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*A Mobile Application for Mapping Forest Fire Risk in Algeria using GIS-AHP
Method*

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Dedication

بسم الله الرحمن الرحيم

(اذ قال يوسف لأبيه ياأبت اني رأيت أحد عشر كوكبا والشمس والقمر رأيتهم لي ساجدين)

أهدي هذا العمل المتواضع الى

من تشرف بنيل اسم رسول الله محمد صلى الله عليه وسلم وبالسير في طريق العلم الذي به نطلب الدنيا

والاخرة

الى روح جدائي وجدتاي المرحومين

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الى أبيها العزيز بلقاسم

محمد الأمين لومي

Dedication

بسم الله الرحمن الرحيم

إلى من بيده كل شيء، خالقي وموجهي، الذي أنار دربي ومنحني القوة لتحقيق أحلامي. أرفع إليك الشكر

والامتنان على كل ما علمتني إياه .

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إلى والدي العزيز، الذي كان دعمي الأول، وأعطاني القوة والثقة لأمضي قدماً. لك مني كل الحب

والتقدير، فأنت من أضأت لي الطريق في كل خطوة .

إلى أُمي الغالية، التي تمثل لي كل معاني الحب والأمان. كانت دعواتك لي دائماً مصدر إلهامي، وحنانك كان

لي ملاذاً في أوقات الشدة. أشكرك على كل ما قدمته لي .

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﴿وَأَخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ﴾

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Introduction

General introduction

Forests represent some of the most essential natural resources, serving vital functions in conserving biodiversity, regulating climate, and promoting economic sustainability. Nevertheless, forest fires present a considerable threat to these ecosystems, resulting in severe environmental, economic, and social repercussions. Forest fires have escalated in Algeria, becoming more frequent and destructive, a trend intensified by climate change, human activities, and natural factors. The Mediterranean climate of the country, marked by hot, arid summers and dense vegetation, renders it particularly vulnerable to wildfires. These incidents lead to the destruction of forested regions and exacerbate soil degradation, air pollution, and habitat loss, adversely affecting both wildlife and local communities. Given the gravity of the situation, there is an urgent requirement for practical tools to predict, evaluate, and manage the risks associated with forest fires. Conventional fire management approaches, which depend on field observations and historical data, tend to be reactive and inadequate for preventing large-scale disasters. Consequently, incorporating advanced technologies such as Geographic Information Systems (GIS) and multi-criteria decision-making methods, including the Analytic Hierarchy Process (AHP), can significantly improve the assessment of fire risks and the decision making processes . Despite numerous initiatives to mitigate forest fires in Algeria, the absence of a comprehensive, real-time, and easily accessible fire risk mapping system continues to pose a significant obstacle. Current methods for assessing fire risk frequently exhibit limitations in spatial accuracy, slow data processing, and inadequate public accessibility. Additionally, the ever changing nature of fire risks, influenced by temperature, wind speed, humidity, vegetation types, and human activities, necessitates a more integrated and adaptive approach to risk assessment. To address these issues, this research proposes the creation of a mobile application that employs Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP) to map and analyze forest fire risks throughout Algeria. By harnessing spatial data and multi criteria decision-making techniques, this application aspires to offer an interactive, real-time, and user-friendly fire risk assessment platform, benefiting policymakers and the general populace.

Proposed Solution and Objectives

The proposed mobile application incorporates Geographic Information System (GIS) technology for the collection, management, and analyzing spatial data of forest fire risks. The Analytic Hierarchy Process (AHP) to rank various risk factors based on expert assessments, thereby ensuring a scientifically robust fire risk model. The primary objectives of this study are as follows:

1. To identify and evaluate the critical factors contributing to Algeria's forest fire risks through GIS-based spatial analysis.

2. To utilize the Analytic Hierarchy Process (AHP) to ascertain the relative significance of different fire risk factors.
3. To create a mobile application that offers interactive fire risk maps, enabling users to visualize areas of high risk.
4. To improve access to fire risk information by providing it to authorities, emergency responders, and the general public via an intuitive mobile interface.
5. To enhance decision-making and fire prevention strategies by delivering data-driven insights and predictive risk assessments.

Manuscript Organization

1. In the first chapter, we will define Geographic Information Systems (GIS), their features, and components. We will also define the Analytic Hierarchy Process (AHP), explain how it works, and describe how it can be integrated with GIS.
2. In the second chapter, we will explore wildfires, examine their causes and consequences, and review the policies adopted to combat them. We will also look into how the AHP method can be used to predict this hazard.
3. In the third chapter, we will study similar applications in the world, compare them, and identify their strengths and weaknesses.
4. In the fourth chapter, we will explain the modeling and design process of the proposed application, along with the tools used.
5. In the fifth and final chapter, we will explore how to use the proposed application.

Chapter 1

GIS and AHP method

1.1 Introduction

Integrating Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP) significantly improves spatial decision-making by merging data analysis with organized decision-making frameworks. GIS offers capabilities for the management and visualization of spatial data, whereas AHP facilitates the systematic prioritization of various criteria. This chapter examines their integration and applications in urban planning, environmental management, and land suitability analysis, illustrating how this combination enhances the accuracy and efficiency of decision-making processes.

1.2 Geographic Information System (GIS)

1.2.1 Definition

The utilization of Geographic Information Systems (GIS) is constrained solely by the creativity of its users, as noted by J. Dangermond. Various authors have proposed differing definitions of GIS, each reflecting the specific context in which it is applied. These systems consist of spatially referenced data units, structured to facilitate the extraction of valuable insights for informed decision-making (Michel Didier, 1990). [1]



Figure 1.1: Geographic Information System. [2]

1.2.2 GIS Components

At a fundamental level, and irrespective of the geographic data production chain that relies on industrial processes, it is feasible to identify five primary components within Geographic Information Systems (GIS): [3]

1. **Hardware:** Modern GIS operates on diverse computing devices, ranging from data servers to personal computers, which may be networked or function independently.
2. **Software:** GIS software encompasses the necessary tools and functionalities for storing, analyzing, and visualizing information. The core software of a GIS includes:
 - Tools for capturing and manipulating geographic data
 - Database management systems
 - Geographic tools for querying, analysis, and visualization
 - Graphical user interfaces are designed for user-friendliness
3. **Data (Geographic Information) :** Undoubtedly, data constitutes the most critical element of GIS. Geographic data, and related tabular data, can be generated internally or sourced from external data providers.
4. **Users (Human Resources):** GIS is fundamentally a tool whose full capabilities are unlocked by its users. It caters to a broad audience, from system developers and maintainers to individuals who utilize geographic information in their everyday tasks. With the rise of web-based GIS, the user base is rapidly expanding, and it is anticipated that soon, everyone will engage with GIS at varying levels.
5. **Methods (Procedures):** The successful implementation and functioning of a GIS necessitate adherence to specific protocols and procedures that are tailored to each organization.

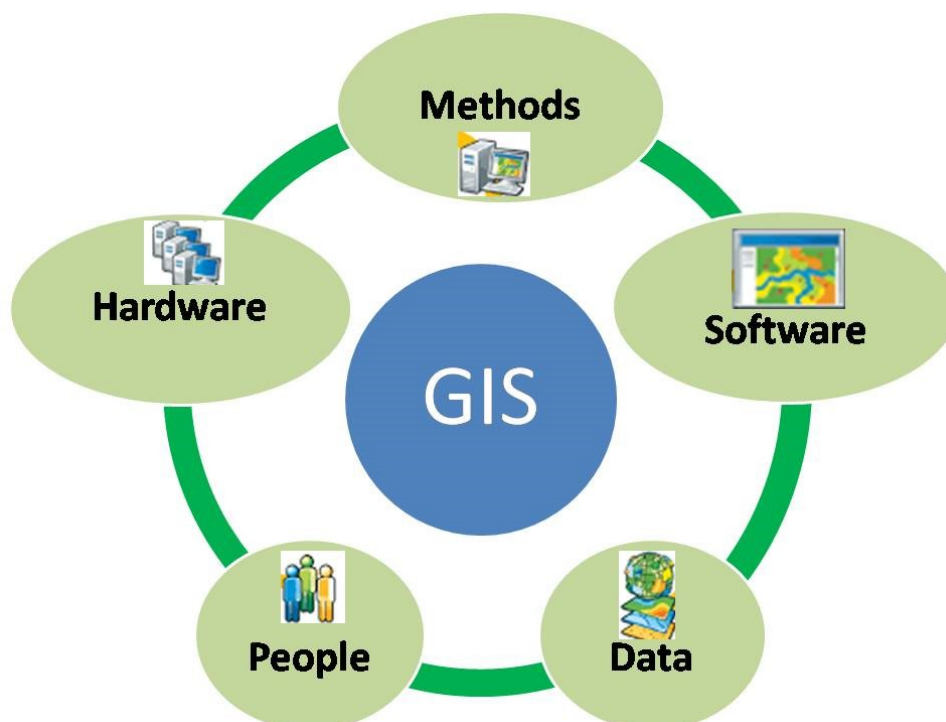


Figure 1.2: GIS Components.[4]

1.2.3 GIS Functions

GIS can be structured to address diverse needs. Since no universal system exists, they must be adapted according to the set objectives. However, they share standard functionalities in each system, grouped into five families under the term "5A": Abstraction, Acquisition, Archiving, Display, and Analysis. [5]

1. **Abstraction:** GIS used to create territorial descriptions allows for obtaining the necessary information to address a specific issue. This information, some of which is representations (modeling) of existing elements or phenomena, aims to faithfully reproduce reality in an understandable way to meet given objectives. Therefore, it is necessary to specify the elements for which information is needed and the nature of that information. Additionally, drawing these elements follows semiological rules designed to make the maximum amount of information easily perceptible to the map reader. When modeling, one must consider the expected objectives of the information system. For this, the methods used for creating "classic" information systems are valid and must clarify the expectations (what do we want to achieve?) and the concrete problems (with what?).
2. **Acquisition:** The system must include elements that are known once the conceptual model is established and the necessary geographic and semantic information is specified. The data must then be integrated and meet the quality requirements set by the expected objectives. These data can come from external suppliers, direct digitization, or specific processing, such as satellite images. The data can be of four different types depending on the geometry associated with them: raster data, vector data, grids or DEM (Digital Elevation Model), and data without geometry.
3. **Archiving:** This module relies on the storage medium for semantic and graphical information.. Using CAD/CAM software is a possible alternative for managing the latter data. Query functions are processed using an assertion language that transforms the user's requests into a series of operations on the database.
4. **Display:** This module encompasses all necessary tools for presenting the processed outcomes. Its primary function is to visually represent spatial phenomena and their relationship with semantic data. Users have the option to select a hypertext mode.
5. **Analysis:** This module highlights the distinctive features of different GIS systems. GIS data represents real-world landscapes, allowing for the analysis and prediction of spatial events. By Using this data, users can address various challenges, such as urban planning, environmental management, and disaster response, thereby maximizing the system's effectiveness. Key capabilities of GIS include spatial data visualization, geographic analysis, pattern detection, and decision support, making it a powerful tool for informed planning and resource management.

1.3 Analytics Hierarchy Process (AHP)

1.3.1 Definition

The AHP method is a technique designed for addressing multi-criteria decision-making challenges, which entails evaluating various solutions that meet a defined set of criteria. This method simplifies decision-making by decomposing the problem into a hierarchical structure. Developed by Thomas Saaty in the 1970s, the alternatives represent the potential solutions to the decision problem. The criteria serve as the parameters for assessing these alternatives,

while the sub-criteria are the specific parameters associated with each criterion. The individual responsible for conducting the evaluations is referred to as the evaluator. [6]

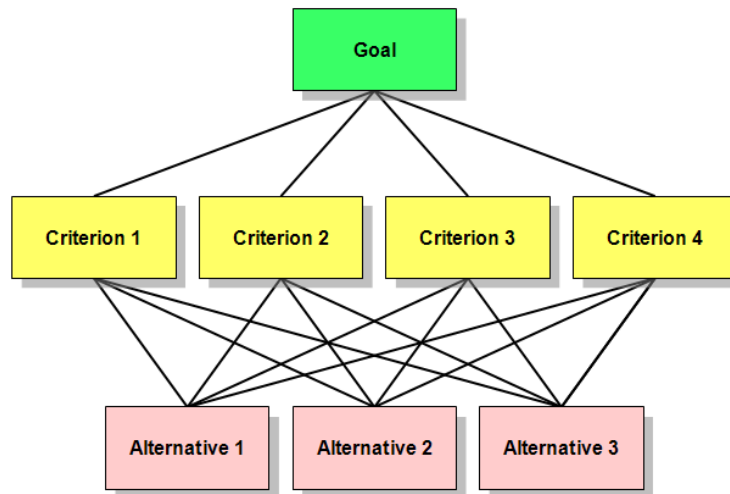


Figure 1.3: AHP method schema. [7]

1.3.2 AHP Steps

The Analytic Hierarchy Process (AHP) is a structured approach to decision-making that breaks down complex problems into a hierarchical framework for more organized analysis. The general steps involved in the AHP method are: [8]

1. **Define the Goal and Alternatives** Start with a clearly defining the overall objective you want to achieve. This could be ranking smartphones to decide which one to purchase.
2. **Define the Problem and Decision Criteria** Break down the challenges into smaller sub problems to establish criteria. These criteria should be an important factors for making decisions.
3. **Structure the Hierarchy Model the problem** as a hierarchy, starting from general aspects to detailed ones. This hierarchy typically includes criteria/sub-criteria, and alternatives.
4. **Assess Relative Value Using Pair-wise Comparisons** Evaluate the importance of each criterion by comparing it with other criteria using a nine-point scale to represent the intensity of preferences. A pair-wise comparison matrix is constructed to facilitate the process.
5. **Establish Priorities** Determine the weights to be given to each criterion.
6. **Synthesize Judgments** Combine the weights and scores to rank the alternatives.
7. **Check Consistency** Ensure judgments made are consistent.
8. **Make a Decision** Come to a final decision based on the results of the AHP process.

Algorithm 1 Analytic Hierarchy Process (AHP)

- 1: **Input:** Decision goal, criteria set $C = \{C_1, C_2, \dots, C_n\}$, and alternatives set $A = \{A_1, A_2, \dots, A_m\}$
- 2: **Output:** Ranked alternatives
- 3: **Step 1: Define the Problem**
- 4: Identify the decision goal, criteria, and alternatives.
- 5: **Step 2: Construct the Pairwise Comparison Matrix**
- 6: Create a matrix $\mathbf{A} = [a_{ij}]$, where:

$$a_{ij} = \begin{cases} 1, & \text{if } i = j, \\ \text{the relative importance of criterion } i \text{ to } j, & \text{if } i \neq j. \end{cases}$$

Ensure $a_{ij} = \frac{1}{a_{ji}}$.

- 7: **Step 3: Normalize the Matrix**
- 8: Normalize \mathbf{A} by dividing each element a_{ij} by the sum of its column:

$$n_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}}, \quad \forall i, j.$$

- 9: **Step 4: Calculate the Priority Vector**
- 10: Compute the priority vector \mathbf{w} :

$$w_i = \frac{\sum_{j=1}^n n_{ij}}{n}, \quad \forall i.$$

- 11: **Step 5: Perform Consistency Check**
- 12: Compute the principal eigenvalue λ_{\max} :

$$\lambda_{\max} = \sum_{i=1}^n \left(\frac{\mathbf{A} \cdot \mathbf{w}_i}{\mathbf{w}_i} \right).$$

- 13: Calculate the Consistency Index (CI):

$$\text{CI} = \frac{\lambda_{\max} - n}{n - 1}.$$

- 14: Compute the Consistency Ratio (CR): $\text{CR} = \frac{\text{CI}}{\text{RI}}$, where RI is the Random Index.
- 15: **if** $\text{CR} \leq 0.1$ **then**
- 16: The matrix is consistent.
- 17: **else**
- 18: Adjust the pairwise comparison matrix.
- 19: **end if**
- 20: **Step 6: Aggregate and Rank Alternatives**
- 21: Combine the criteria weights with the alternative scores:

$$\text{Score for alternative } A_k = \sum_{j=1}^n w_j \cdot a_{kj}.$$

- 22: Rank the alternatives based on their scores. =0

1.3.3 Example

We will apply the AHP method to choose the best smartphone among three options: iPhone 15 Pro, Samsung S23 Ultra, Google Pixel 8 Pro... Based on the following criteria: Performance, Camera Quality, Battery Life, and Price....

