FACULTE DES SCIENCES AIN CHOCK
UNIVERSITE HASSAN II DE CASABLANCA

REPORT OF WWTP

ESSAOUIRA'S LIQUID LEGACY: SUSTAINING PURITY, SHAPING TOMORROW

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DEDICATION

I want to start by expressing my deepest gratitude to my advisor, Prof. Hassan Rhinane, for his invaluable guidance, patience, enthusiasm, and extensive knowledge. His support and mentorship played a crucial role in the successful implementation of this project.

Additionally, I extend my thanks to all those who have offered me help, encouragement, and support throughout this journey.

Finally, I want to sincerely thank my family and friends. They have consistently been a steadfast source of support and motivation for me. Their unwavering encouragement and belief in my abilities have been indispensable, and I cannot thank them enough for their love and support.

INTRODUCTION

Water, often described as our planet's most vital and irreplaceable resource, transcends geographical boundaries, compelling us to embrace a collective responsibility for its preservation and sustainable management. Over the past decade, a notable global shift in consciousness has turned the spotlight toward safeguarding water resources and prioritizing public health, fostering a surge in investments directed at the development and enhancement of wastewater treatment plants (WWTPs) on an international scale.

Morocco, with its diverse landscapes, rich cultural heritage, and historical significance, has also embraced this movement. The country has embarked on a purposeful journey to strengthen its wastewater treatment infrastructure. This initiative signifies a pivotal step in aligning with global sustainability objectives and ensuring the continued well-being of its citizens and ecosystems. Since Morocco has embarked on a transformative journey outlined in the National Liquid Sanitation and Wastewater Treatment Programme (PNA), a visionary initiative launched in 2005, demonstrates Morocco's commitment to this cause, with a significant investment of 52 billion dirhams (equivalent to US$5.2 billion) allocated by 2030, underscoring the nation's steadfast dedication to strengthening its wastewater treatment infrastructure. This multifaceted strategy not only prioritizes the construction and modernization of wastewater treatment plants (WWTPs) but also emphasizes the expansion and enhancement of sanitation networks across the country. By investing substantially in the critical aspects of wastewater management, Morocco demonstrates a resolute dedication to advancing both its citizens' well-being and the preservation of its natural ecosystems.

In the coastal city Essaouira, a vibrant blend of history and modernity, the establishment of a Wastewater Treatment Plant (WWTP) reflects the city's commitment to environmental sustainability and public health. With urbanization and an increasing number of tourists, Essaouira recognizes the urgent need for responsible wastewater management. This crucial facility symbolizes not just infrastructural progress but an essential step toward preserving the environment, conserving resources, and safeguarding public health amidst the city's growth.

The WWTP's role transcends infrastructure; it embodies Essaouira's dedication to mitigating the environmental impact of urban expansion. By treating wastewater before release, this plant safeguards fragile ecosystems and addresses the health risks posed by increasing urban density and tourism. It reflects a holistic approach to sustainable development, ensuring a cleaner environment for both residents and visitors while balancing the demands of progress with environmental preservation.

To ensure Project WWTP’s success and regional benefit, the following plan will outline our approach to studying and analysing how Project WWTP can achieve its goals and positively impact:

Chapter I: The study area: Essaouira city.

Chapter II: Materials, Methods and Results.

Conclusion.

Chapter I:

The study area: Essaouira city.

1. Introduction:

In this chapter we are going to explore the selected study area in bout geological and demographical aspect which will bring as to form a shaped understanding about Essaouira and it’s need for a WWTP.

1.1 Location and Geographical Description of Essaouira:

The late-18th-centry town in the eastern Morocco, Essaouira is rugged terrain on the western slopes of the high Atlas Mountains meets the Atlantic Ocean on the west, bounded by Safi Province to north, Agadir Province to the south, and Chichaoua Province to the east (as mentioned in figure1).

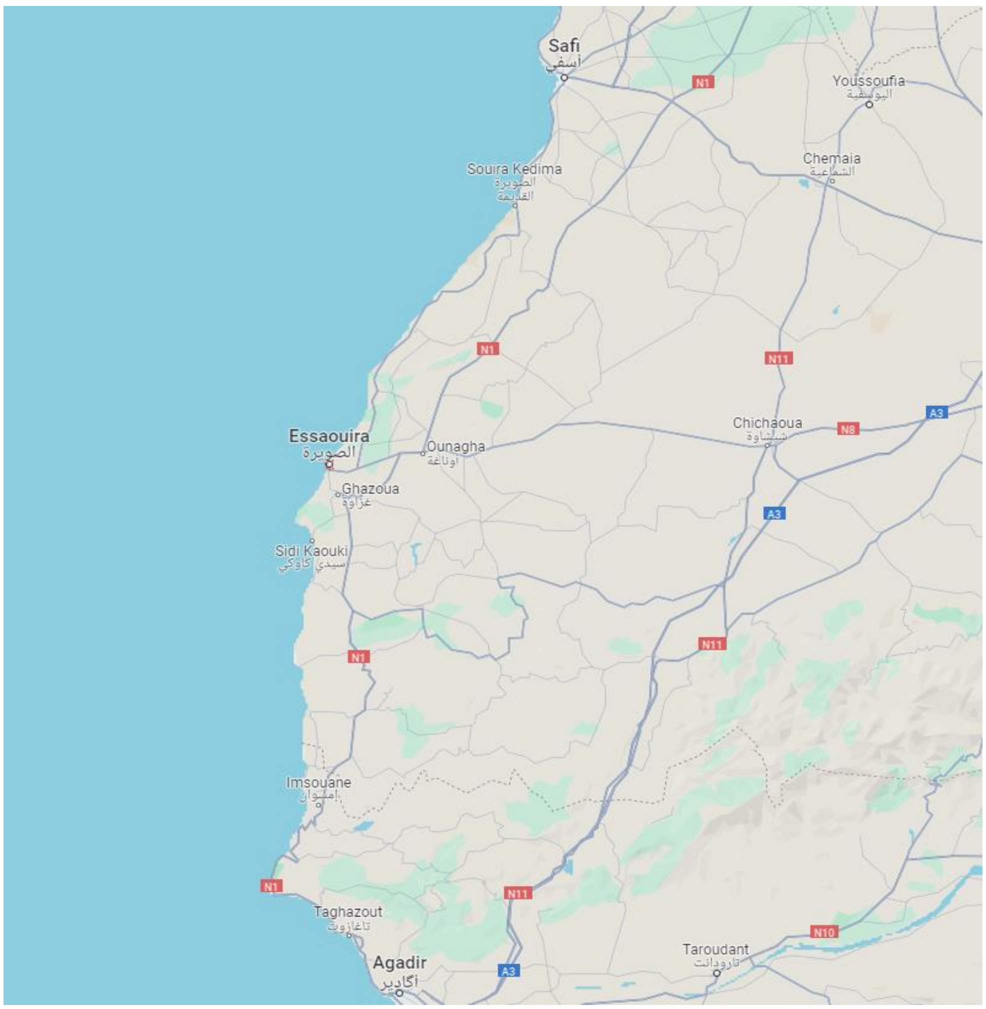

Figure 1: The location of Essaouira city in Morocco

Geographically Essaouira lies on the Atlantic coast of Morocco, with coordinates 31º 31’ North and 9º 46’ west, this beautiful city covers an area of 18 sq Km, in the larger Essaouira province, which has an area stretched across 7,000 sq km.

The geological map of Essaouira: are used to represent the distribution of rock formation, faults, folds, and other geological features, that often provide insights into the subsurface based on the age, type, and structure of the rocks at the earth's surface (as mentioned in figure 2).

