**	**1185,002**
Kanoua	**0,05**	**3,51**	**5,23**	**359,97**	**1,62**	**111,68**	**5,04**	**347,11**	**22,37**	**1540,78**	**65,68**	**4523,82**
Kerkera	**0,05**	**4,41**	**3,87**	**330,41**	**3,79**	**323,75**	**13,86**	**1181,9**	**24,49**	**2087,84**	**53,91**	**4594,37**
kheng maoun	**0,05**	**2,61**	**4,31**	**207,47**	**1,8**	**87,07**	**3,39**	**163,53**	**12,82**	**617,74**	**77,6**	**3737,12**
Oued zhour	**/**	**/**	**1,95**	**171,36**	**1,15**	**100,7**	**4,47**	**392,56**	**9,4**	**825,89**	**83,02**	**7290,54**
Ouldja boulbalout	**2,31**	**162,28**	**2,68**	**188,56**	**0,91**	**64,26**	**10,41**	**730,22**	**15,35**	**1076,21**	**68,32**	**4791,33**
Ouled Attia	**0,007**	**0,8**	**2,81**	**302,08**	**1,23**	**133,27**	**3,75**	**403,58**	**16,91**	**1818,25**	**75,27**	**8089,61**

Ouled Hebbaba	**0,00045**	**0,089**	**4,26**	**846,94**	**1,02**	**203,92**	**20,08**	**3983,9**	**52,49**	**10412,61**	**22,12**	**4387,53**
Oum toub	**0,45**	**82,53**	**2,92**	**530,76**	**1,89**	**343,55**	**20,22**	**3669,46**	**20,82**	**3777,38**	**53,67**	**9737,6**
Ramdan djamel	**0,0038**	**0,45**	**4,65**	**541,23**	**3,76**	**437,82**	**17,69**	**2055,66**	**53,75**	**6244,38**	**20,12**	**2337,43**
salah bouchaour	**/**	**/**	**6,18**	**584,18**	**5,09**	**481,49**	**11,76**	**1111,41**	**66,75**	**6305,84**	**10,19**	**963,36**
sidi mezghiche	**/**	**/**	**2,37**	**224,48**	**3,68**	**348,43**	**20,25**	**1916,69**	**43,9**	**4154,64**	**29,78**	**2818,15**
Skikda	**0,05**	**2,97**	**21,51**	**1192,73**	**29,92**	**1659,75**	**11,03**	**611,67**	**23,45**	**1300,58**	**14,029**	**778,02**
Tamalous	**0,003**	**0,63**	**2,67**	**474,086**	**2,9**	**515,84**	**17,52**	**3108,2**	**23,12**	**4100,47**	**53,76**	**9532,66**
Zerdeza	**0,015**	**1,53**	**8,26**	**825,25**	**2,14**	**214,18**	**22,15**	**2212,15**	**47,78**	**4772,48**	**19,64**	**1962,06**
Zitouna	**/**	**/**	**3,15**	**132,58**	**2,64**	**111,25**	**7,03**	**295,51**	**27,83**	**1169,7**	**59,33**	**2493,24**
Beni bachir	**/**	**/**	**5,84**	**258,35**	**3,57**	**158,19**	**20,18**	**892,74**	**20,16**	**891,39**	**50,23**	**2221,38**
colo	**0,27**	**6,31**	**12,52**	**278,15**	**16,59**	**368,73**	**10,69**	**237,54**	**26,98**	**599,43**	**32,92**	**731,35**
Total coastal municipalities	**1,103**	**119,67**	**118,66**	**13701,716**	**76,34**	**5260,81**	**210,007**	**29317,8**	**273,46**	**30033,87**	**720,139**	**68542,95**
Total non-coastal	**8,82595**	**1170,258**	**136,99**	**15124,773**	**80,99**	**7591,27**	**439,22**	**52787,65**	**953,12**	**108285,25**	**780,31**	**82841,129**

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municipalities												
Total wilaya	**9,92895**	**1289,928**	**255,65**	**28826,489**	**157,33**	**12852,08**	**649,227**	**82105,45**	**1226,58**	**138319,12**	**1500,449**	**151384,08**

Table: Urban land areas in Skikda in 1990, 2000, 2010,2020.