1. **Create a pair-wise comparison matrix for the criteria :** We compare each criterion with the other using the Satay scale (1-9). Suppose we get the following matrix based on the importance of the criteria:

	Performance	Camera	Battery	Price
Performance	1	3	5	7
Camera	1/3	1	3	5
Battery	1/5	1/3	1	3
Price	1/7	1/5	1/3	1

Table 1.1: Benchmark Comparison Matrix .

2. **Calculating the relative weights of the criteria:** To calculate the weights, we calculate the Somme of each column and then normalize it. After the calculations, we find the approximate weights:

Criteria	Performance	Camera	Battery	Price
Weights	0.56	0.27	0.15	0.06

Table 1.2: the relative weights of the criteria

3. **Comparing alternatives for each criterion:** We create comparison matrices for each phone within each criterion using a Performance Matrix..

	iPhone	Samsung	Pixel
iPhone	1	3	5
Samsung	1/3	1	3
Pixel	1/5	1/3	1

Table 1.3: Comparison matrix between phones in terms of performance.

	iPhone	Samsung	Pixel
iPhone	1	1/2	1/3
Samsung	2	1	1/2
Pixel	3	2	1

Table 1.4: Comparison matrix between phones in terms of camera.

	iPhone	Samsung	Pixel
iPhone	1	1/3	1/5
Samsung	3	1	1/2
Pixel	5	2	1

Table 1.5: Comparison matrix between phones in terms of battery.

	iPhone	Samsung	Pixel
iPhone	1	1/2	1/3
Samsung	2	1	1/2
Pixel	3	2	1

Table 1.6: Comparison matrix between phones in terms of price.

	Performance	Camera	Battery	Price
iPhone	0.58	0.17	0.12	0.17
Samsung	0.29	0.33	0.3	0.33
Pixel	0.13	0.5	0.58	0.5

Table 1.7: Final Values .

4. **Calculating the final score for each phone :** We calculate the final rating for each phone by multiplying the relative weights of each criterion in the phone's rating within that criterion, then summing the results:

Final score = (Performance weight * Performance score) + (Camera weight * Camera score) + (Battery weight * Battery score) + (Price weight * Price score)

iPhone 15 Pro : $(0.56*0.58)+(0.27*0.17)+(0.15*0.12)+(0.06*0.17)=0.4$

Samsung S23 Ultra : $(0.56*0.29)+(0.27*0.33)+(0.15*0.30)+(0.06*0.33)=0.33$

Google Pixel 8 Pro : $(0.56*0.13)+(0.27*0.50)+(0.15*0.58)+(0.06*0.50)=0.32$

5. **Determine the best phone :**

iPhone 15 Pro = 0.4 (1st place)

Google Pixel 8 Pro = 0.33 (2nd place)

Samsung S23 Ultra = 0.32 (3rd place)

6. **The Final result:** Based on the analysis, the iPhone 15 Pro is the best choice according to the given criteria and weights.

1.4 GIS-AHP Integration

1.4.1 The Main Steps of The GIS-AHP Method

The GIS-AHP method is used to solve problems requiring decision-making based on multiple spatial and non-spatial criteria. It combines geographic data with a multi-criteria evaluation process to prioritize and make informed decisions. The Main steps of the GIS-AHP method are:

1. **Identify criteria:** The first step involves recognizing the criteria influencing the decision making process. These criteria may pertain to physical or spatial aspects, including soil composition, topography, infrastructure, or climatic conditions. These criteria must be either quantifiable or qualitative .
2. **Collect spatial data:** Relevant data corresponding to each criterion is gathered through geographic data analysis tools. This information may encompass geographic elements such as maps, satellite imagery, or field observations that illustrate the criteria.
3. **Assign weights to criteria:** The significance of each criterion is assessed About the others. A hierarchical analysis is employed to conduct pairwise comparisons among the criteria, allowing for assigning relative weights based on their importance. These weights are derived from expert evaluations or existing data.

4. **Integrate spatial data with weights:** Following the assignment of weights, the spatial data associated with the criteria is combined with their respective weights utilizing spatial analysis tools within a geographic information system.
5. **Generate the final result:** Through the integration and analysis process, a model or map is created that illustrates the outcomes, such as prioritizing areas or identifying regions requiring specific interventions based on the established criteria.

1.4.2 Working Mechanism

The integration of Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP) combines spatial analysis with multi-criteria decision-making to solve complex problems:

1. Various spatial layers, such as vegetation cover, terrain, and road networks, are consolidated into a single layer, with each layer evaluated according to its significance as determined by the designated weights.
2. The outcomes are derived by aggregating the values from each layer by the weights, facilitating the creation of a map or model that accurately represents the spatial distribution of the criteria based on their priority.

The final result is a model or map that is a powerful tool to support decision-making based on spatial analysis of multi-dimensional factors such as risks, needs, or opportunities.

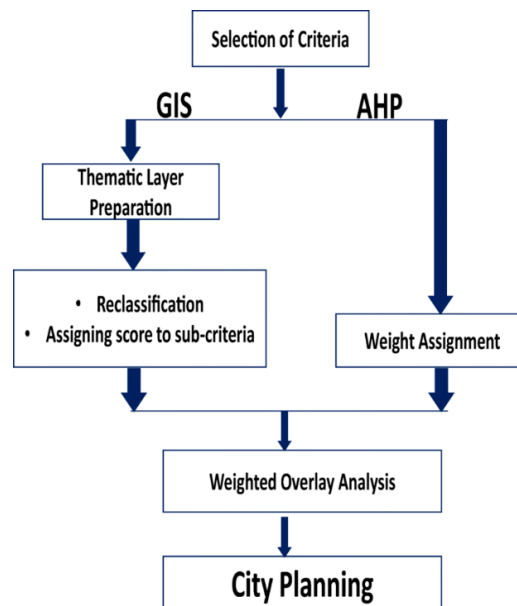


Figure 1.4: GIS-AHP integration.[9]

1.5 Applications of GIS-AHP Method

The AHP-GIS (Analytic Hierarchy Process - Geographic Information System) method is extensively utilized in numerous domains that necessitate decision-making informed by spatial data and multiple criteria. This approach combines spatial data analysis with multi-criteria evaluation to facilitate well-informed and precise decision-making. Below are some significant applications of the AHP-GIS method: [10]

1. **Optimal Site Selection:** Selecting the most suitable locations for various developments is critical to urban and infrastructure planning. By integrating AHP with GIS, decision makers can systematically evaluate multiple criteria to determine optimal sites efficiently:
 - **Urban Planning:** This method assists in identifying the most suitable locations for residential or commercial developments by considering factors such as proximity to transportation, availability of utilities, soil characteristics, and potential hazards.
 - **Power Plant Site Selection:** AHP-GIS can be employed to determine optimal sites for power plants, considering criteria such as distance from populated areas, accessibility to raw materials, and environmental conditions.
2. **Natural Resource Management:** Effective management of natural resources is essential for sustainability and environmental conservation. AHP-GIS helps in evaluating multiple spatial factors to optimize the use of water and forest resources:
 - **Water Management:** AHP-GIS is instrumental in pinpointing ideal locations for constructing dams or water treatment facilities, based on factors like river flow, topography, and population density.
 - **Forest Management:** forest management, AHP-GIS is utilized to identify regions most susceptible to wildfires, considering variables such as vegetation type, wind patterns, and terrain slope.
3. **Risk Assessment:** preparedness and mitigation. AHP-GIS enables the identification of high-risk areas by analyzing relevant spatial factors.
 - **Environmental Risk Management:** AHP-GIS is applied to evaluate and identify areas most vulnerable to natural disasters, including floods, earthquakes, and wildfires, by analyzing factors such as topography, population density, and climatic conditions.
 - **Seismic Risk Assessment:** This method can be utilized to identify areas particularly at risk of earthquakes based on criteria such as historical seismic activity, soil composition, and slope.
4. **Agriculture:** Agricultural productivity heavily depends on site selection and land management. AHP-GIS assists in optimizing agricultural practices by analyzing soil properties, climate conditions, and water availability.
 - **Optimal Agricultural Site Selection:** AHP-GIS can aid in selecting the most suitable land for agricultural purposes by evaluating factors such as soil type, climate, water availability, and slope.
 - **Land Management:** The method supports decision-making regarding land allocation for agricultural use, based on various spatial attributes.

1.6 Conclusion

Integrating of GIS and AHP provides a robust framework for complex spatial decision making, enhancing factor analysis across various disciplines. This approach continues to evolve as technology advances, offering more sophisticated solutions. Incorporating it into a mobile application improves accessibility, enabling efficient spatial analysis and decision-making on portable devices.

Chapter 2

Forest Wildfires Risk

2.1 Introduction

Wildfires are natural occurrences that are essential for the preservation of numerous ecosystems. Nevertheless, there has been a notable rise in frequency and severity in recent years, attributed to both natural phenomena and human activities. This chapter will examine the importance of Forests , the underlying causes of wildfires, the elements that affect their behavior, and the environmental and socio-economic consequences they entail in Algeria . Gaining insight into these factors is crucial for effectively managing and alleviating the impacts of wildfires, particularly in the context of climate change.

2.2 The importance of forests

Forests are renewable natural resources that represent the backbone of other renewable resources... we limit the benefits of forests to three basic functions , Figure 2.1 : economic , ecological , and social function . [11]

The importance of forests		
Economic function	Ecological function	Social and Tourism function
Thermal energy.	80% of amphibian species	Noise reduction
Building and furnishing industry	75% of bird species	Spaces for relaxation and recreation.
Paper industry	Mitigating the adverse effects of climate change	Supplying essential resources, property, and production capabilities

Figure 2.1: The Importance of Forests

Since 1990, the United Nations Food and Agriculture Organization have documented a loss of around 420 million hectares of forests due to changes in land use. From 2015 to 2025, the annual deforestation rate was reported at 10 million hectares, a reduction from the 16 million hectares per year observed globally during the 1990s. Over 100 million hectares of forests have suffered damage from fires, pests, diseases, invasive species, droughts, and extreme weather

events since 1990.

2.3 Forest Wildfire

2.3.1 Forest Wildfire Causes

A fire is a chemical reaction that necessitates three essential components, Figure 2.2: a combustible material (fuel), oxygen (air). In contrast, during hot weather, combustible materials tend to dry out, facilitating their interaction with the other necessary elements. [12]

Forest Wildfire Causes	
Effect of Natural Factors	Effect of Human Factors
The type of trees: species rich in volatile oils plays a crucial role in the ignition process and the fire spreads	Agricultural practices in forested areas...
The age of trees: young with dry branches and low-growing canopies influences more the fire susceptibility	Forestry operations and charcoal production...
Climate change: especially concerning water resources , agriculture, and desertification	Hunting activities and the establishment of camps by hunters...
Geological features: such as slopes and inclines, areas with gentle terrain tend to ignite more readily, with fires spreading due to heat transfer and wind	Industrial and artisanal activities such as waste burning...
	Discarding cigarette butts and leaving smoldering ashes...

Figure 2.2: Forest Wildfire Causes

2.3.2 Forest Wildfire Patterns

Forests are renewable natural resources that represent the backbone of other renewable resources... we limit the benefits of forests to three basic functions, Figure 2.3: the economic function, the ecological function, and the social function [13]

Forest Wildfire Patterns		
Type	Occurrence	Description
Ground Fires	Occurs in the presence of organic material on the ground's surface	Spread slowly and can be easily controlled
Surface Fires	Occurs in dry grasses, trees, leaves, herbs, and surface shrubs	It is the most common type of forest fire
Crown Fires	Crown fires ignite the entire tree, reaching its top.	It can lead to many catastrophic outcomes

Figure 2.3: Forest Wildfire Patterns



Surface Fires [14]

Ground Fires [15]

Crown Fires [16]

2.3.3 Forest Wildfire Consequences

The following outlines the most significant damages and consequences that forest fires inflict on the environment , Figure 2.5: [17]

Forest Wildfire Consequences
Ecosystem Degradation and Biodiversity Loss
Air Pollution
Ecosystem Degradation and Biodiversity Loss
Destruction of Water Sources

Figure 2.5: Forest Wildfire Consequences

2.3.4 Forest wild fire prevention methods

Wildfire prevention designed to diminish the likelihood of fires and to reduce their intensity and spread. It focus on managing air quality, preserving ecological balance, safeguarding re-

sources, and influencing the occurrence of future fires.
[18]

Forest wildfire prevention methods
Integrate Firefighting policies in urban codes
Land-clearing and agricultural practices
Periodic burning of fuels surface practices.
Using flame-resistant materials in construction
Removing flammable materials within a specified distance from the building
The maintain of fire lines that are 5 to 10 meters wide between villages and the surrounding forest
Face residential development in fire-prone regions.

Figure 2.6: Forest wild fire prevention methods

2.3.5 Using AHP in Wildfire Risk Assessment

Using the Analytic Hierarchy Process (AHP) in wildfire risk assessment involves evaluating various factors such as meteorological conditions, vegetation types, terrain features, and human activities. AHP helps in structuring these factors into a hierarchical model, allowing for the comparison and prioritization of different risk factors based on their relative importance. This process enables decision-makers to identify high-risk areas and develop targeted mitigation strategies. By integrating AHP with geospatial tools, risk assessments can be spatially visualized, enhancing the effectiveness of fire management planning. [19]

1. **Risk assessment criteria** Risk assessment criteria include identifying potential risks, analyzing who could be affected by these risks, evaluating the level of risk, recording the findings, and regularly reviewing the assessments. A risk matrix is used to determine the likelihood and impact of risks. Assessments can be qualitative or quantitative, with qualitative assessments relying on personal judgment and quantitative assessments using numerical data. This process helps prioritize and implement measures to reduce risks.