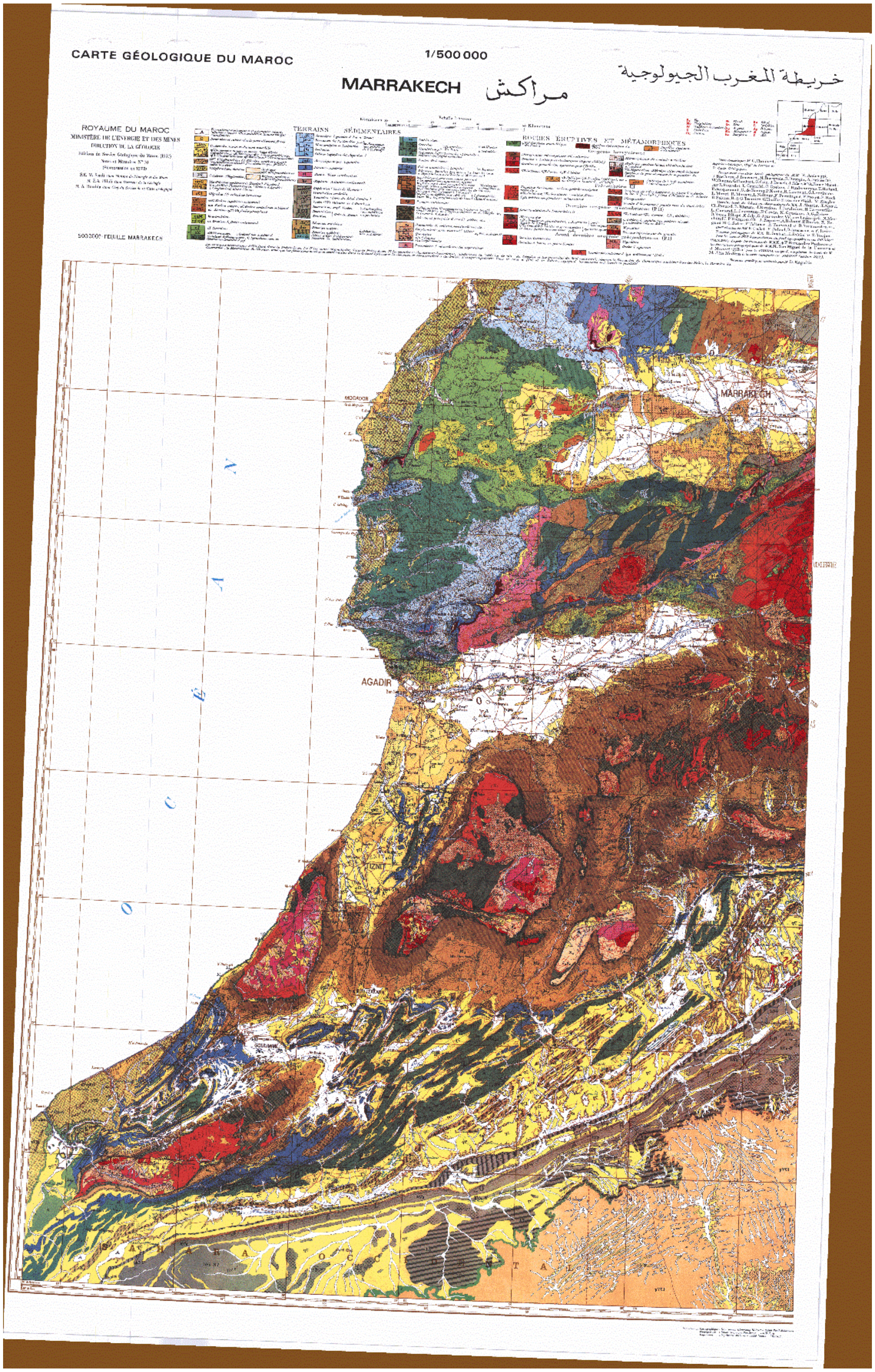

Figure 2: geological map of Essaouira City

Topographic map: allows the understanding of the lay of the land, identify valleys, ridges, cliffs, and other topographical features, which is crucial for various applications like land-use planning, and infrastructure development, since it provides an accurate measurement of distance, areas, and slopes (as mentioned in figure 3).

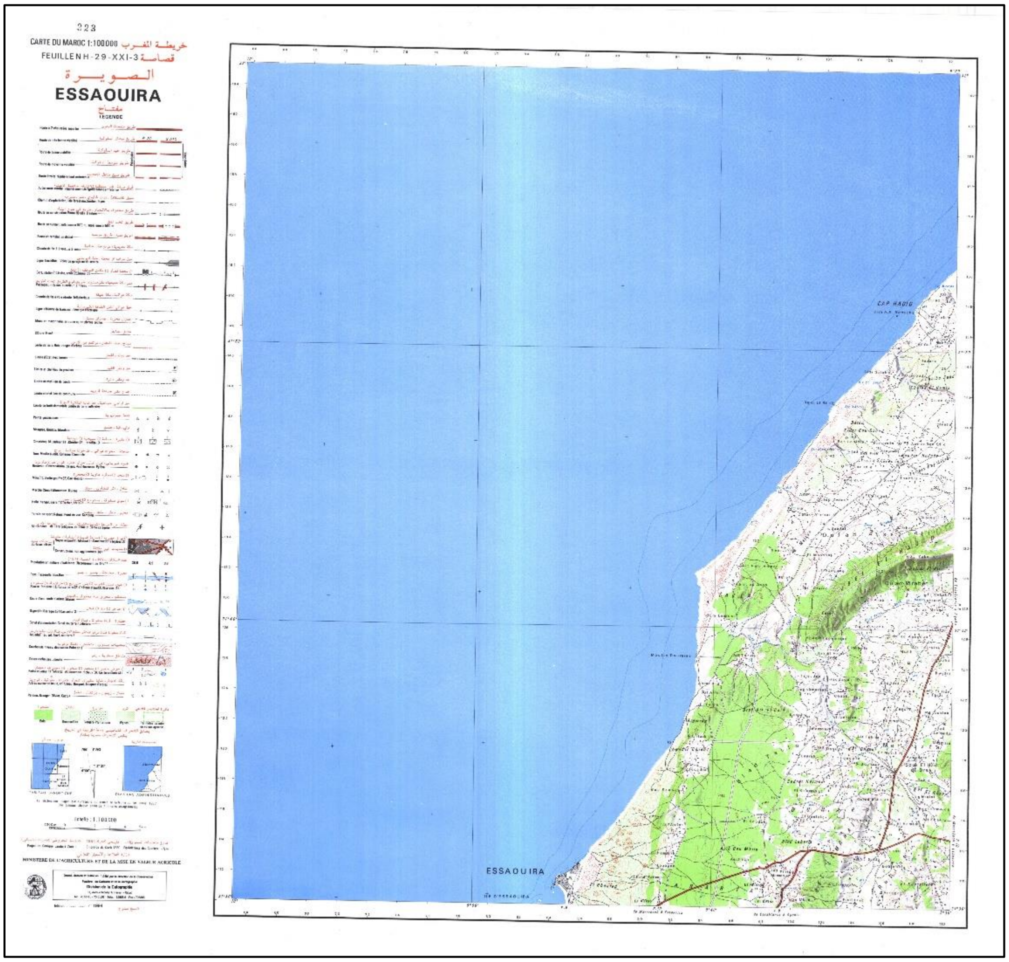

Figure 3: topografic map of Essaouira

1.2 Demographics of Essaouira:

Population Size and growth:

With an estimated population to be over 77,000, the city is experiencing a steady growth in the recent years, driven by tourism especially, trade, and migration from the rural areas.

Activity and Employment:

The city has a variety of industries and sectors that contributes to its economy, such as fishing, crafting, and mainly tourism, these are the city’s key economics drivers.

Hotels, restaurants, transportation, and tour operators, these services are provided by a wide range if not the vast majority of the companies, with a booming visitor number only in 2023 Essaouira tripled it compared to previous summers, welcoming only in July over 26,000 tourists with an increase 42% compared to 2019. Fishing also employs a sizable section of the local population, from exporters to fishermen. The crafts industry is supported by many craftsmen and small enterprises. There are also other industries that contributes to the city's economy such as commerce, and construction. Having an expanding infrastructure and strategic position that makes it appealing to firms and investors especially in the renewable energy industry. Although the unemployment rate and the underemployment continue to rise (as shown in figure 4)., particularly for the youth.

1.3 Climate and Resources of Essaouira

Essaouira "the windy City" unique and delightful climate, characterized by the mild temperatures year-round,

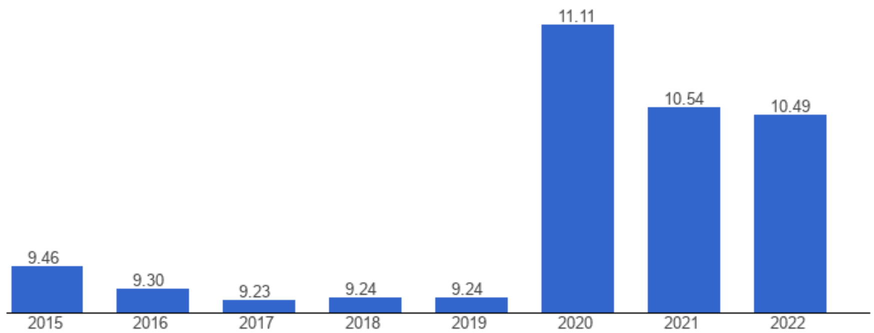

Figure 4: Chart of the unemployment rate

with a variant humidity, true to its nickname, the city is known for its constant, refreshing breezes, especially in the summer.

a. Temperature:

The hot season starts from July 6th to September 25th, with sizzling highs above 24°C. In August, the hottest month, with average highs of 25°C and lows of 20°C. from December 1st to March 5th brings the cool season,

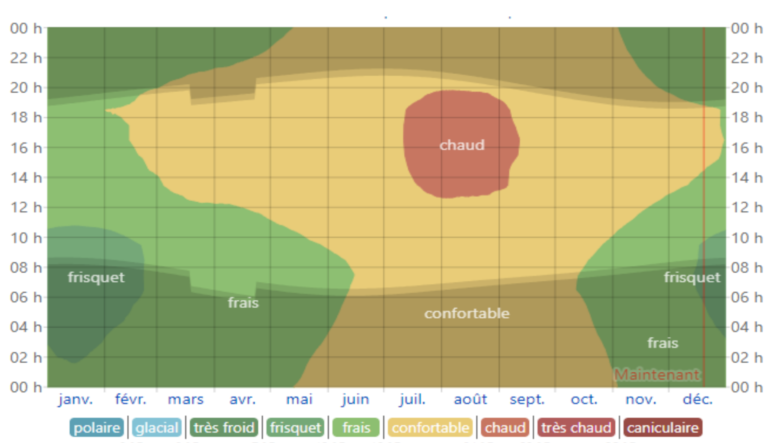

Figure 5: Average Hourly Temperature in Essaouira

with average highs below 20°C. January, the coolest month, offers crisp mornings at 10°C, though afternoons still reach a pleasant 19°C (as mentioned in figure 5).

b. Rain:

The rainy season of the year lasts 6.2 months, from October 12 to April 17, with a rainfall of at least 13 millimeters over a 31-day rolling period. The wettest month in Essaouira is November, with an average rainfall of 36 millimeters. The dry season of the year lasts 5.8 months, from April 17 to October 12 (as mentioned in figure 6). The driest month in Essaouira is July, with an average rainfall of 0 millimeters.

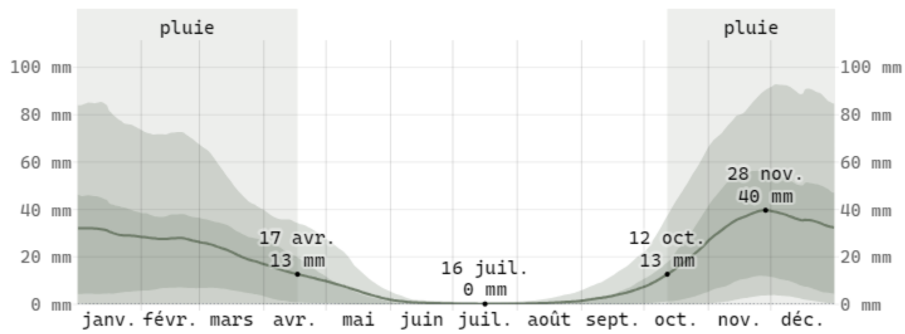

Figure 6: Average monthly rainfall in Essaouira

c. Wind:

The windiest period of the year in Essaouira lasts 4.8 months, from April 7 to September 1, with average wind speeds above 20.8 kilometers per hour. July is the windiest month of the year in Essaouira, with an average hourly wind speed of 23.7 kilometers per hour.