Urban lands area (Ha)	1990	2000	2010	2020
Total coastal municipalities	1190,06	1662,9	2232,28	5260,81
Total non-coastal municipalities	1040,413	1805,58	4069,901	7377,09
Total wilaya	3387,63	5131,38	6302,181	12637,9
Total surface of municipality	411500	411500	411500	411500

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Annexe III

Table: Main indicators of the water sector

Relevant elements	**Data**
Total mobilizable water capacity	155 204 000 M3
Global water capacity mobilized	93 177 000 M3
Number of dams	4
Dam capacity	290 667 000 M3
Number of small dams	13
Small Damms Capacity	1 410 000 M3
Drill numbers	161
Drill capacity (Production volume)	45 000 M3
Number of household connections to the network (DWS)	207 456
Average drinking water consumption per capita	157/Litres/day/capita
Overall rate of connection to the network - DWS	94,34%
Loss rate in the network - DWS	40%
Number of wastewater treatment plants	1
Overall rate of connection to the sewerage system	87,33%

Table: Main indicators of the agricultural sector

Designation	Data
Total agricultural area	193 023 Ha
Total UAA	131 829 Ha
Irrigated UAA	28 550 Ha
Number of sheep	253 028
Number of cattle	139 688
Goats	130 774
Poultry farming (number of battery cages)	44
Afforestation rate	48,18%
Number of dairies	3
Annual milk production	149 693 Hl
Total agricultural area / Total land area	0,68 %
Irrigated UAA / Total UAA	21,66 %

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Table: Agriculture are in Skikda's municipalities.

Municipalities	**Agriculture Area**
Skikda (coastal)	2209
Hamadi Krouma	2768
Fil Fila (coastal)	1010
El Hadaiek	3728
Bouchtata	3272,5
Ain-Zouit (coastal)	2870
Ramdane Djamel	9040
Beni Bechir	2319,5
Collo (coastal)	1339
Beni Zid	3192
Cheraia	2385
Zitouna	1461
Kanoua (coastal)	3157
Ouled Attia (coastal)	801
Khenak Mayoune (coastal)	600
Oued Z'hor	1304
Azzaba	9092,4
Djendel (coastal)	7056,54
Ain Charchar	6231,75
Es-Sebt	13018,5
El Ghedir	3510,5
Ben Azzouz (coastal)	15135
Bekkouche Lakhdar	8589
La Marsa (coastal)	3099,31
El Harrouch	7513
Salah Bouchaour	8551
Emjez Edchich	6018
Zardezas	6029
Ouled Habeba	14072
Sidi Mezghiche	7997
Beni Ouelbene	7027

Ain Bouziane	6029
Tamalous (coastal)	8351
Bin El Ouidene	5000
Kerkera (coastal)	1994
Ain Kechera	2461
Ouldja Boulbalout	1200
Oum Toub	5690
Total coastal municipalities	**50006,85**
Total Wilaya	**193024**

Table: Forest areas by municipalities.

Municipalities	**Forests (ha)**
Skikda (Coastal)	995,56
Hamadi Krouma	1871,43
Fil Fila (Coastal)	5537,68
El Hadaiek	1738
Bouchtata	9149,52
Ain-Zouit (Coastal)	3853
Ramdane Djamel	70
Beni Bechir	2075,61
Collo (Coastal)	1102
Beni Zid	12231
Cheraia (Coastal)	5146
Zitouna	3316,5
Kanoua (Coastal)	6721
Ouled Attia (Coastal)	10255,2
Khenak Mayoune (Coastal)	4298,5
Oued Z'hor	8176,5
Azzaba	10028,63
Djendel (Coastal)	16059,73
Ain Charchar	4537,31
Es-Sebt	7426,23
El Ghedir	1425
Ben Azzouz (Coastal)	7949
Bekkouche Lakhdar	5738
La Marsa (Coastal)	4196
El Harrouch	
Salah Bouchaour	303

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Emjez Edchich	1 800
Zardezas	4 099
Ouled Habeba	6 025
Sidi Mezghiche	1 360
Beni Ouelbene	2 577
Ain Bouziane	1 030
Tamalous (Coastal)	8667,34
Bin El Ouidene	4225,9
Kerkera (Coastal)	4 820,76
Ain Kechera	10 668,87
Ouldja Boulbalout	6 862,87
Oum Toub	12 082,71
Total coastal municipalities	**79 601,77**
Total province	**198420**

Table: Controlled landfills in Skikda .