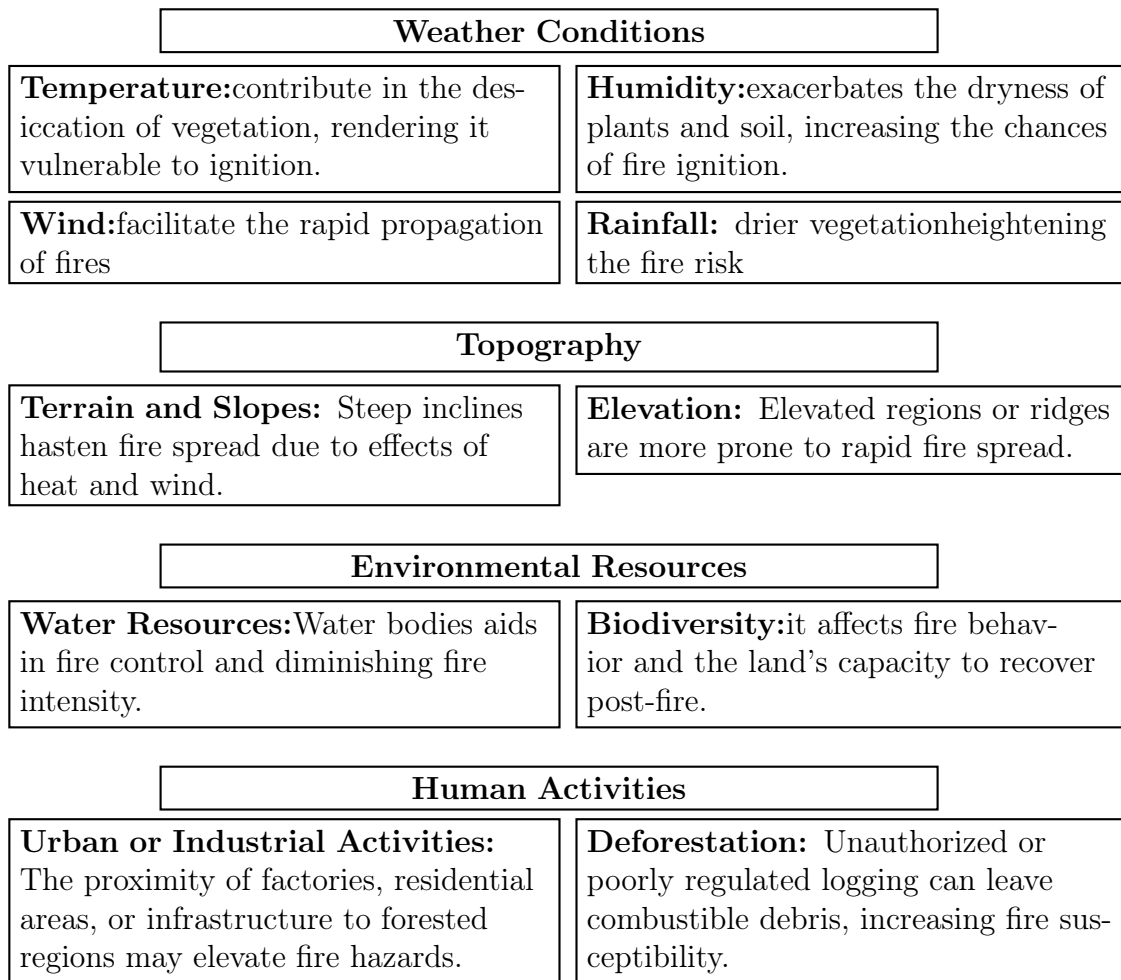


Figure 2.7: Risk criteria

To assess and map forest fire risks (FFR), a comprehensive framework has been established that includes a set of systematic indicators organized into specific classifications. These indicators are designed to enhance our understanding of the various factors influencing fire risks, ultimately facilitating informed decision-making in the management of these risks.

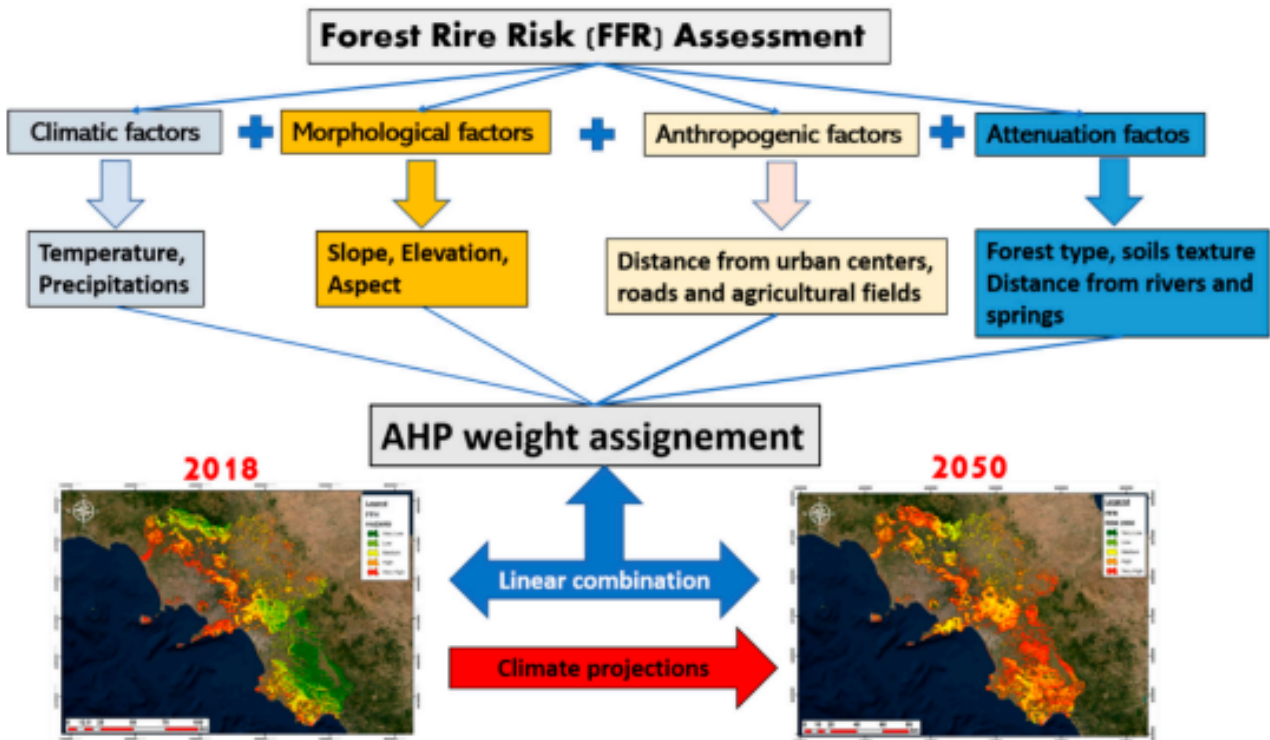


Figure 2.8: Conceptual model of FFR application [19]

- The assignment of weights** The assignment of weights to various thematic layers utilizing the Analytic Hierarchy Process (AHP) is crucial for predicting forest fire zones, as the output heavily relies on the appropriate weighting. Key methodologies employed for calculating the weightage to delineate fire risk zones include fuzzy sets, linguistic variables, and AHP. Among these, AHP is the most commonly utilized method for identifying fire risk zones. This decision-making approach, developed by Saaty, generates relative ratio scales through paired comparisons. In the current study, AHP-based pairwise comparison matrices were constructed for different thematic layers at each hierarchical level. These matrices facilitated the comparison of all factors against one another based on their significance, categorized as equal, moderate, strong, very strong, and extremely strong. A standard 1–9 scale, as proposed by Saaty, was employed to ascertain the relative importance values for all themes and their associated features, where a value of '1' indicates "equal importance" between two themes, and a value of '9' signifies the "extreme importance" of one theme over another, as illustrated in Table 1. The normalized relative weight was computed by dividing each element of the pair wise matrix by the sum of its respective column. The weights for each layer were determined using the principal eigenvector of the square matrix corresponding to each criterion. The greater the weight assigned, the more significant the influence of the parameters on forest fire risk, reflecting their relative importance. The following equations were utilized to derive the weights for each thematic layer.

Intensity importance	Linguistic variables
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate importance
5,6	Strong importance
7	Very strong importance
8	Very to the extremely strong importance
9	Extreme importance

Table 2.1: Scale for a pair-wise comparison matrix [19]

3. Sum the values in each column of the pair-wise comparison matrix using the formula:

$$L_{i,j} = \sum_i^n C_{i,j}$$

Where $L_{i,j}$ is the total column value of the pair-wise comparison matrix and $C_{i,j}$ is the criteria used for the analysis.

4. Divide each element in the matrix by its total row to generate a normalized pair-wise comparison matrix:

$$X_{i,j} = \frac{C_{i,j}}{L_j}$$

where $X_{i,j}$ =normalized pair-wise comparison matrix.

5. Divide the sum of the normalized row of the matrix by the number of criteria/parameter (N) to generate the standard weight by using the following formula:

$$W_{i,j} = \frac{\sum_1^n X_{i,j}}{N}$$

6. For calculating the consistency vector values, the following formula was used:

$$\lambda = \sum_1^n C.V_{i,j}$$

where λ =consistency vector.

7. Consistency Index (CI) was used as a deviation or degree of consistency which was then calculated using the following formula :

$$CI = \frac{\lambda - n}{n - 1}$$

Where CI=Consistency Index, n=Number of criteria.

8. Consistency ratio (Cr) is calculated by using the formula:

$$Cr = \frac{CI}{RI}$$

Where RI=random inconsistency

n	2	3	4	5	6	7	8	9
RI	0	0.52	0.9	1.12	1.21	1.34	1.41	1.45

Table 2.2: Radom Inconsistent Values [19]

If the value of the Consistency ratio (Cr) is less than or equal to 0.10, then the inconsistency is acceptable. Random inconsistency (RI) values for 'n' number of criteria, i.e., number of parameters.

9. **Assignment of weights for forest fire risk zone** The method of the weighted linear combination was applied to identify the forest fire risk zones. The weights of the different thematic layers were multiplied by the weights of features of each thematic layer and summed the products of all the attributes and obtained the total scores by using the formula:

$$TS = \sum_1^n w * R$$

10. **Validation of fire risk zone map using MODISdata** The accuracy of the fire risk zone map was verified using the fire point's data of MODIS satellite for 2011 which was acquired from National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO), and Bhutan. The fire points were overlaid to the forest fire risk zone map of the study area. The percentage of an area which was evaluated from the spatial analyst tool in GIS and imported to Microsoft Excel environment for calculating risk zone percentage, then the percentage of the area under fire was calculated using the equation given as follows

$$\text{percentage of the area} = \frac{\text{estimated area} * 100}{\text{total area}}$$

2.4 Forest Wildfire in Algeria

2.4.1 Location specification

1. **Geographic location :** Algeria is a country in the Maghreb area in North Africa. It is in the Northern Hemisphere. As the Prime Meridian traverses its territory, it is both in east and west hemispheres. Algeria borders seven countries. To the northeast it borders Tunisia, Libya and Niger in turn to east as well southeast. Mali, Mauritania and Western Sahara sit to its southwest. Morocco is the country that stands alongside Algeria, to the west. The Mediterranean also washes onto the country's coast



Figure 2.9: geographic location

2. **Weather Conditions :** Algeria experiences two distinct climates: a Mediterranean climate in northern Algeria and a desert climate in the majority of the country. The sub-humid Mediterranean climate on the coast and in the Tell Atlas Mountains is characterized by wet and mild winters and hot and dry summers. The rest of the country is covered by the Sahara Desert, where the seasonal average winter temperature is 15°C to 28°C and 40°C to 45°C during the summer. In the north, moist winds from the sea bring rain from autumn to spring. Algeria's climate is also influenced by Sirocco winds, which cause increased temperature with dusty, dry conditions and storms in the Mediterranean Sea. Key historical climate trends include:

- **Temperature :**

- Annual mean temperatures have risen across Algeria since the 1960's.
- Inter-annual and decadal variability at the nearest available station show a warming of about 2.7°C per century since the 1900's.

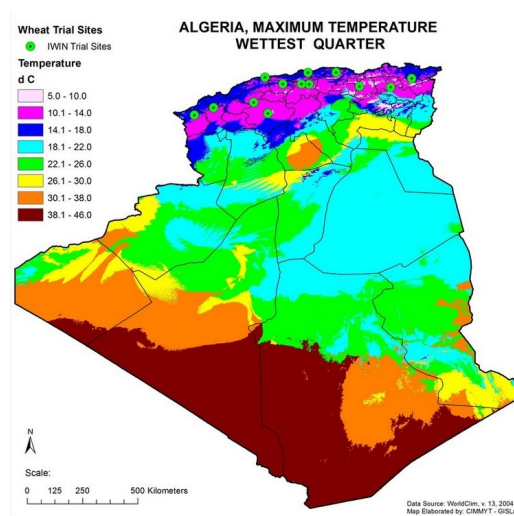


Figure 2.10: temperature in algeria

- **Precipitation**

- Variability in rainfall is high.
- The seasonal average station, decadal variability and linear trend indicate a reduction of 12.4 mm/month per century since 1960's.

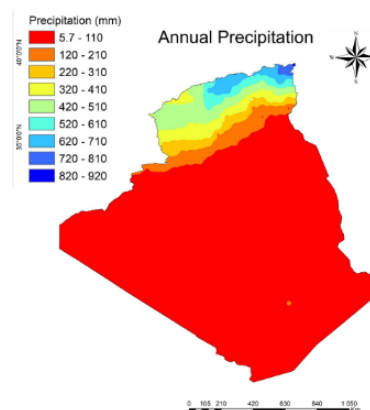


Figure 2.11: percipitation in algeria



Figure 2.13: Vegetation Cover

4. **Topography** : The surface of Algeria consists of three sections:

- **Littoral Section:** the elevations of the northern Algerian coast overlooking the Mediterranean Sea vary significantly from one region to another due to the overlap between the coast and the Tell Atlas mountain range. It ranges from 0 to 200 meters above sea level in the Mitidja plain, while there are highlands that extend across the coastal strip and approach the sea in many areas, and mountains whose height ranges from 900 to 2000 meters.
- **The High Plateaus Ranges** The elevation of the High Plateaus ranges from 600 to 1,300 meters above sea level. It is characterized by a semi-flat or undulating surface, interspersed with hills and plateaus. In addition, there are sabkhas (marshes), such as the Chott Melghir, which are low-salinity areas formed by the accumulation of water during the rainy season.
- **The Sahara Section** It is the largest region in the country, covering about 80 of the total area of Algeria. Although the desert is known for its flatness, its terrain is diverse and includes depressions, plateaus, mountains, and sand dunes ranging in height from 30 m in Wadi Souf to 2,918 m in the Ahaggar Mountains, which are considered the highest peak in Algeria.

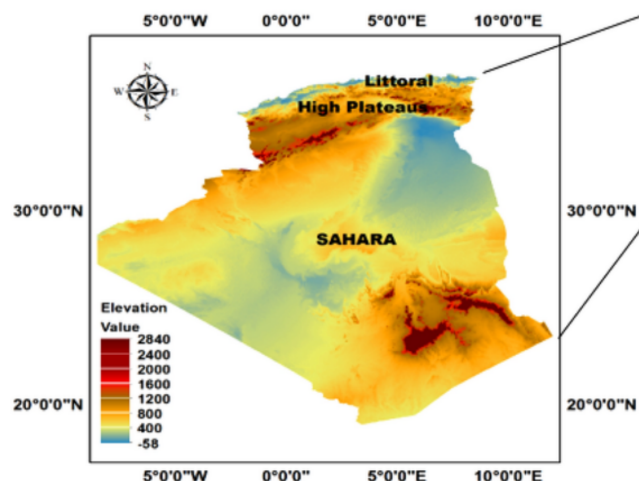


Figure 2.14: Topography

5. **Water Resources and Infrastructure :** Water resources and infrastructure are essential for providing clean water for drinking, agriculture, and industry. Proper management and development of infrastructure like dams, pipelines, and treatment plants help ensure water availability and quality. Investing in sustainable water systems is important to address challenges like pollution, climate change, and population growth.

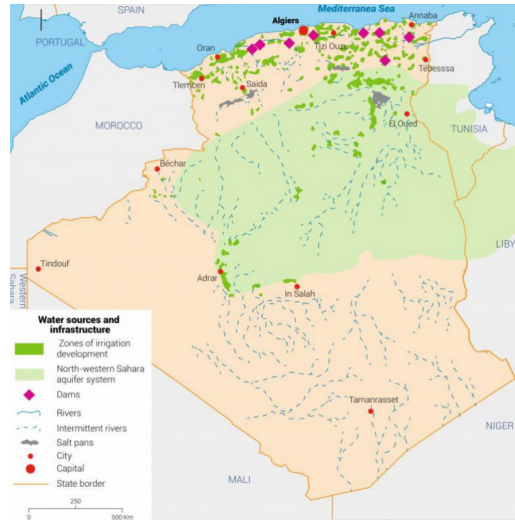


Figure 2.15: Water Resources in Algeria

6. **Human Activities :** The following map shows the distribution of economic activities in Algeria:

- **Agriculture:** Includes farming and herding, and is concentrated mainly in the northern regions such as the Mitidja Plain and the Oran Plains.
- **Industry:** Includes oil and gas extraction and processing industries, and is concentrated in regions such as Hassi Messaoud and Adrar.
- **Services:** Includes education, health, transportation, and tourism, and is concentrated in major cities such as Algiers, Oran, and Constantine.
- **Trade:** it is concentrated in ports such as Algiers, Oran, and Annaba.