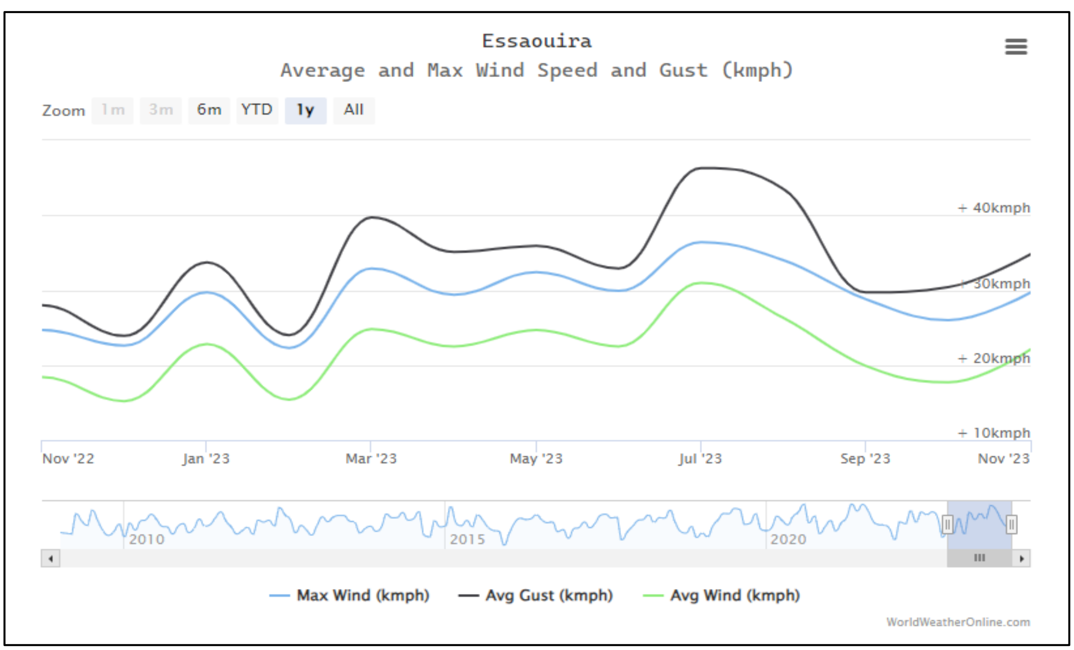

Figure 7: the average, max, and min wind speed and gust in Essaouira

The calmest period of the year lasts 7.2 months, from September 1 to April 7 (as mentioned in figure 7). October is the calmest month of the year in Essaouira, with an average hourly wind speed of 17.5 kilometers per hour.

d. Humidity:

Essaouira has a very humid climate, with the humidity perceived as heavy, oppressive, or suffocating for at least 20% of the time during the summer months of June to October. The heaviest month is August, with 24.7 days of heavy or oppressive humidity. The least humid month is February, with only 0.1 day of heavy or oppressive humidity (as shown in the following figure 8).

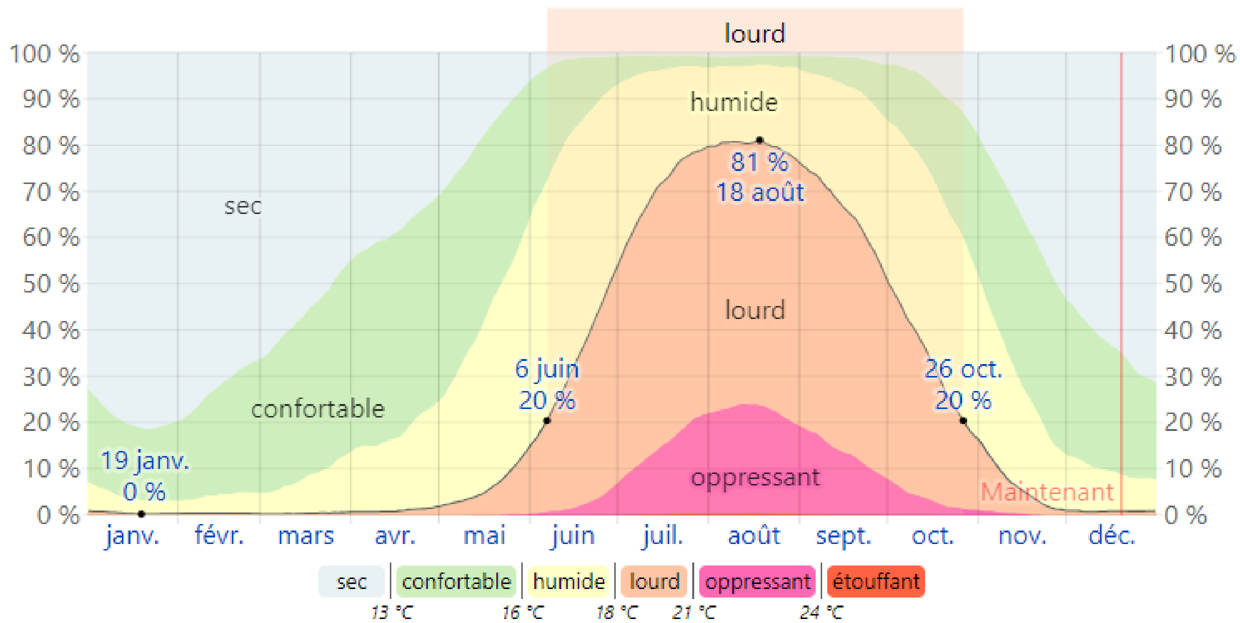

Figure 8: Humidity Comfort Levels in Essaouira

2. Conclusion:

Essaouira is thriving! More people are living and visiting this magical Moroccan city, bringing exciting opportunities. But there's a hidden challenge growing with this excitement: wastewater. As the city gets bigger, more water gets used and dirty, and some factories, especially those processing fish, add their own special mix of waste. This untreated water can pollute beaches and freshwater, which isn't good for anyone.

Chapter II:

Materials and Methods

1. Introduction:

This chapter dig into our analytical approach and methodology employed to attain the project’s objectives. It involves an exploration of the data utilized, materials employed, methods adopted, and an analysis that is pivotal in generating the desired maps.

2. Materials used:

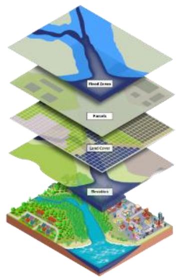

Figure 9: gis representation

GIS stands for **Geographic Information Systems** and is a computer-based tool that examines spatial relationships, patterns, and trends in geography.

The 4 main ideas of Geographic Information Systems (GIS) are:

- Create geographic data.
- Manage it in a database.
- Analyse and find patterns.
- Display it on the map.

Figure10: openStreetMap logo

OpenStreetMap (OSM) is a free, open geographic database updated and maintained by a community of volunteers via open collaboration. Contributors collect data from surveys, trace from aerial imagery and also import from other freely licensed geodata sources. Because OpenStreetMap is publicly licensed under the Open Database License, it is widely used to create electronic maps (Figure 10: OpenStreetMap), assist in humanitarian aid, and visualize data.

Figure 11: Qgis logo

QGIS (Quantum Geographic Information System) is a free, open-source software that allows users to create, edit, visualize, analyse, and publish geospatial information. There are many benefits to using QGIS. First, the software offers many free online resources and maps available to download.

Figure 12: google earth engine

Google Earth Engine is a cloud-based geospatial analysis platform that enables users to visualize and analyse satellite images of our planet.

3. Methods:

3.1 Methodology:

This methodology is crucial in structuring our work by providing clear actions for each task section.

In this project, we developed two essential methodologies: a comprehensive overview (figure 12) defining the upcoming phases, and a detailed breakdown of the individual steps and progress at each stage. Throughout this study, three key sets of data – environmental, geological, and economic criteria – alongside multiple parameters, will be utilised to identify an optimal site for constructing a wastewater treatment plant (figure 13).