Number	Facilities	Area (Ha)	Municipality	Localisation	Number of trenches	Maximum capacity (m^3)
1	Sanitary Landfill Facility	11	EL Hadaiek	Zef zef	(02) trenches saturated	370000
2	Monitored Landfill	17	Azzaba	Zaouia	02 trenches, one has been closed and the second is about 60% full	135000
3	Monitored Landfill	20	Tamalous	Hermala	(03) trenches about 2% full	205000
4	Monitored Landfill	12	Ben Azzouz	Dem El Bagrat	(01) trenche about 5%	130000
5	Monitored Landfill	20	El harrouch	El Machmach	(02) trenches with a completion rate of 75%	250000
6	Inert Waste Disposal Center	9	Skikda	Bouabaz	Saturated (01) Closed since 2015	Closed since 2015

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Table : Uncontrolled landfills

Number	Municipality	Localisation
1	El Harrouch	El Machmach
2	Salah Bouchaour	Bordj Aghlal
3	Emjez Edchich	Ain halouf
4	Zardezas	El Mohgon
5	Ouled Habeba	Bousnib
6	Collo	Boumhadjar
7	Bni Zid	Oum Zghaida
8	Cheraia	Laarakab
9	Tamalous	Lahjar Lazrag
10	Bin El Ouidene	Lamsayer
11	Sidi Mezghiche	El Kiran
12	Ain Bouziane	Prés de l'autourout Est-Ouest
13	Bni Ouelbane	Djnen El Annab
14	Zitouna	Lemjelba
15	Kenoua	El Magtouaa
16	Ouled Attia	Bounaghza
17	Khenak Mayoune	El Medoud
18	Oued Zhor	Echouf
19	La Marsa	Soulet Touba
20	Bekkouche Lakhdar	Tabba Nouara
21	Ain Zouit	El Ayfat
22	Oum Toub	Beni Ghesdoune
23	Ain Charchar	El kalitous

Engineering consultancy for the assessment of the vulnerability in coastal areas

Business Model Canva

VII.The key partners :

- Government Agencies.
- Universities and Research Institutions
- Private Companies.
- External Experts and Consultants.

V.The key activities :

- Data Collection.
- Numerical Modeling.
- Risk Analysis.
- Vulnerability Assessment.
- Adaptation Recommendations.
- Reports and Presentations.
- Scientific and Technological Monitoring.

VI.The Key resources :

- Technical Expertise.
- Data and Information.
- Modeling Software and Tools.
- Field Equipment.
- Collaboration Networks.
- Reputation and Client Relationships.

I. Value propositions :

- Vulnerability identification.
- Recommendations for resilience.
- Specialized expertise.
- Communication and awareness: Facilitate communication and raise awareness among relevant stakeholders about the risks and protective measures in coastal areas.

III.The client relationships:

- Deep understanding of needs.
- Close collaboration
- Transparent communication
- Support and technical assistance.

IV.Potential distribution channels:

- Online Marketing.
- Professional Networks.
- Trade Shows and Conferences.
- Direct Proposals to Clients.
- Collaboration with Local Partners.

II. The Customer segments :

- Government Organizations (Ministry of Environment).
- Development Agencies.
- Environmental and Research Organizations. (National Economic and Social Environment Council- NESEC)
- Educational and Research Institutions (Enssmal).

VIII.The cost structures:

fixed costs:

- Human Resources.
  Salaries (50000 Da for one Engineer*2=100000Da)/one mouth.
- Software and Licenses. (ArcGIS 60000 Da)/one year. (Printer 750000Da). (Pc 32Gb 250000Da).
- Equipment and Technology (Rental 35000Da*36=1260000Da). (Management of the seat 100000Da).
- Research and Development.Train Exit (25000 Da. for one Engineer*4=100000 Da).
- Invoice 26 %.
- TVA /Taxes.

Variable costs:

- External Services
  (Formation GIS 15000).
- Communication and Marketing.
  For media: (Facebook 10000 Da /one mouth). (Oued Kniss 10000 /one mouth)

2655000Da

IX The revenues:

- Sale of Data and services(300000Da) in local project,
  In big zones + 100000 for the Ha and +200000 in distance).
- Research and Development Projects (20000Da for one formation).
- Vulnerability Studies and Assessment (it depends on the calculus from 250000 Da).
- Consultation and Advisory Services.

It’s going to be *2 the coasts in the first year.
And we use them for widen the project (Rolling Stock).

I. value propositions

1. Vulnerability identification:

Identify specific vulnerabilities of coastal areas, such as critical infrastructure, natural habitats, residential communities, economic activities, etc. This allows clients to prioritize actions for strengthening and protecting the most exposed areas.