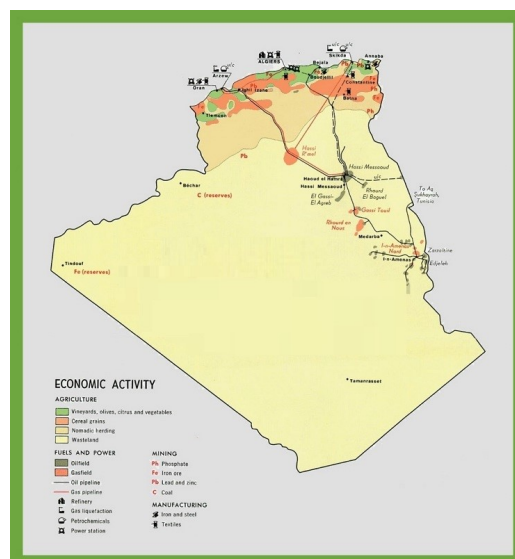


Figure 2.16: Human Activities in Algeria

7. **Population :** The population density in Algeria is considered heterogeneous, as it varies greatly from one region to another due to natural, climatic, and economic factors. The population density in Algeria is considered heterogeneous, varying significantly from one region to another due to natural, climatic, and economic factors. The North (the coast and the north-central) it Contains more than 75 of the population, although it represents only about 17 of the country's area. Population density may exceed 300 people per km² in some regions. While it represents about 80 of Algeria's area, the sahara region is home to less than 10 of the population. With Less than 2 people per km²..

2.4.2 The evolution of Forest Fires in Algeria

The following histogram: present the evolution of forest fires in Algeria (2009-2024) : The

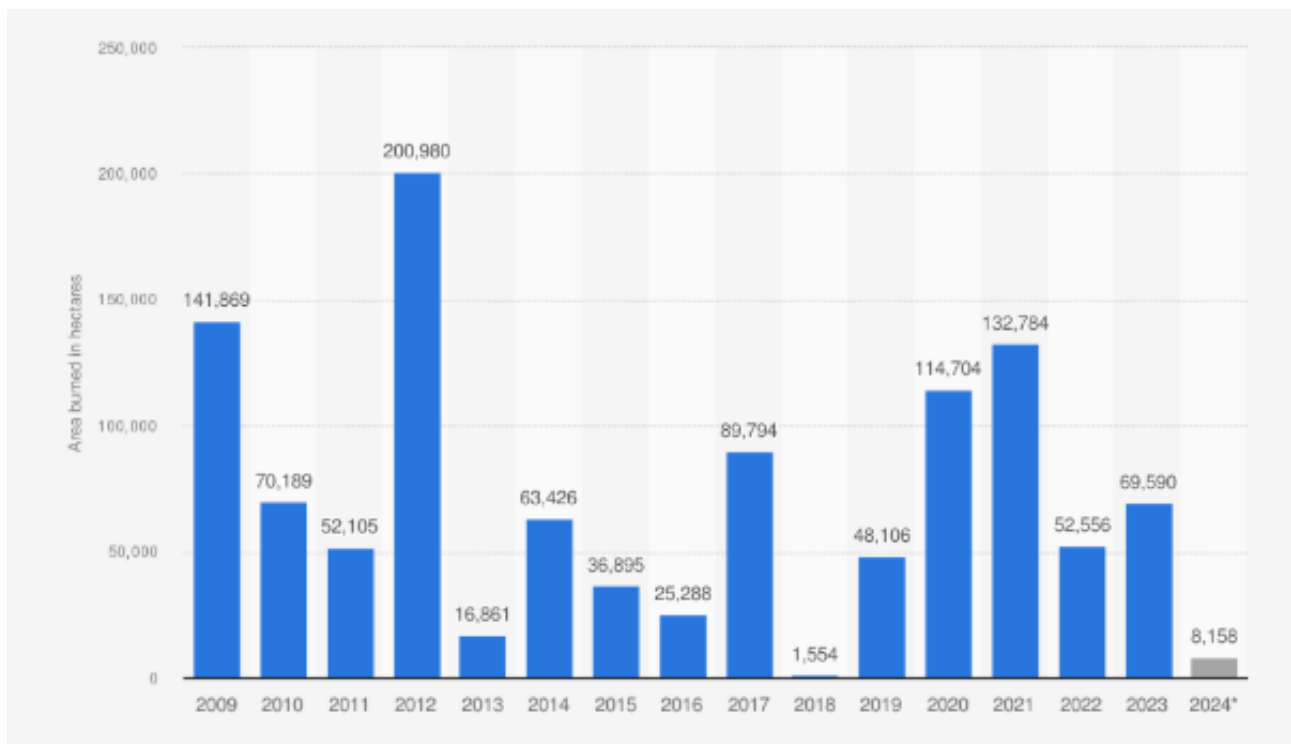


Figure 2.17: Area Burned by Wildfires in Algeria from 2009 to 2024 [20]

data reveals:

1. A highly fluctuating trend in forest fires in Algeria from 2009 to 2024. Some years, such as 2012, 2009, 2020, and 2021, experienced massive wildfires, while others, like 2013 and 2018, recorded significantly lower burned areas. The sharp increases in certain years suggest the impact of extreme weather conditions, such as drought and heat waves, as well as possible human activities. The periods of decline may indicate successful fire prevention strategies or less favorable conditions for fire outbreaks.
2. Wildfire trends are inconsistent, influenced by climate, human factors, and governmental intervention. The sharp rise in burned areas in specific years suggests that external factors, such as rising temperatures and prolonged dry seasons, play a major role.
3. The presence of years with low wildfire activity suggests that effective fire prevention and response measures can significantly reduce damage. With increasing climate change effects, wildfires may become more frequent and severe unless strong preventive measures are taken. Investments in early detection systems, improved fire-fighting equipment, and community awareness programs will be crucial in mitigating future disasters.

2.4.3 Algerian Policy Against Forest Fires

Algeria has been actively working to combat forest fires through various policies and strategies. Key elements of their approach include:

1. **Legal Measures:** A law was passed in January that imposes life imprisonment on those caught deliberately starting forest fires. This law combines different articles into one dedicated law that carries harsher penalties.
2. **Prevention Strategies:** Algeria's forest fire prevention strategy is based on the principle of "minimum damage", given the technical limits and resource constraints in protecting all forest lands [22]. The country is working to improve alert systems and communication, and to intensify preventive culture in high-risk areas to reduce forest vulnerability [22]
3. **Resource Allocation and Modernization:** Algeria is modernizing its firefighting equipment and techniques and allocating sufficient resources to enable key stakeholders to perform their duties [23]
4. **Early Warning System:** Development of an integrated Early Warning System (EWS) that includes forest fire warning, and raising public awareness to encourage behavior change [23]
5. **Collaboration and Participation:** The government is encouraging close collaboration between government institutions, civil society, local communities, and stakeholders [21]
6. **Infrastructure Improvement:** Local officials have built landing pads for heavy-lift helicopters to transport water tanks, as well as watchtowers for the forestry service. Paths have been cut through thick forests to improve firefighter access.
7. **Technology Deployment :** A drone and a high-resolution camera using artificial intelligence have been deployed to monitor hot spots.
8. **Public Awareness:** Public awareness campaigns are being conducted to increase preparedness, utilizing TV and radio spots in Arabic and French to educate the population on preventive measures and actions to take during forest fires.
9. **Post-fire Forest Recovery:** Civil Society Organizations (CSOs) have joined forces to strengthen community resilience through reforestation efforts. Reforestation actions with the participation of SCOs resulted in the planting of more than 185.400 seedlings to reforest nearly 1400 hectares of land.
10. **International Cooperation:** The World Bank and the Algerian government are collaborating to strengthen the sustainability and climate resilience of Algeria's forest resources [21]

Despite these efforts, forest fires remain a significant problem in Algeria, with an average of 20,000 hectares of forest land consumed by fires each year[31]. Between 2010 and 2019, nearly 3000 fires were recorded annually, burning an area equivalent to about 30,000 soccer fields[33]. In summary, wildfires represent intricate phenomena influenced by various elements, including climatic conditions and human actions. Although they are a natural occurrence within numerous ecosystems, their escalating intensity presents considerable challenges. By examining the underlying causes and effects of wildfires, we can formulate more efficient approaches for prevention, management, and recovery. Ongoing research and proactive initiatives are crucial

to mitigate the harm inflicted by these devastating events, and we study behavior of forest fire in Algeria.

2.5 Pictures of Forest Fires in some Algerian States

Images of forest fires in Algeria reflect the scale of the environmental and humanitarian disaster experienced by some provinces, especially during the summer. The fires ravaging vast areas highlight the challenges the country faces in protecting its natural resources and rural communities :



Figure 2.18: Forest Fires in Tipaza State in 2020 [24]

The 2020 forest fires in Tipaza province, Algeria, were devastating, destroying vast areas of vegetation and claiming lives, including two firefighters. Triggered by a mix of dry conditions and high winds, the fires spread rapidly, causing significant environmental and economic damage. The tragedy highlighted the urgent need for improved fire prevention measures and emergency response systems , As shown in the Figure 2.18 .



Figure 2.19: Forest Fires in Tizi Ouzou State in 2021 [25]

The 2021 forest fires in Tizi Ouzou were among the deadliest in Algeria's history, claiming dozens of lives and devastating large forested areas. Fueled by extreme heat and strong winds,

the fires destroyed homes, farmland, and wildlife habitats. This tragedy underscored the pressing need for stronger disaster management and climate resilience strategies , As shown in the Figure 2.19 .



Figure 2.20: Forest Fires in Chelef State in 2022 [26]

The 2022 forest fires in Chlef province caused significant environmental and economic damage, destroying vast areas of forests and farmland. High temperatures and dry conditions contributed to the rapid spread of the fires, which also threatened nearby communities. The incident highlighted the urgent need for proactive fire prevention measures and climate adaptation policies, As shown in the Figure 2.20.



Figure 2.21: Forest Fires in Bedjaia State in 2023 [27]

The 2023 forest fires in Bejaia were catastrophic, ravaging thousands of hectares of forests and displacing numerous residents. Intense heatwaves and strong winds exacerbated the situation, making containment efforts challenging. The fires underscored the region's vulnerability to climate change and the need for enhanced firefighting resources and preventive strategies,

As shown in the Figure 2.21

2.6 Conclusion

Wildfires pose a significant threat in Algeria, driven by natural factors such as high temperatures and drought, as well as human negligence. The AHP method was utilized to prioritize risks and optimize preventive measures. The findings highlight the need for enhanced prevention through early warning systems, public awareness, and technological investments. Achieving sustainable forest protection requires coordinated efforts between government institutions and local communities.

Chapter 3

Similar Applications

3.1 Introduction

This chapter discusses applications of wildfire risk assessment using Geographic Information Systems (GIS) and Analytic Hierarchy Process (AHP) techniques. These applications aim to provide effective solutions for understanding and analyzing wildfire risks by integrating geographical data and various criteria to identify areas most vulnerable to danger. This chapter will review key studies that have utilized these techniques and analyze their effectiveness in improving prevention and prediction strategies.

3.2 Mobile Applications

3.2.1 Definition

A mobile application is a software program designed specifically for small, wireless computing devices like smartphones and tablets, as opposed to traditional desktop computers. Mobile applications can be classified as either web-based or native, the latter being tailored for a specific platform. Additionally, there are hybrid applications that integrate features of both native and web apps. In the current digital era, mobile applications have become integral to the daily routines of many individuals, facilitating activities ranging from social networking and entertainment to productivity and business, thereby significantly influencing our technological interactions. [28]

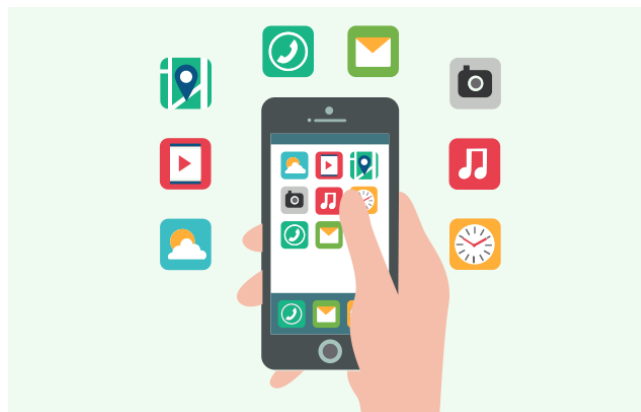


Figure 3.1: Mobile Application [29] .

3.2.2 Importance

Mobile phones have become essential for people as a wallet through which they can purchase items, capture images guide their travel. Mobile app development is required in today's digital mobile-centric world. Below, we will discuss the importance of mobile app development: [30]

1. **Helps in Omni Channel Approach :** Mobile applications provide strong personalization and targeted marketing strategies for businesses, thereby improving the omnichannel customer experience. Customers can effortlessly buy products through various channels, ensuring a smooth and cohesive experience.
2. **Increased Accessibility :** Mobile applications play a crucial role in enhancing business operations by enabling prompt notifications to customers regarding updates related to services and products. This capability fosters positive relationships with customers, thereby increasing their trust and facilitating the maintenance of robust connections with clients.
3. **Improved Customer Experience :** The advancement of mobile applications enables the digital transformation of customer loyalty programs. This innovation enhances the overall experience for businesses by meeting customer expectations regarding products and services, ultimately improving customer satisfaction. Through mobile applications, users receive prompt updates and information about the items they wish to purchase or seek, including details about product features and interfaces.
4. **Increased Sales :** Mobile applications have the potential to boost sales and brand visibility by offering customers a user-friendly and efficient experience. Through these applications, businesses can enhance customer interaction and increase revenue by implementing pricing strategies that allow customers to explore and purchase a variety of products and services. Companies can also advertise major events through mobile applications, such as seasonal sales, product introductions, promotional codes, and more; they can utilize push notifications to deliver targeted promotions, engage in in-app marketing, and much more.
5. **Enhanced Brand Recognition :** The creation of mobile applications serves as an optimal means to improve brand visibility among consumers. This can be likened to customizable billboard advertisements, allowing users to access information effortlessly and stylishly, while also being informative and practical. Users are more inclined to interact with and purchase branded products or utilize services through mobile applications.
6. **Improved Communication :** Mobile application users can engage in more interactive collaboration and communication through gamification, social features, multimedia elements, and feedback mechanisms. Additionally, companies have the opportunity to host various webinars, training sessions, and video conferences.
7. **Direct Marketing :** The development of mobile applications appears to be essential to digital marketing, as it provides a direct means to gather information, engage customers, and deliver personalized marketing experiences. Companies can oversee direct marketing efforts by performing market research and employing email marketing strategies.
8. **Unique Payment and Services :** Mobile applications possess unique functionalities tailored to different sectors. For instance, if you operate within the service industry, such as healthcare, spas, or salons, your application would be ideally suited for your target clientele to schedule appointments.