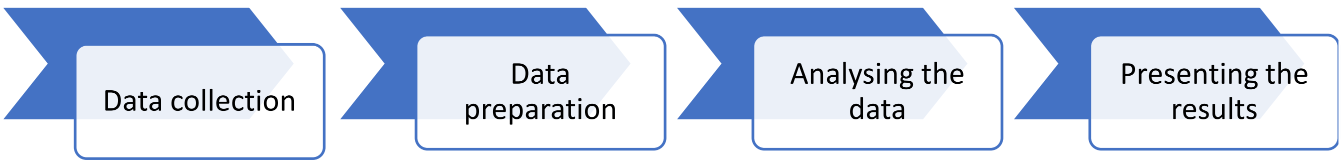

Figure 12: General Methodology of a GIS project

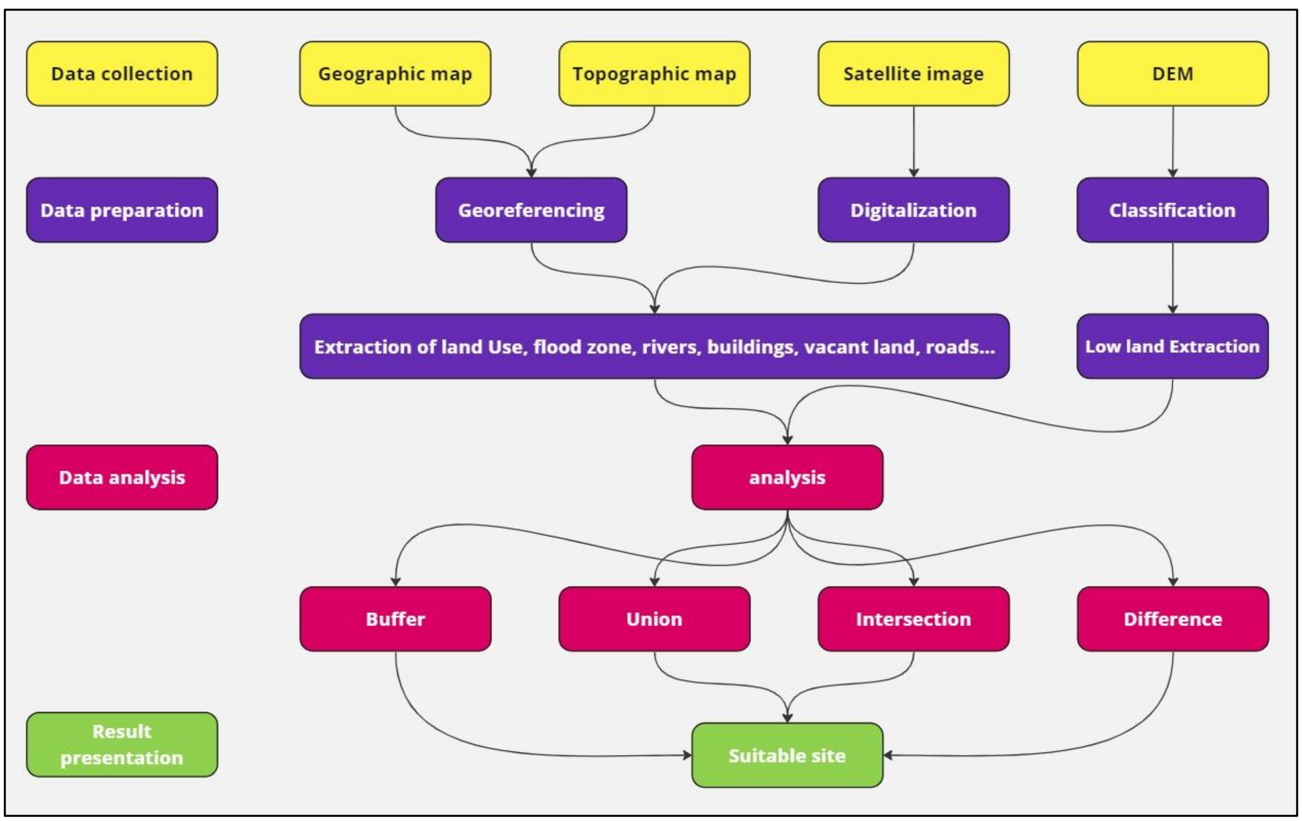

Figure15: detailed methodology of WWTP project

3.2 Data collection:

Data collection stands as a pivotal phase within GIS projects, as the ground upon which we build, and secure the project. The comprehensiveness of this data constructs our ability to meet project goals with reliability and efficiency (table 1).

Layers	Source	Uses
Land use	OpenStreetMap	Locating the vacant lands
Cost line	OpenStreetMap	To check the possible flood zone
Elevation (DEM)	Google maps (MNT de maroc)	To extract the low land
Roads	OpenStreetMap	To extract the existing roads and its nature.
Buildings	OpenStreetMap, satellite image	To make sure our WWTP is far from residential properties, and won't cause any conflict.
Geological map	GeoRachid	To learn about the geology of our study location and to decide whether our selected area can support the project geologically

Table 1: Layers its uses and sources

3.3 Data preparation:

- The digitalization:

Digitizing in GIS is the process of converting geographic data either from a hardcopy or a scanned image into vector data by tracing the features. During the digitizing process, features from the traced map or image are captured as coordinates in either point, line, or polygon format.

In our project, we will digitize the roads, then the residential areas, the agricultural areas, land cover, the flood zones, parks, and the vacant land areas (figure 14).

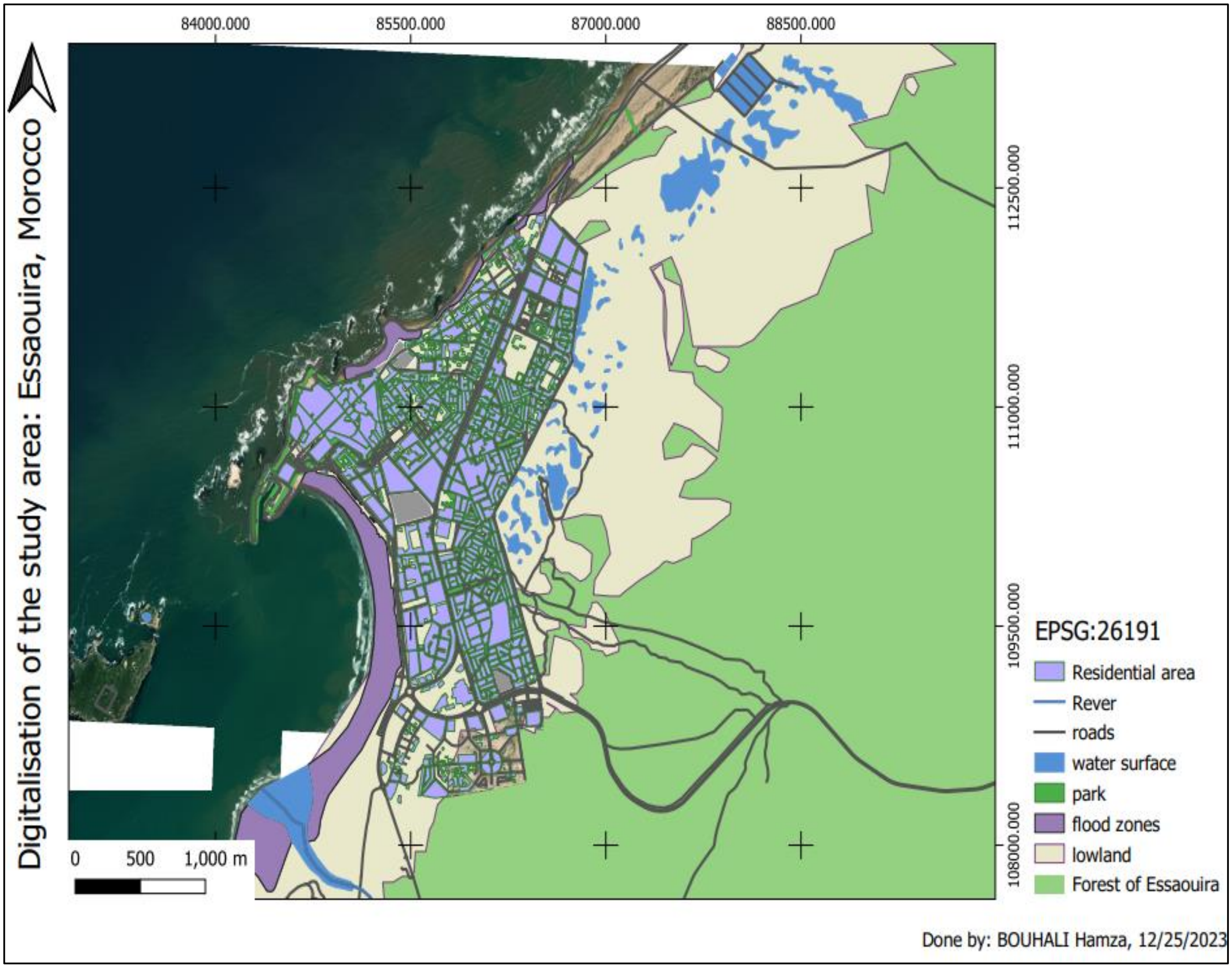

Figure 13: digitalised map of Essaouira

- The classification:

Image classification is the process of assigning land cover classes to pixels. For example, classes include water, urban, forest, agriculture (figure 16). is also the most significant technique used in remote sensing for the computerized study and pattern recognition of satellite information, which is based on the diversity structures of the image and involves rigorous validation of the training samples depending on the used classification algorithm.

In our case we used Rule-based classification, Use the raster calculator to create a new raster layer where elevation values fall within the specified entrance for each class (figure 15).