2. Recommendations for resilience:

Provide specific recommendations to enhance the resilience of coastal areas against the identified risks. This may include land-use strategies, adaptation measures, coastal protection techniques, evacuation plans, etc.

3. Emergency planning:

Assist clients in developing appropriate emergency plans for disasters or emergency situations related to coastal areas. This may include evacuation protocols, early warning systems, communication plans, etc.

4. Specialized expertise:

Bring specialized expertise in the analysis of coastal areas, including the use of numerical models, geospatial data, risk assessment techniques, etc. This ensures high-quality assessments and recommendations based on scientific data.

5. Regulatory compliance:

Assist clients in complying with environmental regulations and specific construction standards related to coastal areas. This helps reduce legal risks and ensures the sustainability of coastal projects.

6. Communication and awareness:

Facilitate communication and raise awareness among relevant stakeholders about the risks and protective measures in coastal areas. This promotes a collaborative approach and shared understanding of the issues.

II. customer segments

1. Government Organizations:

Ministries and government departments responsible for risk management, civil security, environment, urban planning, etc. (Ministry of Environment).

Agencies involved in emergency planning and disaster preparedness for natural or man-made hazards.

Regulatory bodies involved in setting safety and construction standards.

2. Development Agencies:

Agencies responsible for urban planning and housing construction.(the promoters).

3. Insurance and Risk Management Agencies:

Insurance organizations working with the government to assess risks related to natural disasters or cyberattacks. (GIZ).

Agencies responsible for risk assessment for public insurance programs.

4. Environmental and Research Organizations:

Government or non-profit organizations focused on environmental protection that may require vulnerability assessments related to environmental risks.

5. Local Communities:

Municipalities and local councils seeking to assess the vulnerability of their infrastructure and develop emergency plans for their community.

6. Educational and Research Institutions:

Universities and research institutes working on projects related to risk management, resilience, and vulnerability. (ENSSMAL…).

7. Other Consultancies and Consultants:

Engineering, environmental, or security consultancies seeking to outsource vulnerability assessment services.

III. The client relationships

1. Deep understanding of needs:

Establish close communication with clients to understand their specific needs in terms of assessing vulnerability in coastal areas. This may involve initial meetings, in-depth discussions, and regular exchanges to align project expectations and objectives.

2. Close collaboration:

Work closely with clients throughout the vulnerability assessment process. This may involve joint working sessions, regular information exchanges, and active client participation in data collection and validation of results.

3. Transparent communication:

Maintain transparent communication with clients by regularly sharing updates on project progress, preliminary findings, potential issues, and recommendations. This can be done through progress reports, follow-up meetings, and exchanges via email or phone.

4. Presentation of results:

Provide detailed and clear reports on the vulnerability assessment findings in coastal areas. These reports should include the methodologies used, analyzed data, key conclusions, relevant maps and graphs, as well as specific recommendations for enhancing coastal area resilience.

5. Support and technical assistance:

Offer support and technical assistance to clients to help them interpret the results, understand the implications of vulnerability assessments, and implement recommendations. This may include training sessions, additional meetings to clarify questions, and personalized guidance based on the specific needs of the client.

6. Ongoing monitoring:

Maintain a long-term relationship with clients by ensuring regular follow-up after the delivery of the final report. This may include periodic exchanges to assess the effectiveness of implemented resilience measures and address new client questions or concerns.

IV. Potential distribution channels

1. Online Marketing:

Utilize a professional website to showcase the consultancy's services and provide detailed information on vulnerability assessments of coastal areas. Also, employ search engine optimization (SEO) strategies to improve online visibility and attract potential clients through search engines.

2. Professional Networks:

Develop partnerships with other industry professionals, such as environmental consultants, architects, urban planners, or government agencies involved in coastal risk management. These partnerships can provide referrals and facilitate access to new clients.

3. Trade Shows and Conferences:

Participate in professional trade shows, conferences, and events related to integrated coastal zone management. This provides an opportunity to present the consultancy's services, establish contacts with potential clients, and stay updated on the latest trends and advancements in the field.

4. Specialized Publications:

Contribute to specialized journals and scientific publications in the field of coastal risk management. This enhances the consultancy's credibility and reaches a targeted audience of decision-makers and industry experts.

5. Direct Proposals to Clients:

Identify organizations and government agencies involved in integrated coastal zone management and directly propose your services. This can be done through presentations, letters of interest, or customized business proposals.