3.3 Similar Applications

3.3.1 Wildfire Analyst

1. Definition :

WFA Pocket is a mobile application that integrates the most recent advancements in wildland fire behavior science into a comprehensive tool for firefighters and Fire Behavior Analysts. Utilizing research from the US Forest Service Missoula Fire Sciences Lab, this application improves calculations through a 3D interactive map interface, real-time weather data integration, and efficient assimilation of fuels information. WFA Pocket serves the wildland fire community by offering a robust analytical resource intended for field use. The application functions effectively both online and offline, delivering outputs and results in a format that is easily comprehensible and practical. [31]

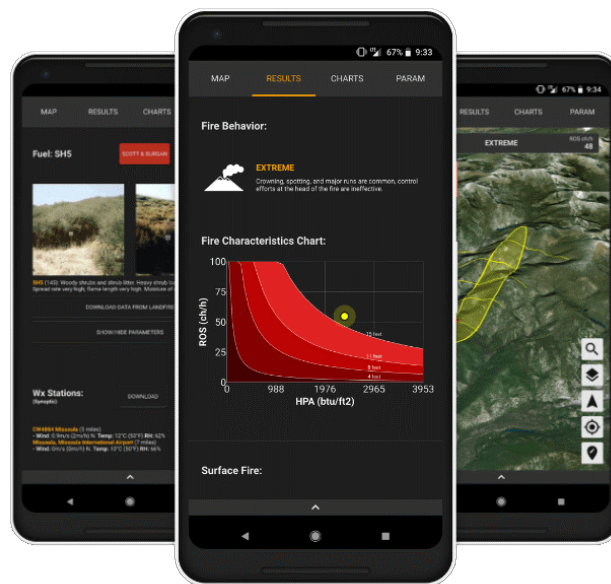


Figure 3.2: WildFire Analysts [31]

2. How to use it?

- First enter environmental data such as terrain, weather, vegetation type, and geographic information using GIS data.
- Then, use the app's tools to analyze the risk based on the input factors, such as wind, humidity, and terrain.
- Next, apply the AHP (Analytic Hierarchy Process) model to determine the importance of each factor and its impact on wildfire risk assessment.
- After analyzing the data, classify areas based on risk levels (high, medium, low) using the geographic analysis.
- Monitor predictions using real-time weather or satellite data to update forecasts on fire spread.
- Finally, generate graphical reports and interactive maps that show risk areas and response recommendations, and use the information for emergency response planning, such as directing firefighting teams and identifying safe zones.

3.3.2 Watch Duty

1. Definition :

Watch Duty is an application for wildfire mapping and alerts, driven by real individuals who provide real-time information that has been verified by trained professionals rather than automated systems. Unlike many other applications that depend exclusively on government notifications, which may frequently be delayed, Watch Duty offers immediate, life-saving updates through a committed team of active and retired firefighters, dispatchers, first responders, and reporters who continuously monitor radio communications. [32]

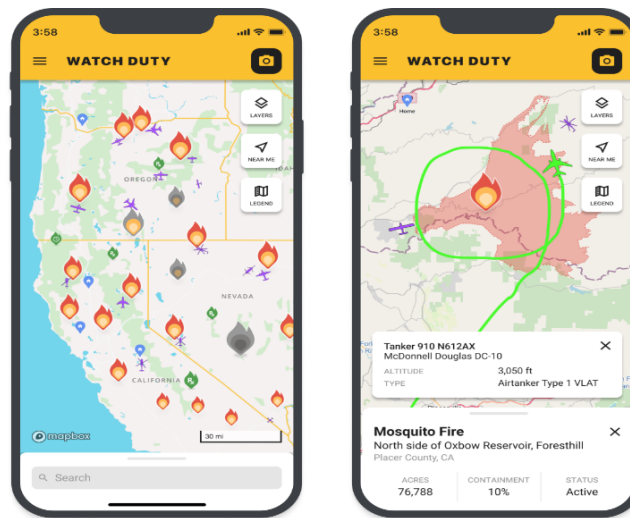


Figure 3.3: Watch Duty gui [33]

2. How to use it?

- 911 dispatch center receives a call about a vegetation fire.
- Our automated monitoring system hears that 911 dispatch and alerts our team in Slack.
- All available Watch Duty reporters in that region begin monitoring their radio scanners, wildfire cameras, satellites, and other public sources such as official announcements from law enforcement and fire services.
- The team vets all available information and awaits for on-scene personnel to give an official report on conditions.
- if the system perceive a threat to life or property, it will notify the affected public via the Watch Duty app. Our reporters follow a strict code of conduct when notifying the public.
- Reporters will continually monitor the incident and update the public along the way until it is extinguished or no longer a threat to life or property [34]

3.3.3 FireMapper

1. Definition :

FireMapper for Enterprise is a sophisticated mapping solution aimed at facilitating the management of medium to large-scale vegetation fires. This tool enables key members of Incident Management Teams to simultaneously input and access a shared 'live map' while on-site. The live map can be disseminated to other operational personnel, crews,

coordination centers, and, when necessary, additional agencies such as Civil Defence, Police, the Department of Conservation, and the forestry sector. The ability to share the live map promotes a unified comprehension of the ongoing situation and the intended actions. [35]



Figure 3.4: FireMapper [35]

2. How to use it?

- Upon launching the app, set your location or the area you want to monitor for wildfire risks. It typically allows you to input coordinates or select from predefined regions.
- View Real-time Data: Once set up, the app displays real-time fire data, such as active fires, fire perimeters, and smoke plumes. You can track the status of fires using satellite data or real-time updates from fire authorities.
- Use GIS Layers: FireMapper provides GIS-based tools to visualize various layers, such as land cover, topography, weather conditions, and fire history.
- Monitor Risk Factors: The app allows you to monitor different risk factors like wind speed, temperature, humidity, and vegetation type. These elements contribute to determining the fire's potential spread and intensity.
- Analyze Fire Spread: FireMapper lets you use predictive models to estimate fire behavior and potential spread based on the current weather and terrain data. This feature helps in assessing the fire's future movement.
- Set Alerts and Notifications: Users can set up notifications for fire updates or alerts about nearby fire outbreaks, helping to stay informed about threats in real time.
- Download Reports and Maps: The app allows you to download fire risk reports and maps. You can generate visual reports based on the current data, which can be shared with emergency teams or stakeholders.
- Emergency Response Planning: Use the information from FireMapper to assist in emergency response planning.

3.3.4 Fire Alert

1. Definition :

This application enables users to receive notifications and alerts from their Fire Alert

Home System. The system facilitates early detection and monitoring of potentially expensive and destructive disasters, including those caused by fire or smoke, water leaks, freezing temperatures, and carbon monoxide. Alerts are dispatched to the Fire Alert App, informing users of the location and nature of the emergency, and allowing for direct response through the app.[36]

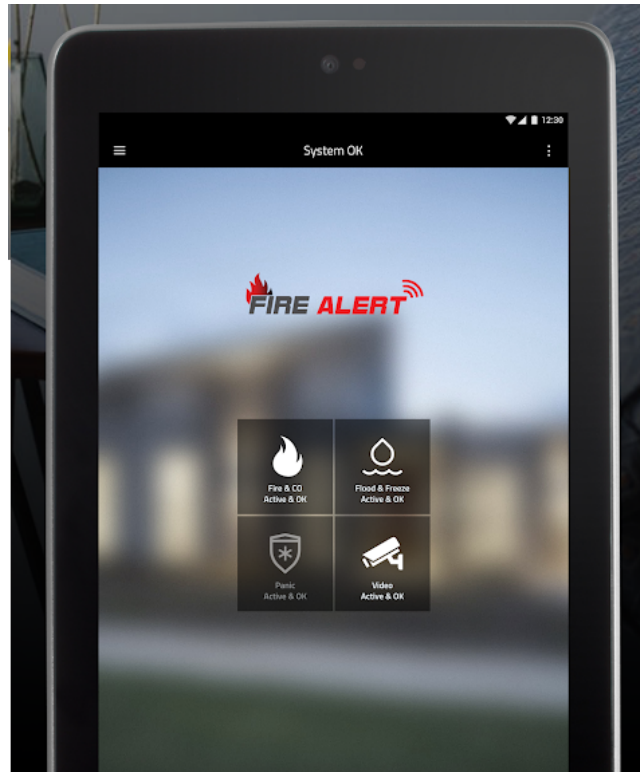


Figure 3.5: Fire Alert [36]

2. How to use it?

- Upon launching the app, set your location or the area you want to monitor for wildfire risks. It typically allows you to input coordinates or select from predefined regions.
- Set up the App: Open the app and create an account if required. You need to provide basic information like your location or the area of interest.
- Location Services: Allow the app to access your location to receive relevant fire alerts.
- Set Alert Preferences: Customize your notification preferences to receive real-time alerts for nearby wildfires. You receive notifications based on proximity, fire danger levels, or specific risk factors.

3.3.5 Comparison of this Applications

From our comparison between the previous applications, we reached the following results:

The Application	Advantages	Disadvantages
Wildfire Analyst	<ul style="list-style-type: none"> • Provides real-time wildfire behavior predictions. • Helps emergency responders make quick decisions. • Offers detailed fire spread simulations. • Integrates with GIS for accurate mapping. 	<ul style="list-style-type: none"> • Requires technical expertise to use effectively. • Can be expensive for small organizations. • Relies on accurate weather and terrain data for best results.
Watch Duty	<ul style="list-style-type: none"> • Delivers real-time wildfire alerts from verified sources. • Community-driven with reports from local firefighters. • Free and easy to use for residents in fire-prone areas. • Proactively updates via notifications. 	<ul style="list-style-type: none"> • Coverage may be limited to specific regions. • Relies on volunteer updates, which may lead to occasional delays. • Lacks advanced fire behavior modeling.
FireMapper	<ul style="list-style-type: none"> • Allows users to map and track wildfires accurately. • Useful for firefighters and emergency planners. • Provides customizable fire mapping tools. • Works offline, which is beneficial in remote areas. 	<ul style="list-style-type: none"> • Requires manual data entry, which can be time-consuming. • Limited real-time data compared to AI-driven applications. • Might not be as user-friendly for non-experts.
Fire Alert	<ul style="list-style-type: none"> • Sends real-time notifications about wildfires. • Helps individuals and communities stay informed. • Often integrates with weather and emergency services. • Simple and easy-to-use interface. 	<ul style="list-style-type: none"> • Accuracy depends on data sources and updates. • May not always provide detailed fire behavior analysis. • Some versions may have ads or require a subscription for full features.

Table 3.1: Comparison of Applications

Characteristics	Wildfire Analyst	FireMapper	Watch Duty	Fire Alert
Target Users	Firefighting professionals; requires technical expertise, not suitable for general public.	Firefighting teams and planners; manual data entry limits its efficiency in emergencies.	General public; provides instant alerts, but relies on volunteer reports, leading to possible inaccuracies.	Same as Watch Duty.
Complexity and Technology	Advanced analysis tools; detailed predictions but expensive and complex.		User-friendly alert tools; fast but lack detailed fire evolution data.	
Accuracy vs. Speed	Highly accurate; slower data processing.		Fast notifications; potential inaccuracies due to delayed updates.	
Coverage and Data Dependency	Dependent on satellite data and climate models; accuracy varies with data quality.		Relies on volunteer reports; coverage may be incomplete or delayed.	

Table 3.2: Comparison Between Wildfire Monitoring Tools

From the results of the two tables below we can say that: Applications that offer advanced analysis are more accurate but also more complex and costly, making them less suitable for everyday users. Applications that provide real-time alerts are easy to use but may have limitations in accuracy and coverage, leading to incomplete or outdated information. The best strategy for wildfire management is to combine different applications, where professionals use Wildfire Analyst for in-depth analysis while the public relies on Fire Alert or Watch Duty for quick updates. Developing an application that integrates advanced fire analysis with real-time alerts and improved data accuracy would be the ideal future solution.

3.4 Conclusion

Through reviewing previous applications, it is evident that GIS and AHP techniques have proven effective in providing accurate wildfire risk assessments. These applications contribute to improving risk management strategies and offer a solid foundation for developing more advanced solutions in the future. However, there remains a continuous need for further research and development to integrate new technologies and improve the accuracy and effectiveness of wildfire risk assessment.

Chapter 4

The Design of the Proposed Application

4.1 Introduction

This chapter focuses on modeling and designing the application using Unified Modeling Language (UML). It explains how UML is used to visually and systematically represent the application's structure and workflows. The chapter covers UML tools and diagrams, such as use cases diagrams, activity diagrams, and class diagrams, to simplify the design of complex systems. The goal is to help developers create a clear and cohesive design that is easy to understand and implement.

4.2 Requirements Analysis

This application was designed and developed to meet the needs and solve the following problems:

- Reducing fires through early prediction.
- Protection of forests and natural resources
- Improve emergency response.
- Increase community awareness of the importance and safety of forests.
- Interactive fire hazard map .
- Providing data-driven recommendations to improve local forest management policies.
- Support coordination between neighbouring countries in cases of trans boundary forest fires .
- Identify areas of high environmental or economic importance for special protection.
- Create dynamic emergency plans that are updated based on field data.
- Track long-term weather changes to assess their impact on fire risk.

4.3 UML

4.3.1 UML Definition

During the course of this project, UML serves as a standardized modeling language widely utilized in software engineering. It offers a collection of graphical notation methods to develop visual representations of software-intensive systems. UML is employed for the specification, visualization, construction, and documentation of software system artifacts, in addition to its application in business modeling and various non-software systems. [37] [38]

4.3.2 The importance of using the Unified Modeling Language (UML)

- Professional software design.
- Easy to modify and maintain at a low cost.
- UML diagrams help developers understand the system quickly and easily.
- A communication language between developers and designers.
- Document the design before starting programming.
- Independence from any specific programming language or development process. [39]

4.3.3 UML Diagrams

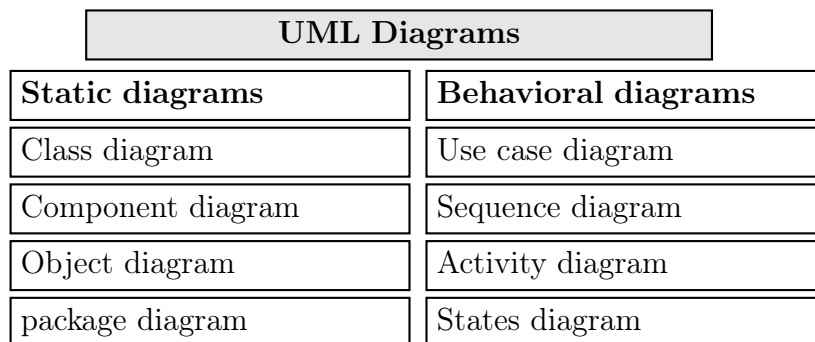


Figure 4.1: UML Diagrams

4.3.4 Diagrams used in the Implementation

Use Case Diagram

The status of use chart is a diagram showing the relation- ships between users and the system being designed. Below we will show the status of the use chart of our application [40] , the following figure 4.2 shows the use case diagram of the application :

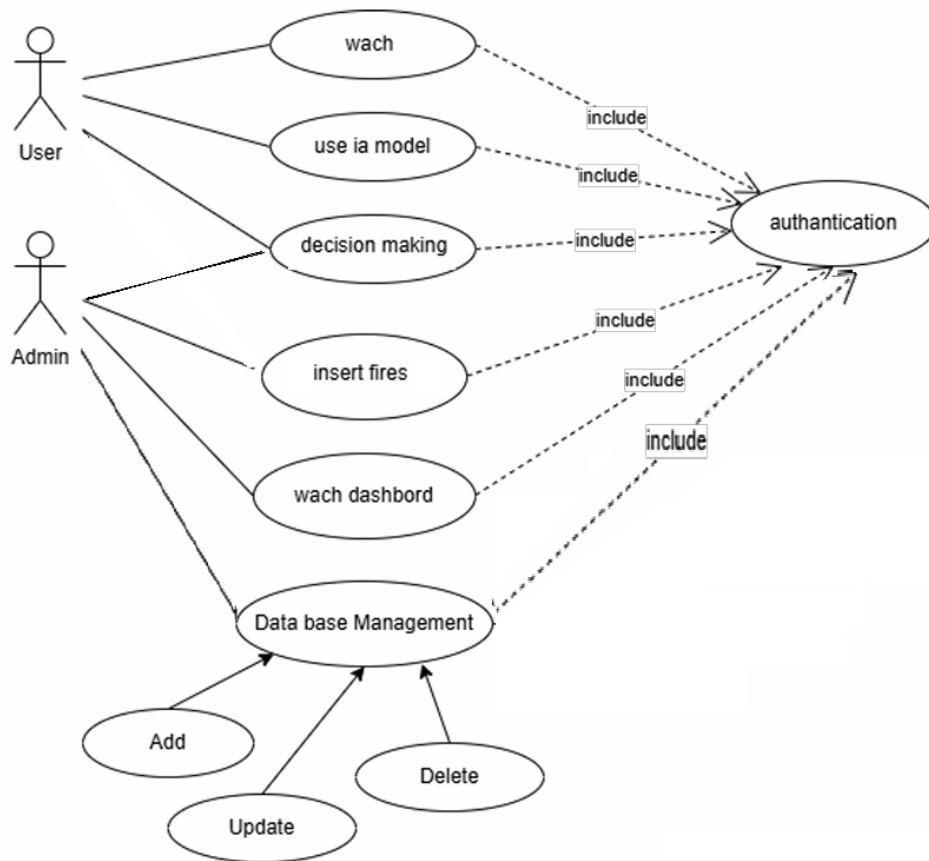


Figure 4.2: Use Case Diagram

Role	Use Cases
User	<ul style="list-style-type: none"> • Monitoring the risk degree of forests. • Using an AI model for prediction. • Making decisions based on data.
Admin	<ul style="list-style-type: none"> • Using a dashboard for fire analysis. • Making decisions based on analysis. • Adding, updating, and deleting forest data. • Inserting forest fire data in real-time.