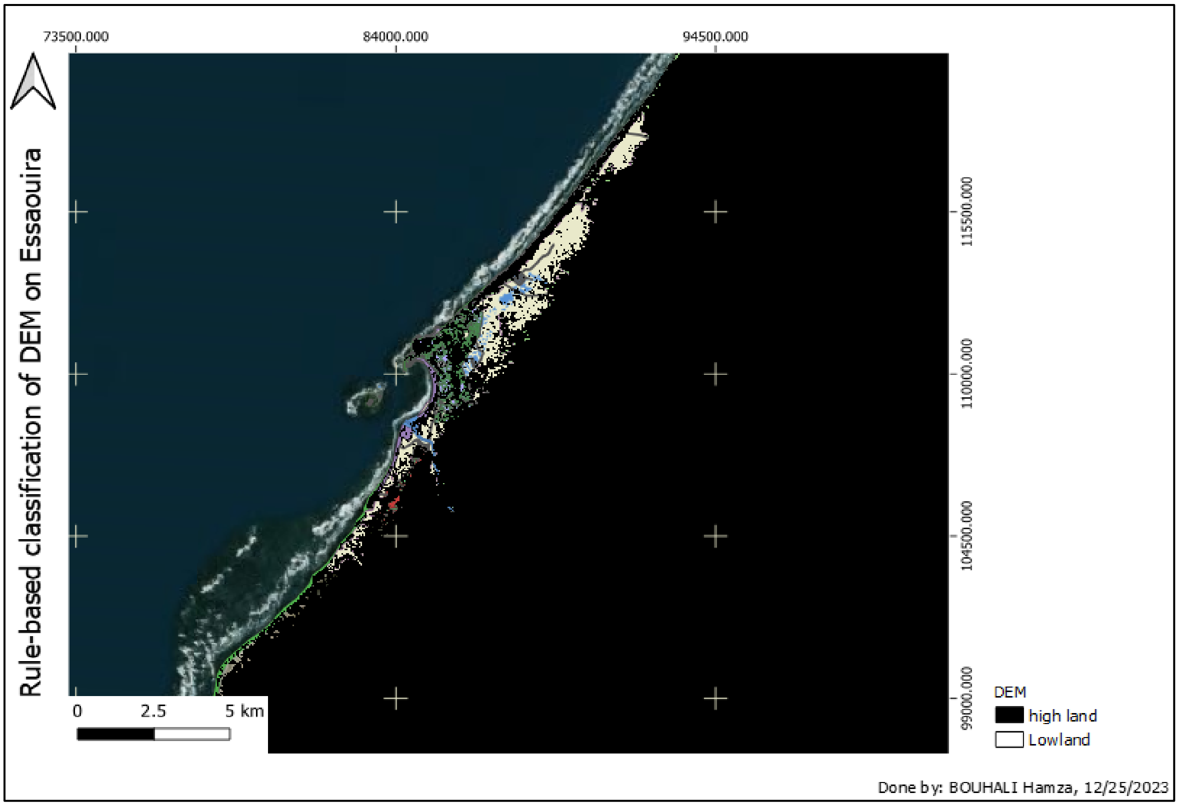

Figure 14: Rule-based classification on DEM

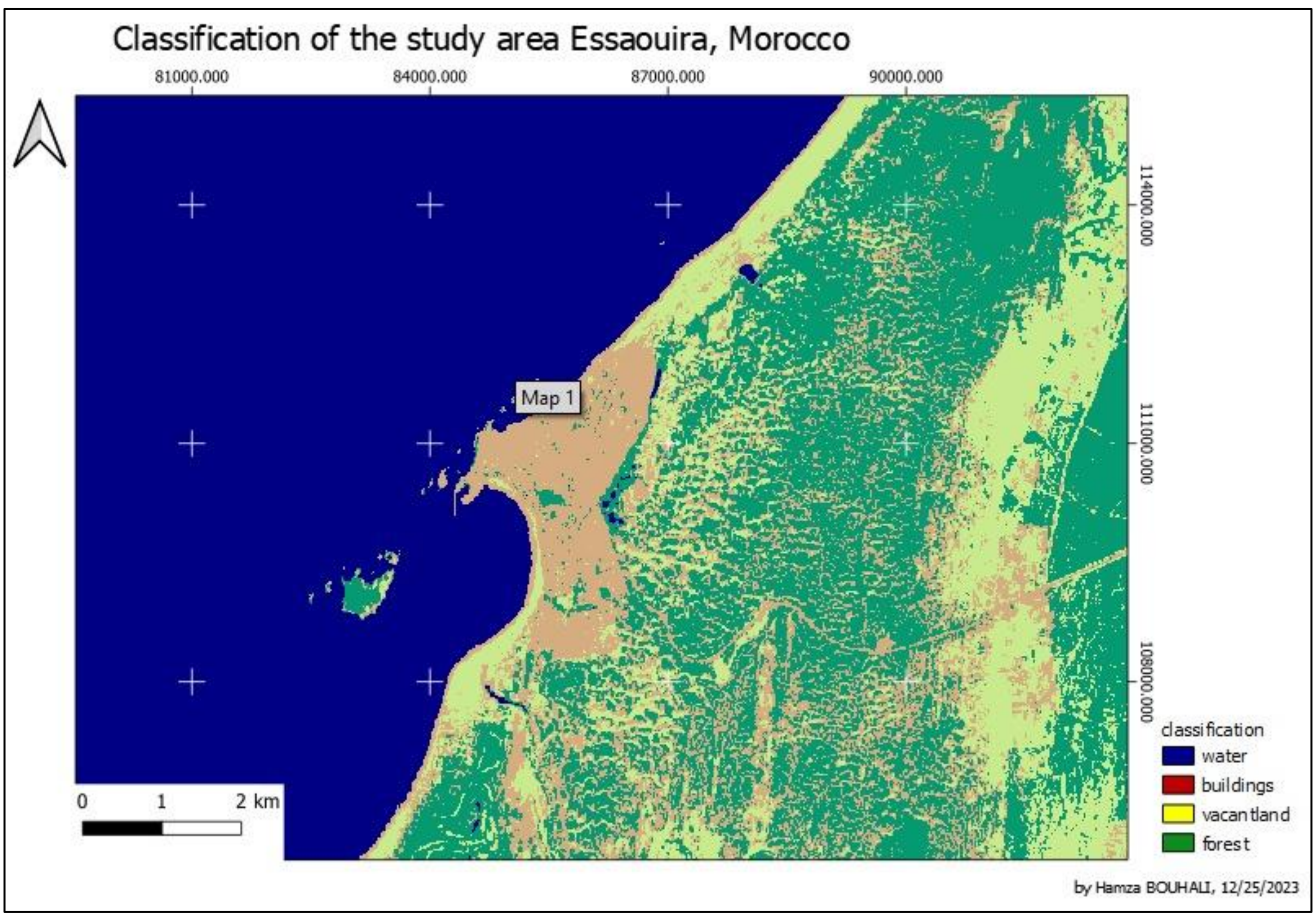

Figure 15:Classification of Essaouira city

➢ The Georeferencing:

Georeferencing is the name given to the process of transforming a scanned map or aerial photograph so it appears "in place" in GIS. By associating features on the scanned image with real world x and y coordinates, the software can progressively warp the image so it fits to other spatial datasets. As we did with the topographic map (figure 16).

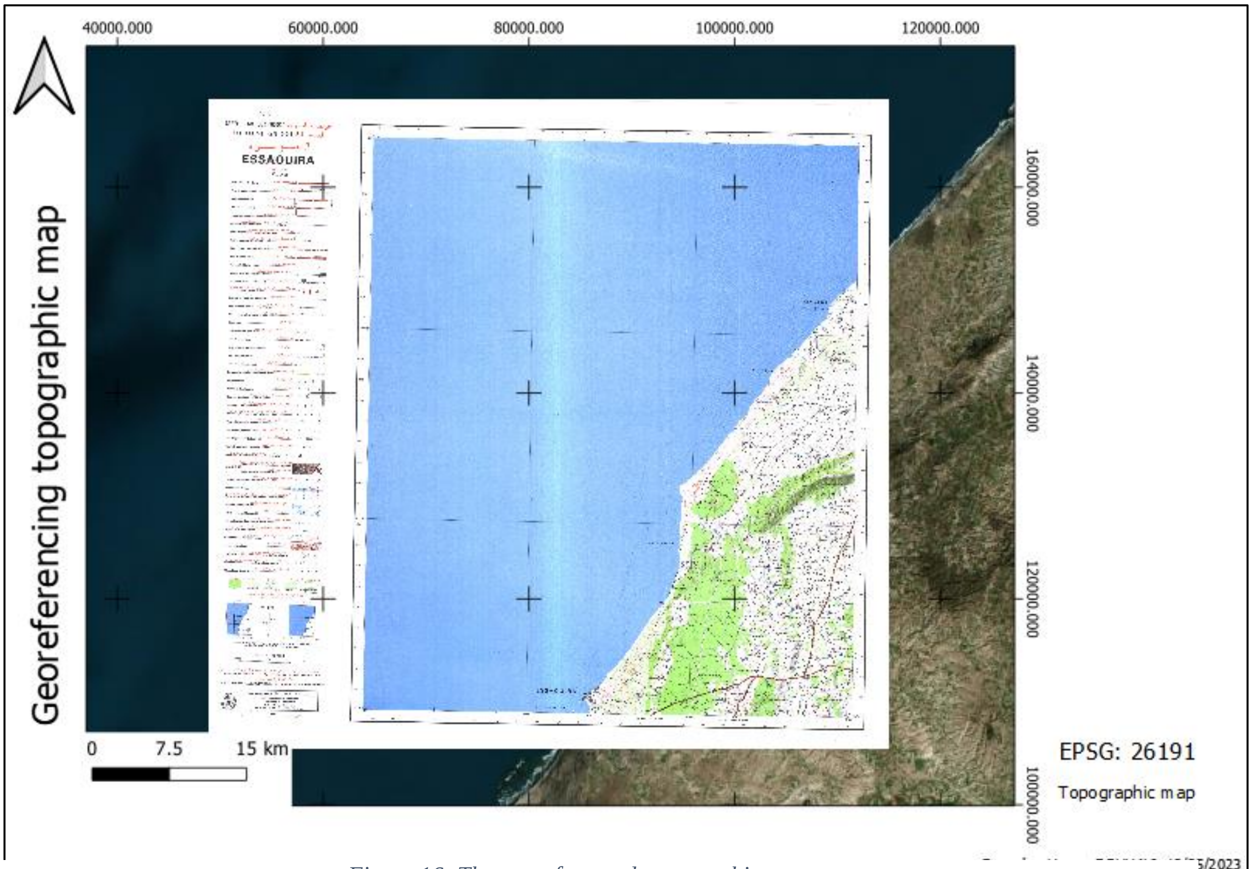

Figure 16: The georeferenced topographic map

3.4 Data analysis:

In this section, we will explore how we can manage our collected data using tools such as buffers and geoprocessing tools. These tools will help us analyze and determine the optimal site for building our WWTP (Wastewater Treatment Plant).

To achieve this, our approach involves defining criteria for the areas where our WWTP should be located and the areas where it should not be located.

a. Defining the tools used:

Buffers:

Are areas of equal distance are established around a specific feature, facilitating the analysis of data situated either within or outside the defined distance from the feature.

Union:

This process involves combining features from two layers into a single layer.

Intersection:

The integration of spatial datasets involves preserving only those features that fall within the common spatial extent of both layers.