6. Referrals and Recommendations:

Ensure to obtain positive referrals and recommendations from satisfied clients. Client testimonials can be used on the consultancy's website and in marketing materials to build trust and attract new clients.

7. Collaboration with Local Partners:

Establish partnerships with local businesses or consultancies that complement your services. This can help expand your geographical reach and access new markets.

8. Social Media:

Utilize relevant social media platforms to promote your services, share information about coastal risks, engage with potential clients, and establish a strong online presence.

V. The key activities:

1. Data Collection:

Gathering relevant geographical, geological, oceanographic, climatic, and socio-economic data for the assessment of coastal area vulnerability. This may involve using primary sources such as field surveys, satellite data, existing databases, socio-economic surveys, etc.

2. Numerical Modeling:

Utilizing numerical models to simulate coastal processes such as erosion, flooding, submergence, storms, etc. This may involve using hydrodynamic models, wave propagation models, sediment transport models, etc., to estimate potential impacts on coastal areas.

3. Risk Analysis:

Assessing the risks associated with coastal areas by identifying potential threats such as storms, tides, sea-level rise, coastal erosion, etc. This may include quantitative risk analysis using appropriate methodologies to assess the probability and impact of extreme events.

4. Vulnerability Assessment:

Evaluating the vulnerability of coastal areas by integrating the collected data, modeling results, and risk analysis. This may involve identifying vulnerable elements such as critical infrastructure, sensitive ecosystems, residential communities, economic activities, etc.

5. Adaptation Recommendations:

Providing specific recommendations to enhance the resilience of coastal areas in response to identified risks. This may include adaptation measures such as land management, coastal protection infrastructure, land-use strategies, evacuation plans, etc.

6. Reports and Presentations:

Preparing detailed technical reports and presentations to communicate the results of the coastal area vulnerability assessment to clients, stakeholders, and decision-makers. These reports should include analysis, maps, graphs, recommendations, and proposed mitigation measures.

7. Stakeholder Collaboration:

Working closely with stakeholders such as government agencies, NGOs, local communities, environmental experts, etc., to incorporate their knowledge and needs into the vulnerability assessment and facilitate a collaborative approach to coastal risk management.

8. Scientific and Technological Monitoring:

Staying up-to-date on the latest scientific advancements, new methodologies, numerical models, and calculation tools used in the assessment of coastal area vulnerability.

VI. The resources:

1. Technical Expertise:

Qualified professionals with technical expertise in vulnerability assessments, including expertise in geography, geology, oceanography, climatology, numerical modeling, risk analysis, etc.

2. Data and Information:

Reliable and up-to-date databases on the geographic, geological, climatic, oceanographic, and socio-economic characteristics of coastal areas. This may include topographic data, tidal and current data, climate data, demographic data, information on existing infrastructure, etc.

3. Modeling Software and Tools:

Specialized software and numerical modeling tools to simulate coastal processes, assess risks, and estimate the vulnerability of coastal areas. This may include hydrodynamic modeling software, geospatial data processing tools, risk assessment software, etc.

4. Field Equipment:

Equipment necessary for collecting field data, such as wave measurement instruments, GPS devices, drones for aerial mapping, sediment samplers, etc.

5. Access to Information Sources:

Agreements or partnerships with institutions, government agencies, or organizations that can provide additional data or specialized information relevant to vulnerability assessments of coastal areas.

6. Collaboration Networks:

Partnerships with other experts, consultancy firms, government agencies, universities, research laboratories, etc., to exchange knowledge, share resources, and collaborate on specific projects.

7. Funding:

Financial resources to support research activities, data collection, modeling, and risk analysis necessary for vulnerability assessments of coastal areas.

8. Reputation and Client Relationships:

A strong reputation based on successful previous projects, positive references, and established relationships with clients, stakeholders, and decision-makers in the field of coastal risk management.

VII. The key partners

1. Government Agencies:

Government agencies responsible for natural resource management, environmental protection, land use planning, urban planning, coastal protection, etc. They can provide guidelines, regulations, data, and financial support for vulnerability assessments of coastal areas.(The National Agency for Support and Development of Entreneurship ANADE).(Ministry of Knowledge Economy, Startups and Microenterprises).

2. Non-Governmental Organizations (NGOs):

NGOs working in the fields of environment, conservation, risk management, sustainability, etc. They can contribute expertise, additional resources, specific data, and partnerships to strengthen vulnerability assessments of coastal areas.(Together for Blue and Green).