Table 4.1: Roles and Their Use Cases in the System

Sequence Diagram

A relay chart, sequence chart, or sequence diagram is one type of category chart in the uniform modeling language (UML) and shows the interaction between elements during a chronological sequence and depicts objects and items (classes) that are included in a particular software scenario and the sequence of messages exchanged between objects to properly execute the

scenario. [41] , the following figures 4.3,4.4,4.5 shows the sequences diagrams of the application :

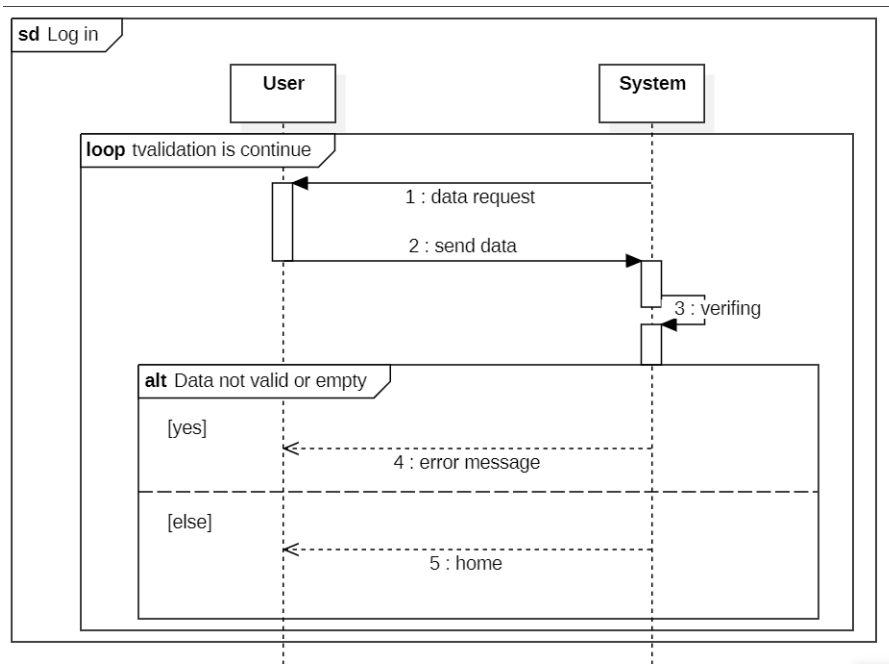


Figure 4.3: Sequence Diagram of the login

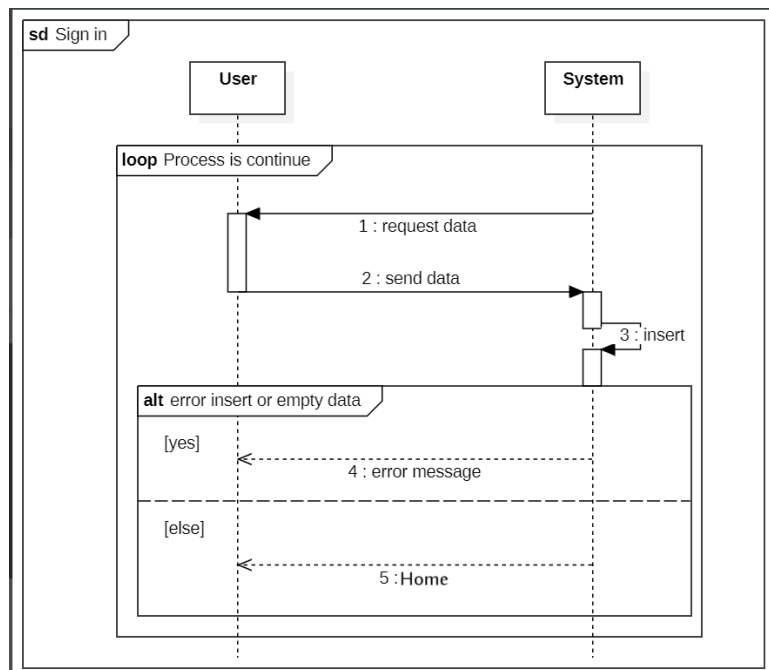


Figure 4.4: Sequence Diagram of the Sign in UI

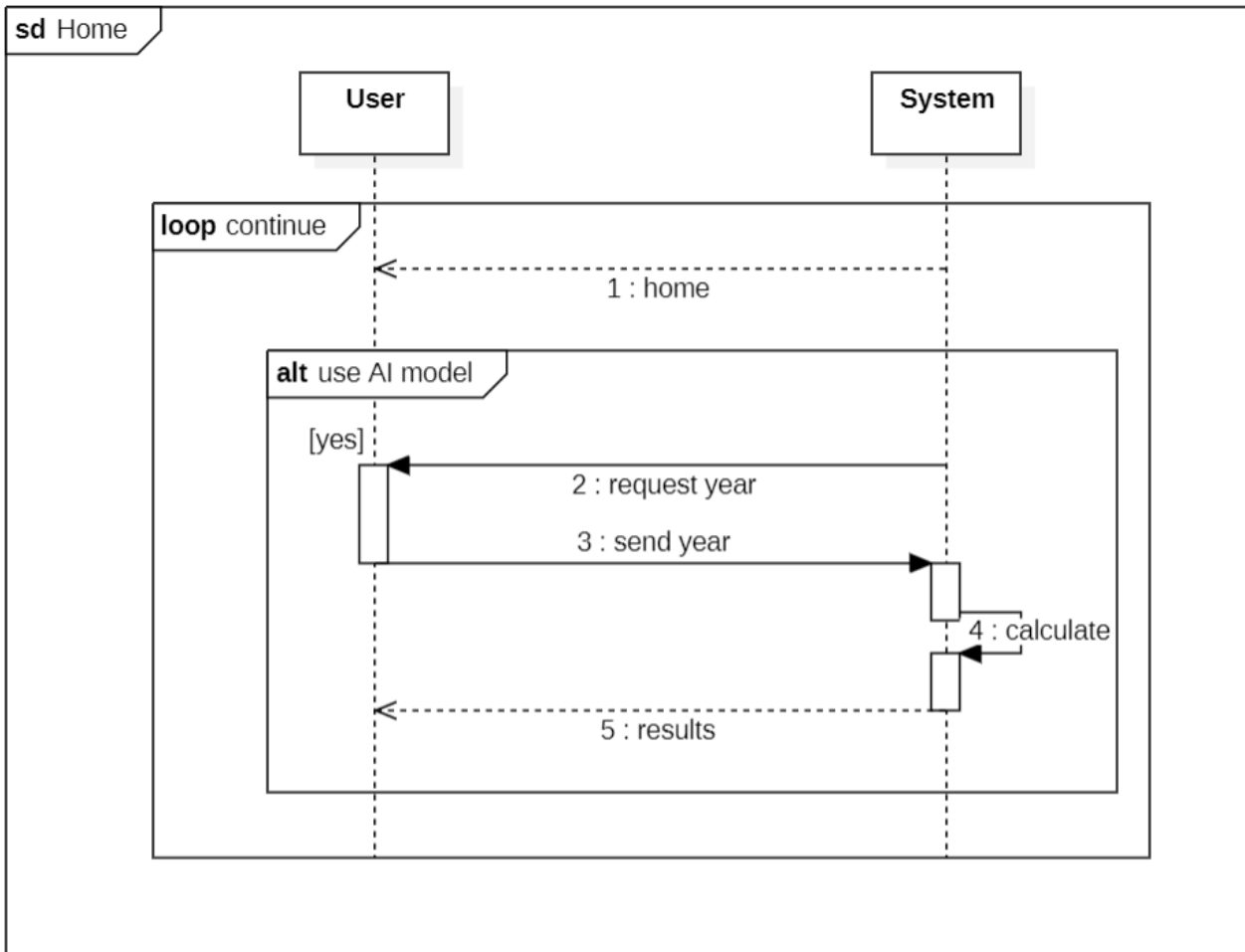


Figure 4.5: Sequence Diagram of the Home Interface

the user has 3 chooses :

- **Login** : from 4.3 he input his phone number and password and the system get theirs to verified by data base and if it catch a error it send error message else the user can watch the map .
- **Sign in** : from 4.4 he use phone number and password to creating his account to log in the home .
- **Home** : from 4.5 he can watch a map of the evaluation of forests fire risk and he can use AI .

Class Diagram

Classes are a very important part of UML, a structural blueprint tasked with presenting categories in a particular system with all their relationships. After completing the determination of each user's role and their representation in the previous schemes, the following chart shows the information we need we build the database of the application. [42] , , the following figure 4.6 shows the class diagram of the application :

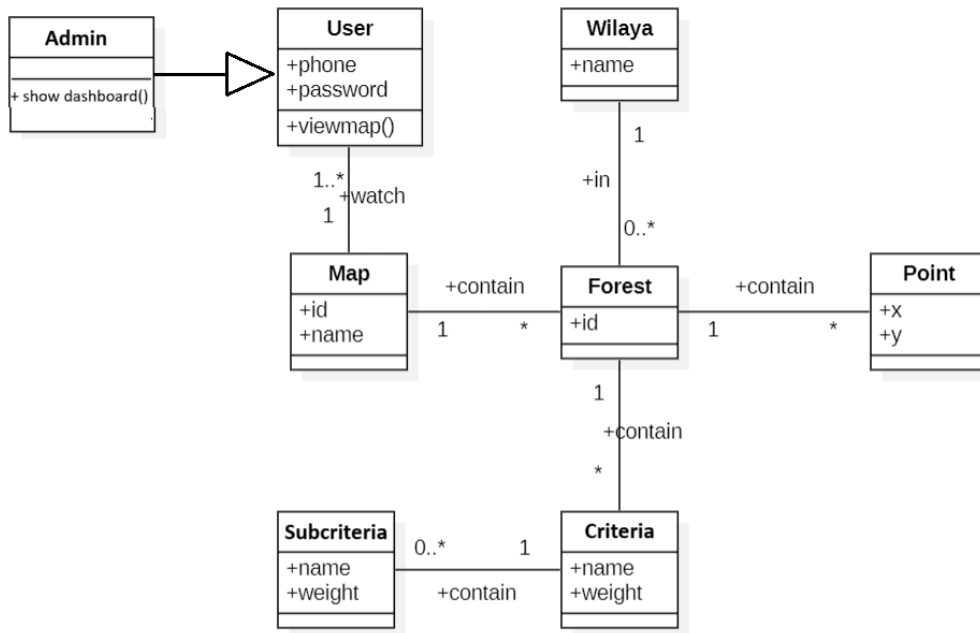


Figure 4.6: Class Diagram

from the class diagram we have 7 class :

class name	description
User	it has a phone and password , it can watch a only map
Wilaya	it has a name and it contain a number of Forests
Forest	it has id and it contains a many criteria and many points
Point	it has a coordinates x and y
Criteria	it has a name and weight and it can contain a sub criteria
Sub criteria	it is like a criteria
Admin	it can watch a dashboard to analyses a fires and decision making

Table 4.2: Class Diagram Description

Activity Diagram

The activity diagram serves as a fundamental behavioral diagram within UML, utilized to illustrate the dynamic features of the system. It can be regarded as a more sophisticated iteration of the flowchart, representing the progression from one activity to the next. [43] , the following Figure 4.7 shows the use case diagram of the application :

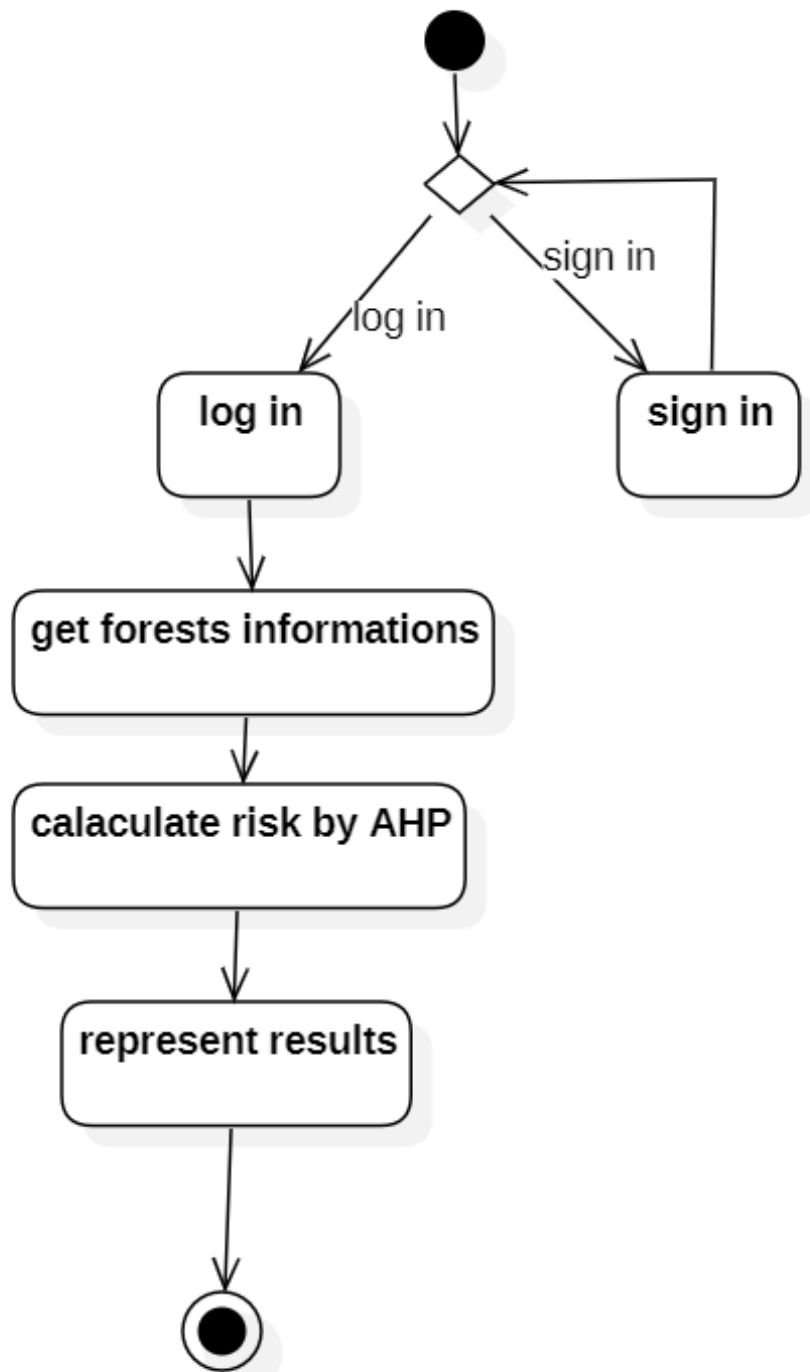


Figure 4.7: Activity Diagram

the user input his data (phone , password) to log in the application , if he has not account , he can create a new account .

in this application , the user can visualize a dashboard like map which contains information about forest fire risk and he can make decision with this application and he can use AI for prediction such as linear regression and KNN algorithm .