Difference:

Identify features present in the input layer but not in the other layer, resulting in a new dataset that represents spatial features unique to one dataset in comparison to the other.

b. Defining the criteria:

The withing areas (lowland and water ways):

In this stage, we aim to determine the optimal location for our station by employing the following methods to ensure the site is within the lowland and near the coast line.

- Establish a buffer of 1000 meters around the coastline.
- To define the suitable location for our wastewater treatment plant, we performed an intersection between the coastline buffer and the lowland area.

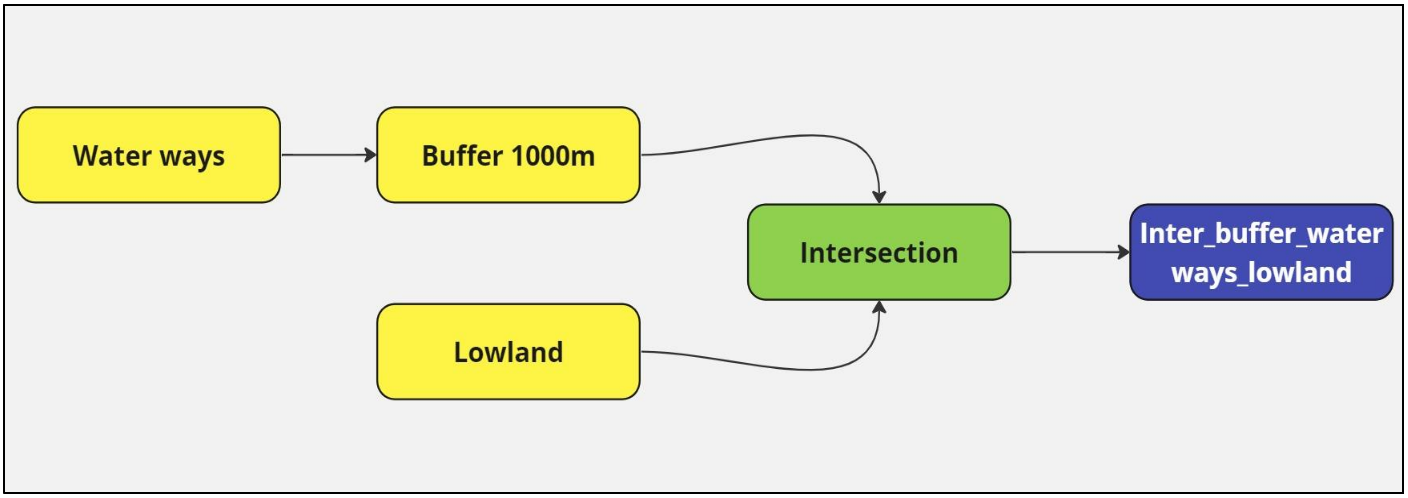

Figure 17: flowchart of the process

The result of the previous flowchart:

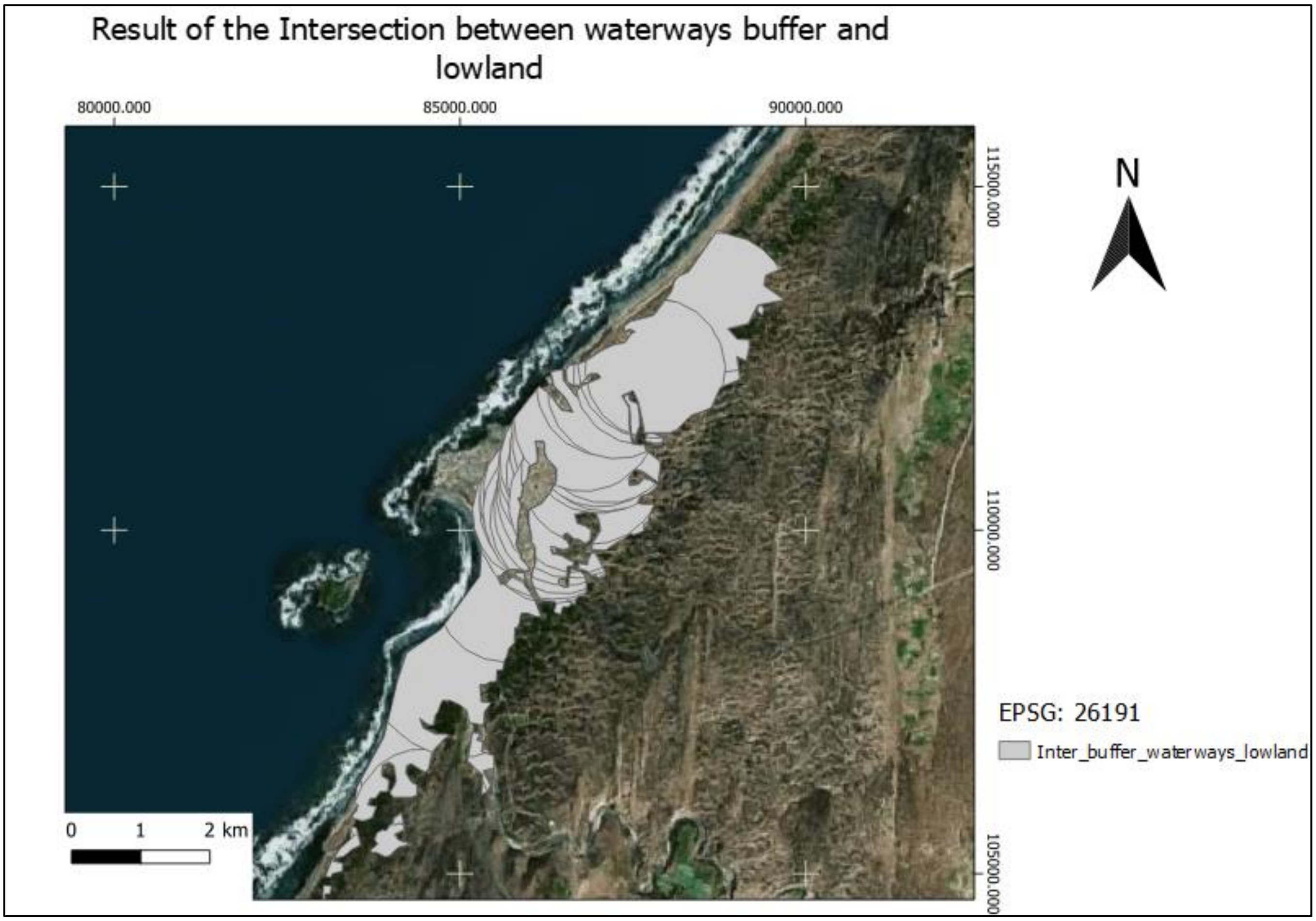

Figure 18: the result of the flowchart of the intersection between waterways and lowland

The withing areas (Roads and Junction point):

In the bellow flowchart, our objective is to identify the optimal location for the wastewater treatment facility, aiming for a distance of approximately 50 meters from the roadways and roughly 2500 meters from the wastewater junction.

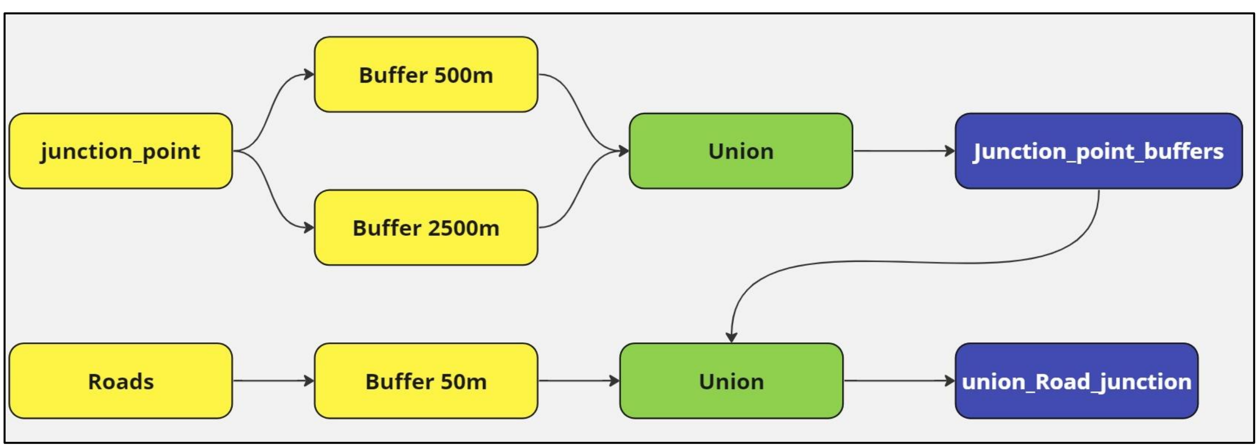

Figure 19: Delineating the area in which the plant should be within

Result of the previous flowchart:

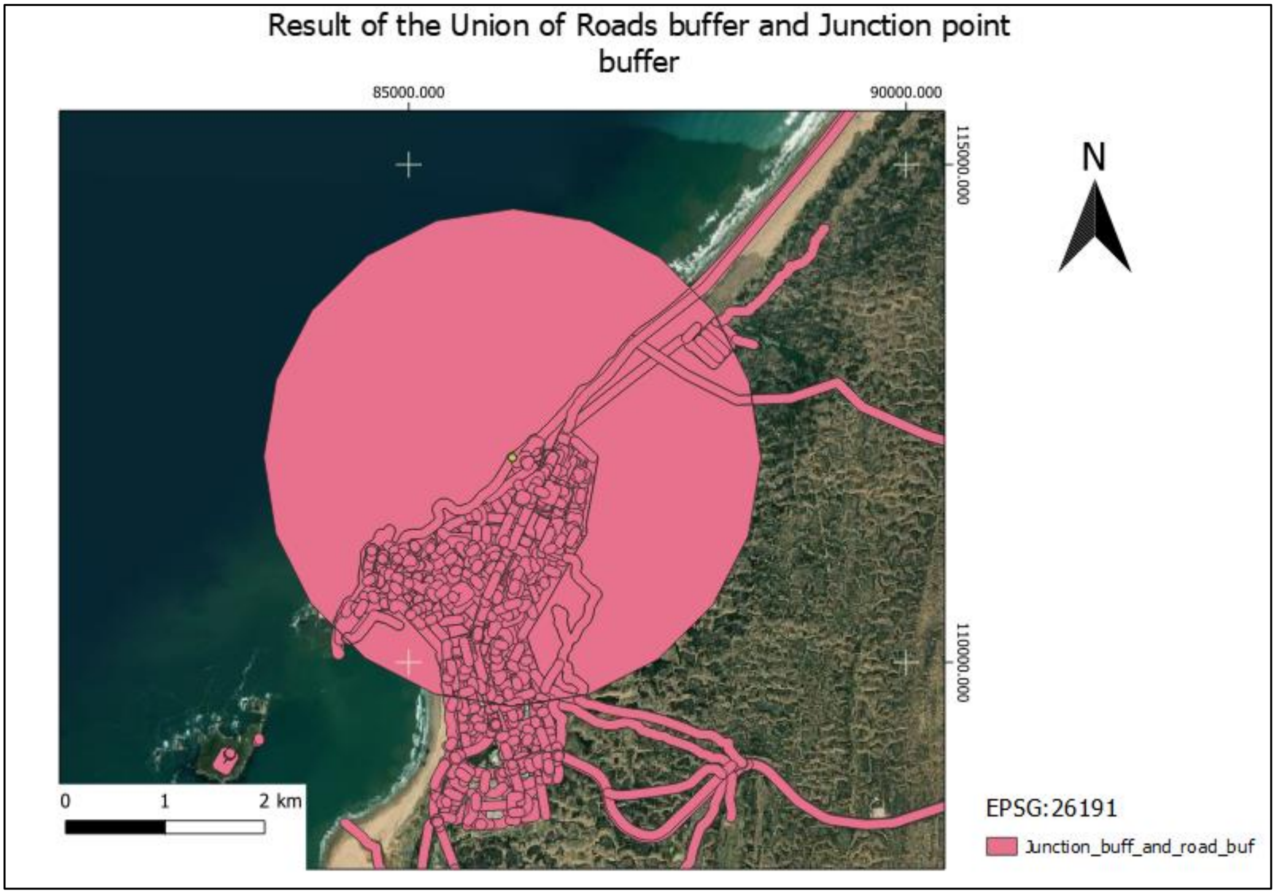

Figure 20:the map of the area in which the plant should be within

Delineating the area in which the plant should be outside of:

The station must be positioned a minimum of 150 meters away from parks, residential parcels, and flood-prone areas. This involves creating a 150-meter buffer around houses and parks, subsequently intersecting it with both the flood zone layer and the buffer of two layers (parks and buildings), below is a flowchart outlining the process:

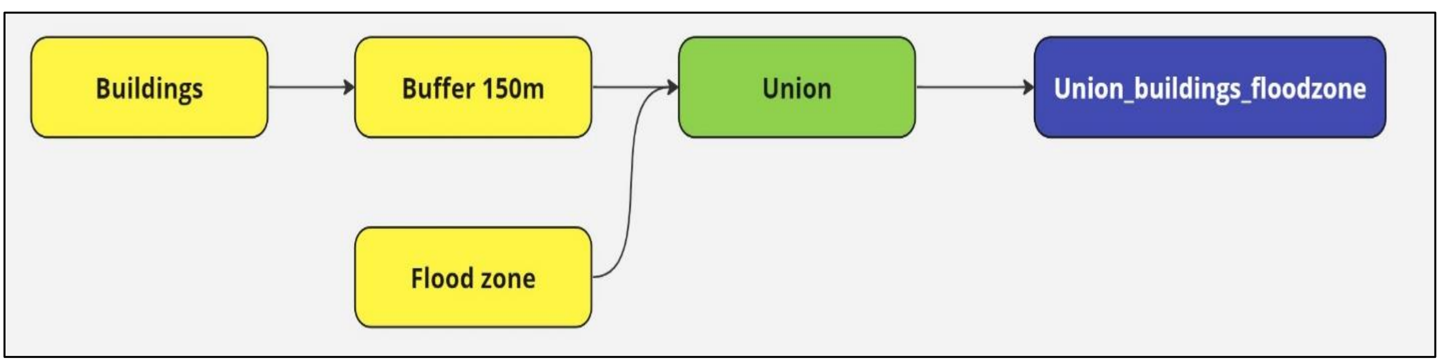

Figure 21: Delineating the area in which the plant should be outside of

Result of the previous flowchart:

Now that we have gathered all the necessary data to identify the optimal location for constructing a wastewater treatment plant, our next step involves utilizing the difference tool. This tool assists in extracting features from the input layer that do not fall within the boundaries of the overlay layer, aiding us in refining our site selection. The upcoming section will unveil the insights derived from applying the difference tool, focusing on our refined understanding of the optimal site for the wastewater treatment plant.

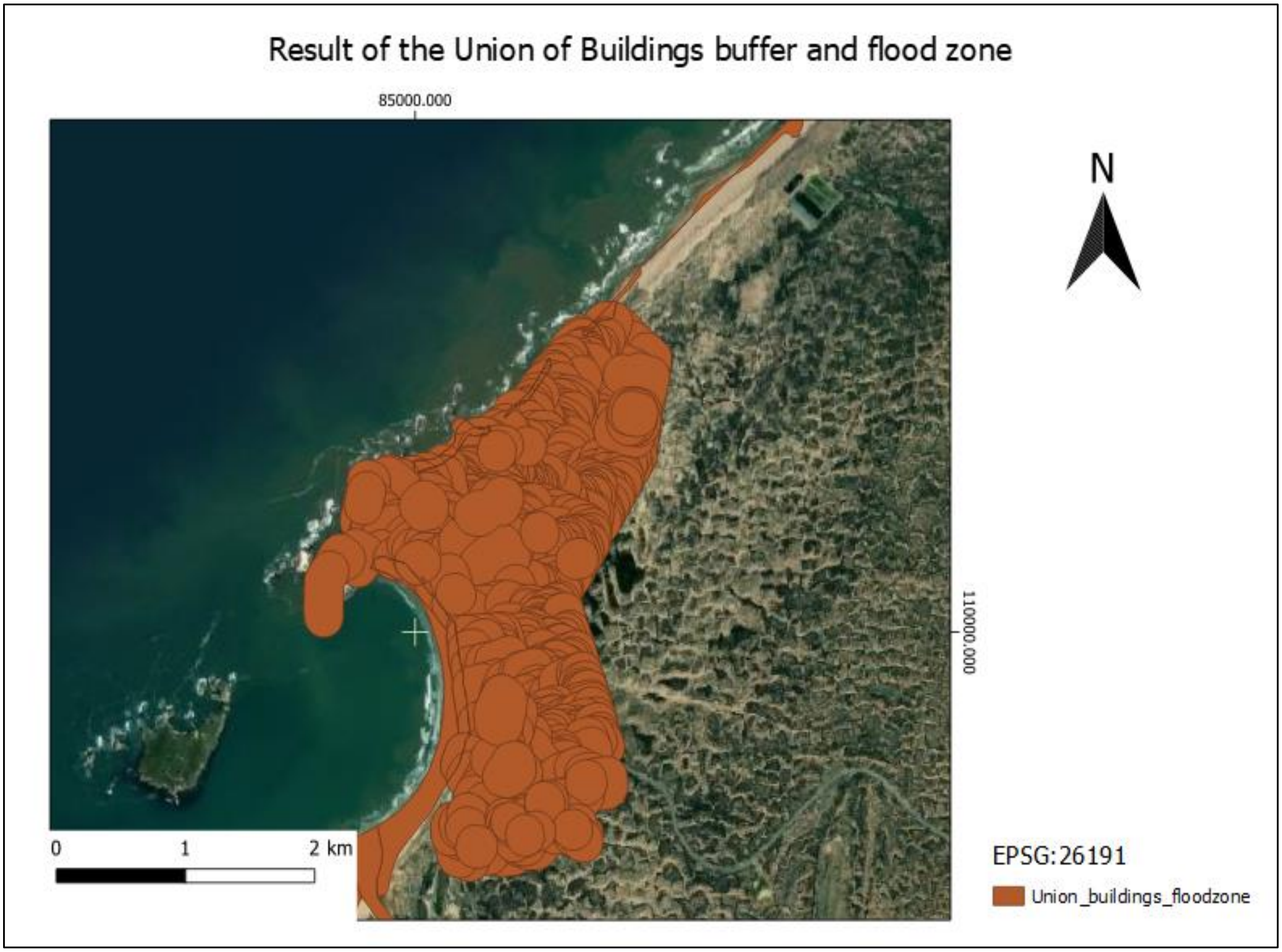

Figure 22: the map of the area in which the plant should be outside of

The best site for building the step:

Establishing a conclusive layer of acceptable locations involves the following procedure, as illustrated in the accompanying flowchart.