3. Universities and Research Institutions:

Universities, research laboratories, and other academic institutions conducting studies in environmental sciences, geology, oceanography, climatology, numerical modeling, etc. They can contribute to knowledge advancement, applied research, and validation of methodologies used in vulnerability assessments. (ENSSMAL).

4. Private Companies:

Companies specializing in related fields such as coastal engineering, mapping, remote sensing, construction, etc. They can bring complementary technical expertise, material resources, and collaboration opportunities for projects related to vulnerability assessments of coastal areas.

5. Local Communities:

Local communities living in coastal areas and local interest groups can provide valuable knowledge and understanding of local issues, perceived impacts, traditional practices, as well as specific needs and priorities in coastal risk management.

6. Clients and Stakeholders:

Clients who seek the services of the consultancy, such as government agencies, local authorities, property developers, businesses, etc. Stakeholders also include community organizations, environmental groups, professional associations, and other parties interested in coastal risk management.

7. External Experts and Consultants:

Independent experts, specialized consultants, and other professionals who can provide additional expertise, technical advice, or expert opinions in specific areas related to vulnerability assessments of coastal areas.

Collaboration with these key partners can enhance capabilities, improve the quality of vulnerability assessments of coastal areas, provide access to additional resources, and facilitate an integrated approach to coastal risk management.

VIII. The cost structure

Fixed Coasts:

1. Human Resources:

Costs related to salaries, benefits, training, including technical experts, data analysts, modelers, researchers, project managers, etc.

(Salaries for in 50000 Da).

2. Software and Licenses:

Costs associated with acquiring, licensing, and updating specialized software used for numerical modeling, risk analysis, mapping, etc.
(ArcGIS 60000 Da).
(Printer 750000Da).
(Pc 32Gb 250000Da).

3. Equipment and Technology:

Costs of purchasing, maintaining, and upgrading equipment and technologies necessary for field data collection, numerical modeling, risk analysis.
(Rental 35000Da*3).
(Management of the seat 100000Da).
(Microsoft 2021 Professional Office 50000 Da).

4. Data and Information:

Costs related to acquiring relevant data and information for vulnerability assessments, including topographic data, oceanographic data, climate data, socio-economic data, etc. This may involve purchasing data from external providers or incurring costs for field data collection.

5. Research and Development:

Costs associated with research and development of new methodologies, models, analysis techniques, etc., to enhance the vulnerability assessment capabilities of the consultancy.

Train Exit (15000 Da).
With Invoice about 26%
And 15% and 1.5%

Variable Coasts

6. External Services:

Costs related to external services such as subcontracting certain specialized tasks, consulting external experts, laboratory analysis, translation services, etc.

7. Communication and Marketing:

Costs associated with communication, promotion, and marketing of the consultancy's services, including website design, participation in conferences, printing promotional materials, etc.

IX. The revenues

1. Research and Development Projects:

Revenues can come from participation in research and development projects funded by government institutions, international agencies, foundations, etc. These projects may focus on developing new methodologies, creating advanced models, technological innovation, etc. (it’s depending on the project, zone, distance).

2. Vulnerability Studies and Assessments:

The consultancy can generate revenues by conducting vulnerability studies and assessments for clients such as local governments, natural resource management agencies, real estate developers, private companies, etc. These studies may involve identifying risks, mapping vulnerability, estimating impacts, recommending adaptation measures, etc.

3. Consultation and Advisory Services:

The consultancy can provide consultation and advisory services to clients to help them develop coastal risk management strategies, assess the effectiveness of existing measures, develop adaptation plans, etc. These services can be billed on an hourly basis, per project, or as a package.

4. Training and Awareness Programs:

The consultancy can offer training and awareness programs on coastal risk management, understanding vulnerability, best adaptation practices, etc. Revenues can come from participant fees or training contracts with organizations or institutions.

5. Sale of Data and services:

The consultancy can generate revenues by selling products or data derived from its studies, such as technical reports, vulnerability maps, specific databases, software tools, etc.

6. Grants and External Funding:

The consultancy can obtain revenues in the form of grants, external funding, or research contracts with government agencies, international organizations, foundations, etc., to support its research and development activities or specific projects.

It is important to note that revenues may vary depending on the size of the consultancy, its reputation, client network, ability to win projects, market competitiveness, etc.

It’s going to be *3 of coasts.