4.4 The Data Base Architecture

in our application , we use a data base which it contain a 04 tables like in Figure 4.8 :

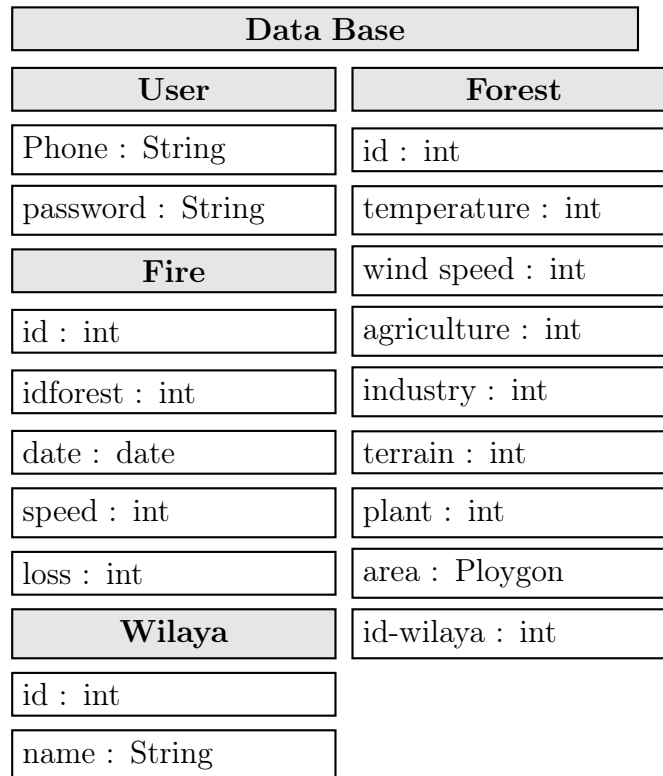


Figure 4.8: Data Base Schema

4.5 Used Criteria

In any decision-making process, establishing clear and effective criteria is essential to ensuring consistent and objective results. "Criteria used" refers to the standards or benchmarks applied to evaluate options, measure performance, or make judgments. Based on the opinions of experts in the field of risk management and the sources [44] [45] [46] [47] , the following criteria were adopted.

Weather	
Temperature	wind speed
<20°C => 2	<10km/h => 3
[20°C , 30°C] => 5	[10km/h , 30km/h] => 4
>30°C=> 8	>30km/h => 5

Figure 4.9: Weather Criteria

Plants	Terrain
Desert steppes => 2	<200m => 2
Oases => 3	[200m , 500m] => 3
Steppe woodland areas => 3] 500m , 1000m] => 4
Evergreen forests => 4	>1000m => 5
Mediterranean plants => 5	

Figure 4.11: Plants and Terrain Criterias

Human Activity	
Agriculture	Industry
Deserts => 1	Electronic Industry => 2
Oases => 3	Mechanical and Metal Industry => 3
Field crops => 3	Textile Industry => 4
Fruit trees => 4	Food Industry => 5
Forests => 5	Paper Industry => 7
	Chemical Industry => 8
	Petrochemical Industry => 9
	Petroleum Industry => 10

Figure 4.10: Human Activity Criteria

4.6 AI Model used

in this application it use two AI models : Linear Regression , KNN

4.6.1 Linear Regression

Linear regression is a statistical technique employed to represent the relationship between a dependent variable and one or more independent variables. It offers significant insights for forecasting and data analysis. This article will examine its various types, underlying assumptions, implementation strategies, benefits, and evaluation metrics. [48]

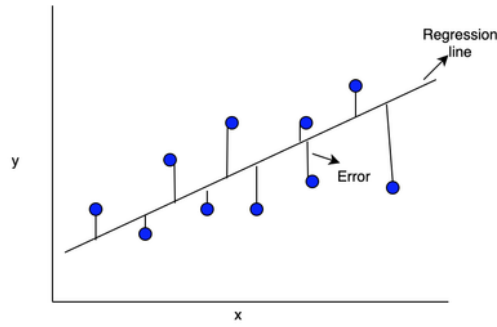


Figure 4.12: Linear regression model [49]

Algorithm 2 Simple Linear Regression

- 1: **Input:** Feature values $X = \{x_1, x_2, \dots, x_n\}$, Target values $y = \{y_1, y_2, \dots, y_n\}$
- 2: **Output:** Slope m , Intercept b
- 3: Compute the mean of X : $\text{mean}_X \leftarrow \frac{1}{n} \sum_{i=1}^n x_i$
- 4: Compute the mean of y : $\text{mean}_y \leftarrow \frac{1}{n} \sum_{i=1}^n y_i$
- 5: Compute the numerator for the slope m :

$$\text{numerator} \leftarrow \sum_{i=1}^n (x_i - \text{mean}_X)(y_i - \text{mean}_y)$$

- 6: Compute the denominator for the slope m :

$$\text{denominator} \leftarrow \sum_{i=1}^n (x_i - \text{mean}_X)^2$$

- 7: Compute the slope m :

$$m \leftarrow \frac{\text{numerator}}{\text{denominator}}$$

- 8: Compute the intercept b :

$$b \leftarrow \text{mean}_y - m \cdot \text{mean}_X$$

- 9: **Return:** $m, b = 0$
-

4.6.2 KNN (K-Neares Neighbors)

The K-nearest neighbors algorithm, commonly referred to as kNN, is a straightforward and easily implementable machine learning algorithm that falls under the category of supervised learning. It can be utilized to address classification and regression problems. This article will revisit the definition of this algorithm, its operational mechanics, and a direct application in programming.[50]

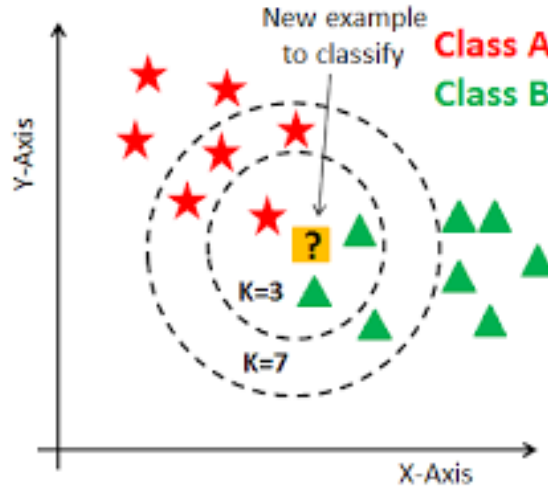


Figure 4.13: KNN model [51]

Algorithm 3 K-Nearest Neighbors (KNN) Algorithm

Require: Dataset $D = \{(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)\}$, number of neighbors k , test point x_{test} .

Ensure: Predicted class y_{pred} .

- 1: # Step 1: Initialize an empty list to store distances
 - 2: distances = []
 - 3: # Step 2: Calculate distances between x_{test} and each point in the dataset
 - 4: **for** (x_i, y_i) in D **do**
 - 5: $d = |x_i - x_{\text{test}}|$
 - 6: Append (d, y_i) to distances
 - 7: **end for**
 - 8: # Step 3: Sort distances by d in ascending order
 - 9: distances.sort()
 - 10: # Step 4: Select the first k elements
 - 11: $N_k = \text{distances}[0 : k]$
 - 12: # Step 5: Extract the classes of the k -nearest neighbors
 - 13: classes = [y for (d, y) in N_k]
 - 14: # Step 6: Determine the majority class
 - 15: $y_{\text{pred}} = \text{mode}(\text{classes})$
 - 16: **return** y_{pred}
-

4.7 Data Warehouse Model

4.7.1 Definition

A data warehouse is a data management system that stores current and historical data from multiple sources in a business-oriented format to facilitate the generation of insights and reports.

Data warehouses are typically utilized for business intelligence (BI), reporting, and data analysis.

They enable the rapid and straightforward analysis of commercial data from various operational systems, such as point of sale systems, inventory management, and marketing or sales

databases. Data may pass through an operational data store and require cleansing to ensure quality before being utilized in the data warehouse for report generation. [52]

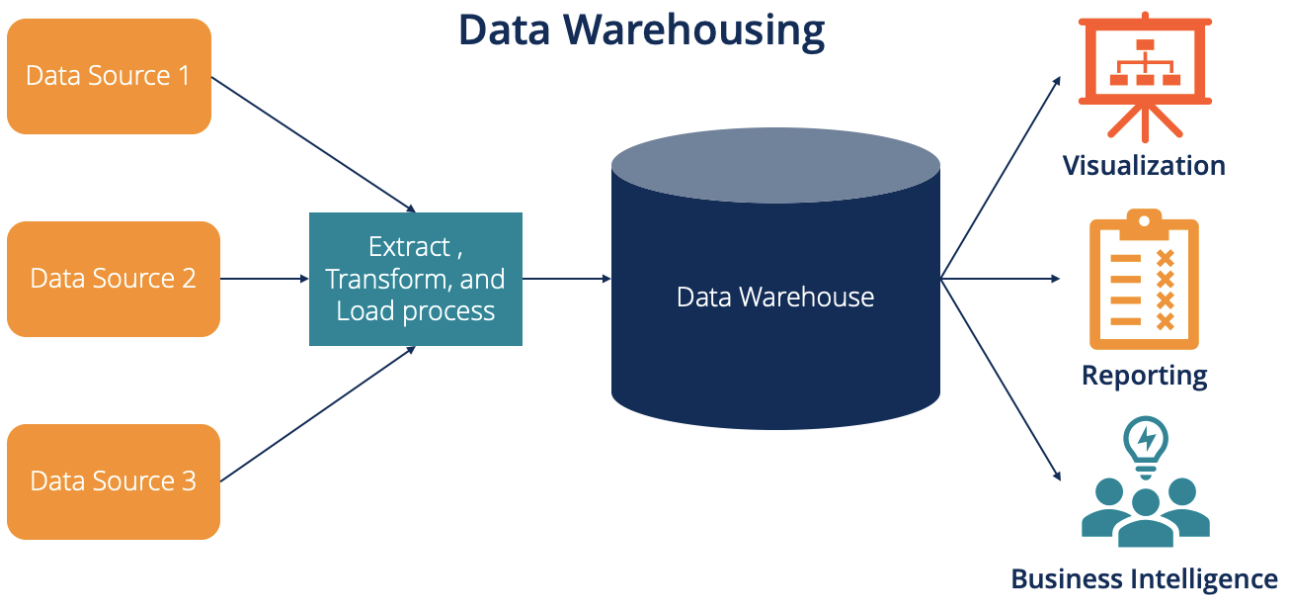


Figure 4.14: Data Warehouse [53]

4.7.2 Star Schema

In the realm of data warehousing, a star schema serves as a dimensional model designed to structure data in a manner that enhances the performance of analytical queries. This schema consists of two primary types of tables: fact tables and dimension tables. At the core of the model lies the fact table, which is encircled by one or more dimension tables. The fact table holds quantitative data (facts) pertaining to a process, event, or condition, and includes foreign keys that link to the adjacent dimension tables. Additionally, a star schema may encompass one or more dimension tables that contain attributes which provide descriptions of the facts. [54]

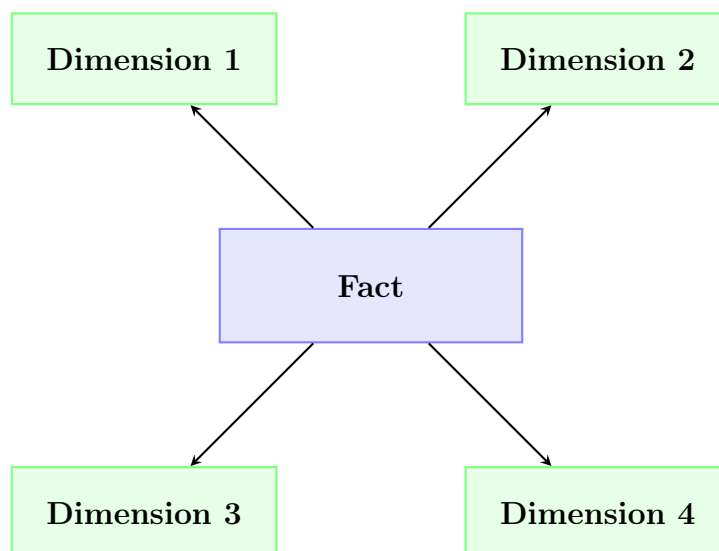


Figure 4.15: Star Schema

4.7.3 Star Schema Model

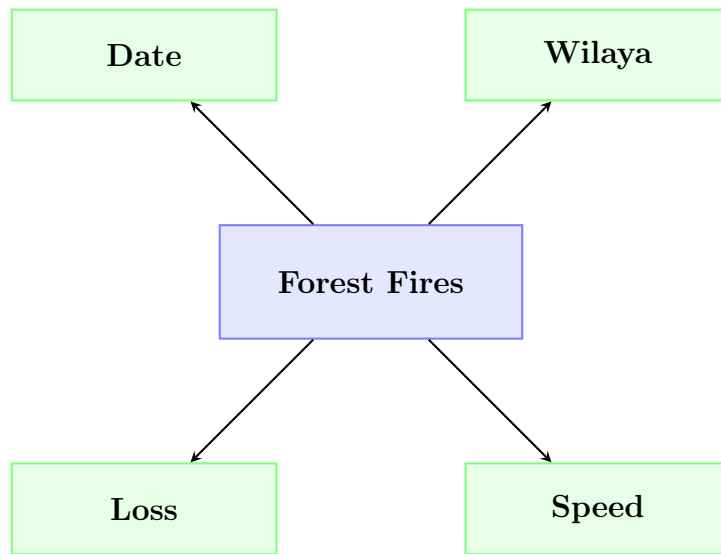


Figure 4.16: Star Schema of fires

from Figure 4.16 the data warehouse is used to analyse a **forests fires (fact)** by a dimensions :

- Regions (Wilaya)
- Date
- Speed (weak , middle , strong)
- Loss (Economic , Social , Health)

4.8 Conclusion

At the end of this chapter, we have completed the design and development phase and reached a prototype of the application through diagrams. We have also learned about the criteria used in assessing fire risk, as well as a model of the database used, and we have learned about the use of artificial intelligence models in this field.

Chapter 5

Implementation of the Proposed Application

5.1 Introduction

In this chapter, we present the proposed solution in the form of a mobile application. We describe the equipment, tools, and development environments used, along with the graphical interfaces that demonstrate the features and characteristics of the proposed application.