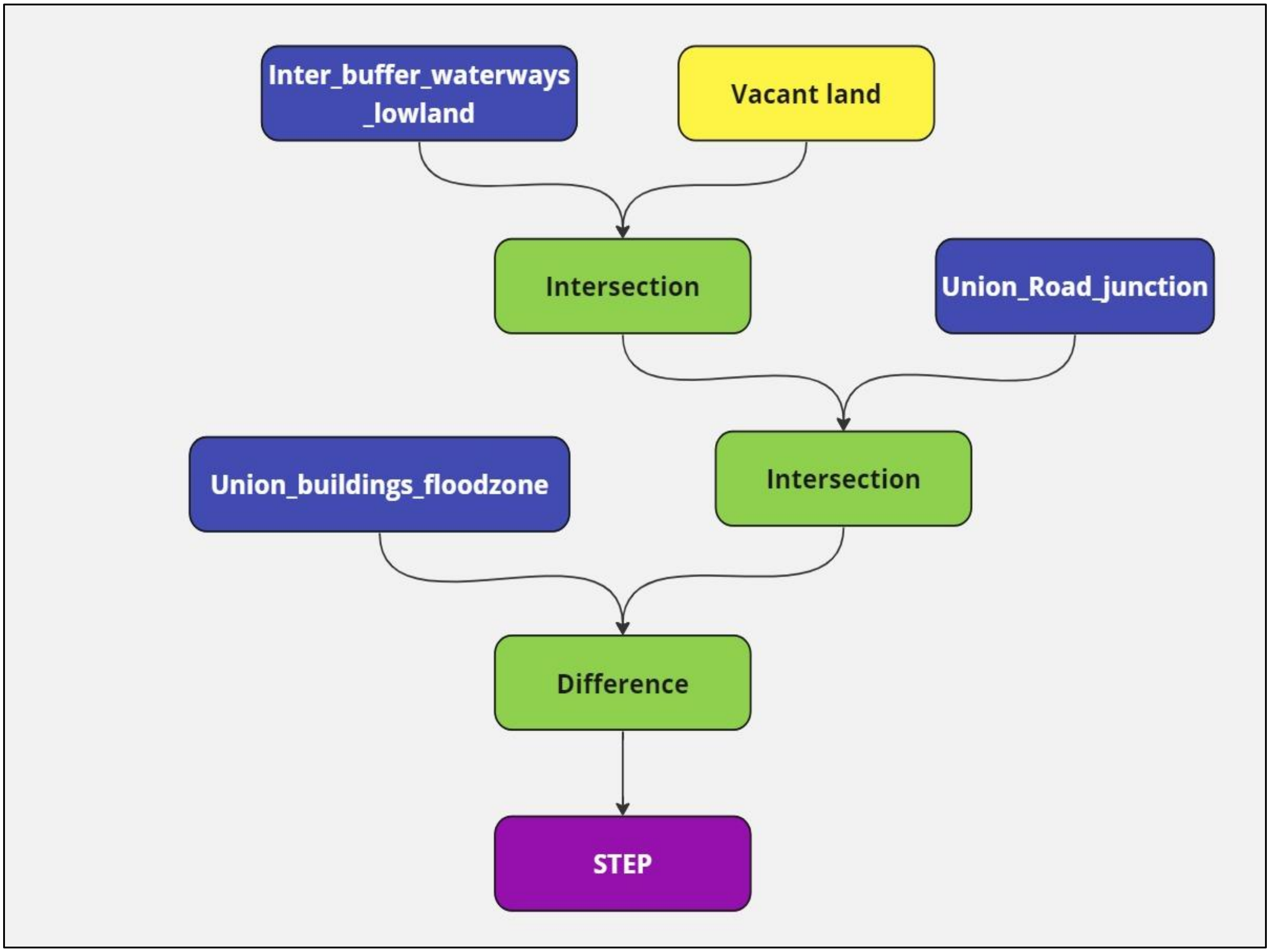

Figure 23: The flowchart for of the procedure followed to get the STEP site

Result of the previous flowchart:

The analysis phase of the project is concluded, affirming that GIS simplifies the process of adjusting criteria and revisiting the study as needed. GIS analysis can provide valuable insights and address various questions, employing a range of techniques to enhance decision-making.

Figure 24: map of the best site for building the step

3.5 Presenting the results:

At this stage, our project for selecting an appropriate location for constructing a sewage treatment facility has been successfully concluded. To facilitate a comprehensive overview of the GIS results, we will compile three maps on a single page in a poster style, including:

a. A map illustrating the location of our research area in relation to the road networks and digital elevation model (DEM) of the study region.
b. A map of the research region highlighting all pertinent parcels.
c. A map specifically showcasing parcels deemed highly suitable for the intended purpose.

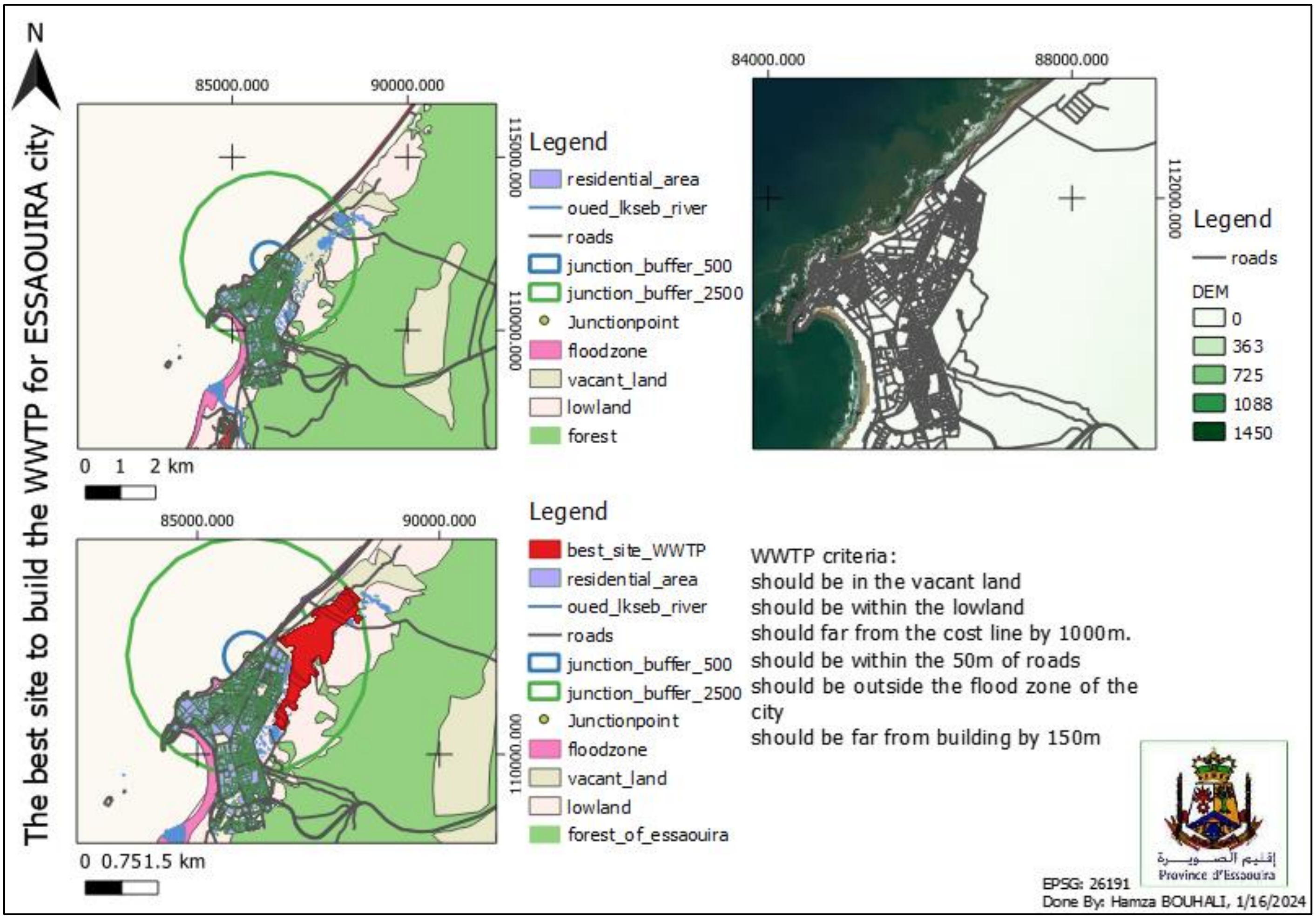

Figure 25:Presenting the final results

This comprehensive map fuses essential points obtained from the intensive analysis conducted on QGIS. It encapsulates a wealth of information highlighting the ideal area for the wastewater treatment plant, with sticking to the criteria outlined in this report.

4. Discussion:

4.1 Spatial Relationships and Patterns:

The first map is a crucial reference point, illustrating the research area's position concerning road networks and the digital elevation model (DEM). Our analysis focused on parcels within 50 meters of roads, meeting our accessibility criterion. Simultaneously, the DEM helped assess elevation, ensuring selected areas are below 80 meters, aligning with our elevation criterion.

4.2 Parcel Suitability and Highlights:

The second map strategically highlights relevant parcels based on a comprehensive suitability assessment. These parcels not only meet proximity criteria to the river (within 5000 meters) but also consider distance from the junction point and the presence of vacant land (within 500 and 2500 meters). This map effectively narrows down the selection to areas aligning closely with the project's criteria.

4.3 External Factors and Influences:

The third map, presenting the union of the road buffer and flood zone, offers a clear representation of external factors influencing parcel suitability. Prioritizing parcels outside the flood zone ensures resilience against potential environmental challenges. The analysis also considers parcels within vacant land, aligning with our criteria for appropriate land use.

In all three maps, a comparative analysis ensures that selected parcels not only meet individual criteria but also form a well-rounded choice. Prioritizing areas exceeding 150 meters from residences and parks contributes to a balanced selection, considering both project-specific needs and community considerations.

5. Conclusion:

In conclusion, this chapter represents a fusion of data collection and the methodological approach employed in the overall analysis. The methodology unfolded as a detailed process, lead up to the creation of the final map picturing the optimal area for the wastewater treatment plant (WWTP).

CONCLUSION

In summary, the utilization of GIS technology has been pivotal in the identification of an ideal location for our wastewater treatment station. This advanced tool seamlessly combined spatial data, conducted thorough analysis, and generated detailed maps, facilitating informed decision-making throughout the process. The significance of GIS extends beyond mere simplification; it acted as a guiding force in our commitment to minimizing environmental impact through criteria analysis.

GIS empowered us to conduct a thorough assessment of potential parcels, ensuring that our selections align seamlessly with the specific needs of the project. Its iterative nature provides room for ongoing enhancements, transforming GIS into an indispensable tool that not only ensures precision in site selection but also enhances overall efficiency. With GIS at the frontline, our project is poised for success, benefiting from the continuous refinement and precision offered by this powerful technology.

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