5.2 Development Environment

5.2.1 Hardware

Table 5.1: Used hardware

Device Name	Features
Dell (Laptop)	RAM: 8GB
	CPU: Intel i5-1135G7 @ 2.40 GHz
	Hard Disk: 255 SSD
	Operating System: Windows 11
Oppo A17K (Phone)	RAM: 3GB
	Internal Memory: 64GB
	Android Version: 12
Oppo A12 (Phone)	RAM: 3GB
	Internal Memory: 32GB
	Android Version: 9

5.2.2 Software Tools

1. LATEX

LATEX stands out as a complimentary tool employed for the organization and composition of research papers and scholarly communications. It holds its place among the suite of programs available on Linux and Unix operating systems. Offering robust support for rendering mathematical equations with precision, LATEX enables researchers to depict them graphically following their specific requirements and the standards of scientific rigor. [55]

2. Flutter

In the world of software development, "Flutter" is a user interface toolkit developed by Google to create locally assembled applications for mobile, web, and desktop platforms from a single software instruction base. It allows developers to create beautiful and high-performance apps using the Dart programming language. Flutter's main features include: [56]

- **Quick Development:** Flutter provides a quick reload feature that allows developers to see the changes they made to the code almost immediately without restarting the app, thereby accelerating the development process.
- **Expressive User Interface:** Flutter provides a rich range of customizable tools and layouts that enable developers to create visually attractive and responsive user interfaces.
- **High performance:** Flutter applications are directly grouped into the original device code, resulting in high performance and smooth animation.

3. Dart

Dart is a powerful and versatile programming language developed by Google. It was first released in 2011 and is designed to be easily used to build web, mobile and server applications. Dart provides an efficient and flexible development experience with detailed features (ahead of time) that help improve the speed and performance of your applications. Key features of Dart include: [57]

- Easy-to-learn and use programming language with clear and intuitive structure
- High performance through fine-grained technology
- Multi-platform application development support
- Strong memory management system
- Support for object-oriented programming concepts
- Active community and strong support from Google

4. Visual Studio Code

Visual Studio Code (VS Code) is a source code editor created by Microsoft, compatible with Windows, Linux, macOS, and web browsers. It offers features such as debugging support, syntax highlighting, intelligent code completion, code snippets, code refactoring, and integrated version control using Git.[58]

5. Android Studio

Android Studio serves as the official integrated development environment (IDE) for developing Android applications. It is built on IntelliJ IDEA, a Java-based IDE for software development, and includes its code editing and development tools. To facilitate application development on the Android platform, Android Studio utilizes a Gradle-based build system, an Android Emulator, code templates, and integration with GitHub. Each project within Android Studio consists of one or more modules containing source code and resource files. [59]

6. GeoJSON

GeoJSON is a standardized open format intended for the representation of basic geographical features and their associated non-spatial attributes. It is derived from the JSON format and encompasses various features such as points (representing addresses and locations), line strings (depicting streets, highways, and boundaries), polygons (illustrating countries, provinces, and parcels of land), as well as multi-part collections of these feature types. [60]

7. PHP

PHP (Hypertext PreProcessor) is a programming language whose main application is the management of dynamic websites. It can create the content of HTML pages according to different parameters. The capabilities of PHP extend beyond web pages to include image manipulation, PDF creation, and database connectivity. [61]

8. XAMPP

XAMPP (X (cross) Apache MariaDB Perl PHP) is a set of software to easily set up a web server and a File Transfer Protocol (FTP) server. This is a distribution of free software with good flexibility of use, known for its simple and fast installation. [62]

9. Star UML

StarUML is an open-source UML (Unified Modeling Language) modeling software that can replace in many situations commercial and expensive software. Being easy to use, requiring few system resources, and supporting UML 2, this software is an excellent option for modeling familiarization. [63]

5.3 Implemented Technologies

The logo for LaTeX, featuring the word "L^AT_EX" in a classic serif font.

LaTeX



StarUML



Flutter



Dart



Visual Studio



Android Studio



PHP



XAMPP



Geojson

5.4 The Application Architecture

To create and design this application, we relied on a set of patterns commonly used in the field of software engineering:

5.4.1 Object-Oriented Programming (OOP)

Object-oriented programming (OOP) is a programming paradigm that structures software design by focusing on data, or objects, instead of functions and logic. An object is characterized as a data entity possessing distinct attributes and behaviors. [64] Key aspects of OOP include:

- Encapsulation
- Inheritance
- Polymorphism
- Abstraction

5.4.2 Model-View-Controller (MVC)

In the field of programming, the model-view-controller (MVC) serves as an architectural design pattern that structures an application's logic into separate layers, each responsible for a particular set of functions. These layers communicate with one another to guarantee synchronized operation. [65] Benefits of MVC include:

- Simultaneous component development
- Component re usability
- Independent deployment and maintenance
- Support for test-driven development

5.4.3 Application Components

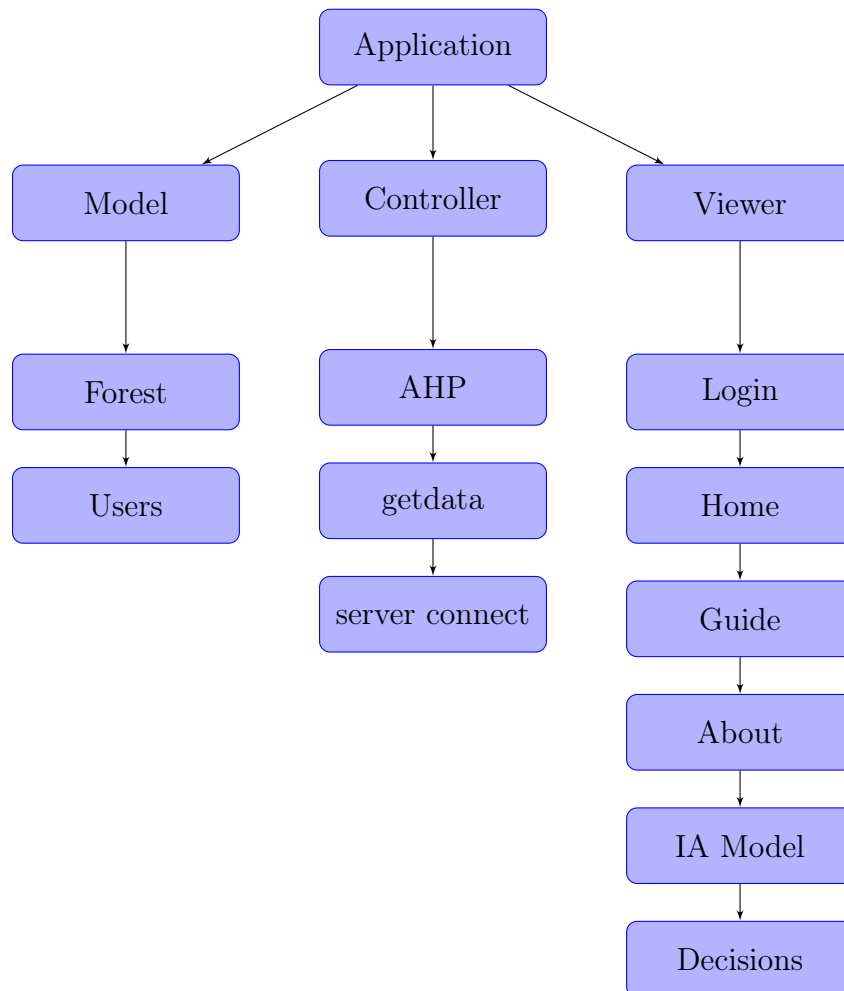


Figure 5.2: Application Components

5.5 Application Interfaces

5.5.1 Login and Sign In

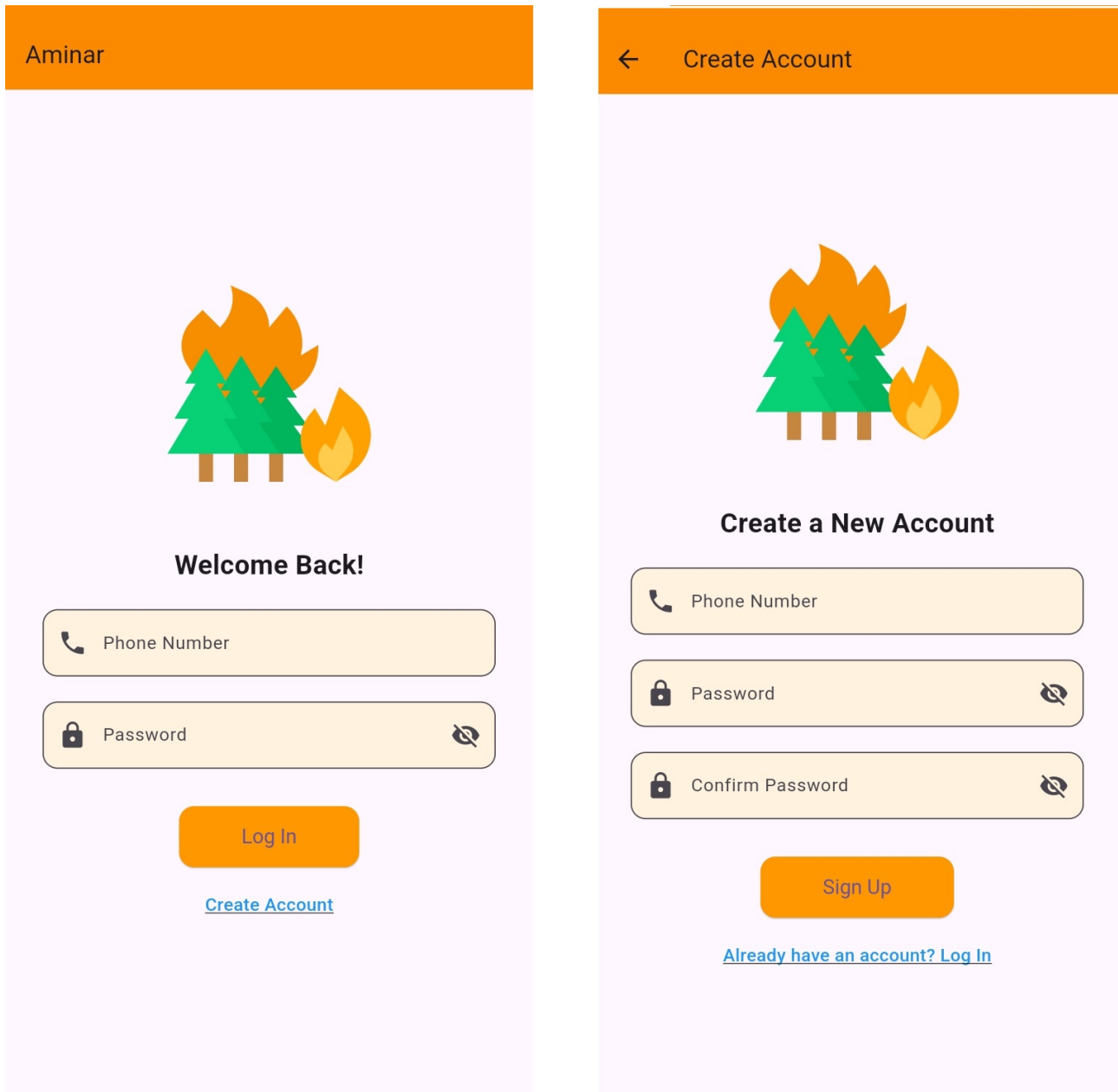


Figure 5.3: Login and Registration Interface

In Figure 5.3 The user enters their phone number and password, and if they do not have an account in the application, they create their own account.

5.5.2 Risk Analysis

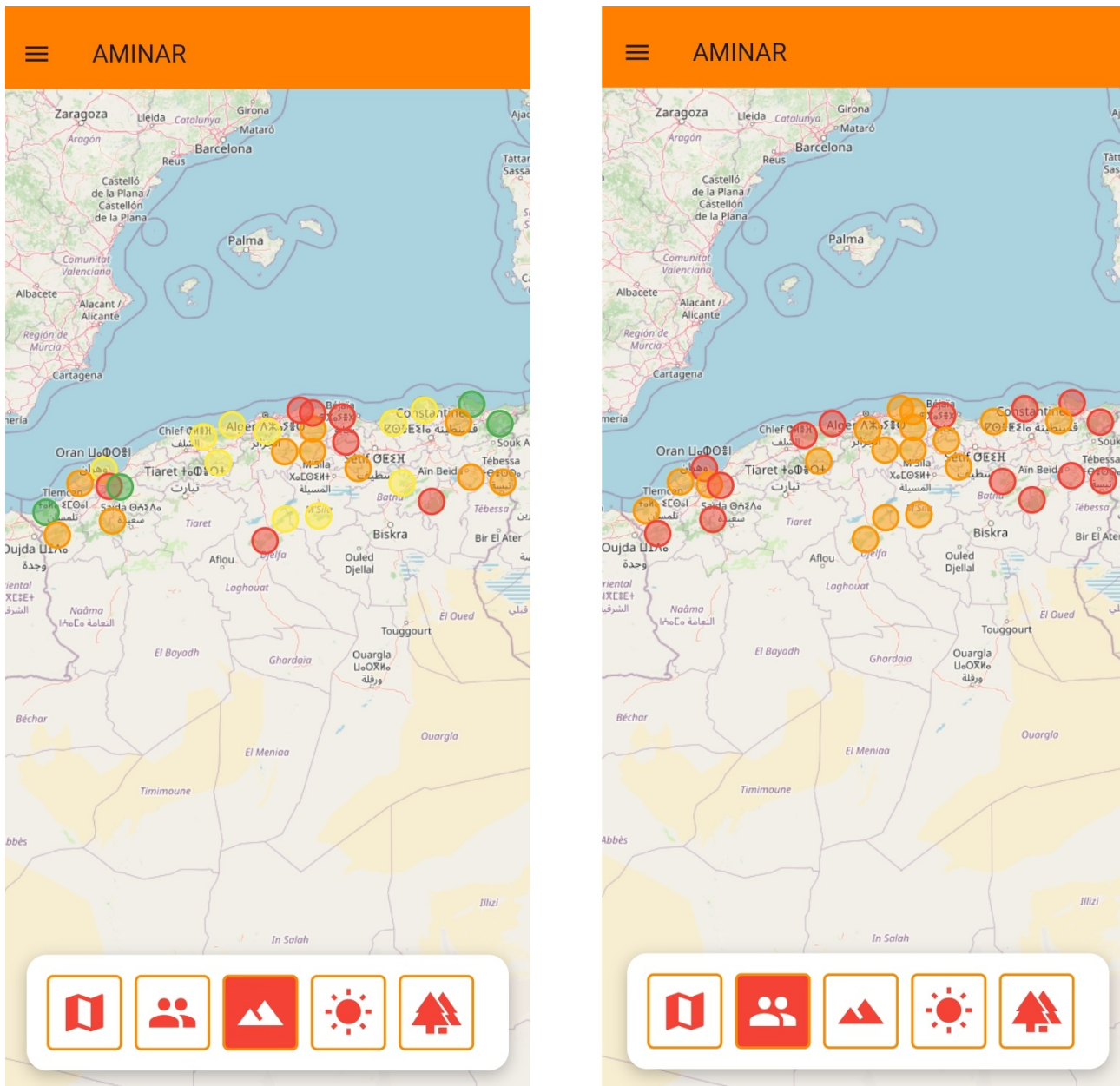


Figure 5.4: Risk Analysis Home Screen

The Figure 5.4 illustrates the impact of human activity on fire risk, as shown on the right, while on the left, it depicts the impact of terrain on fire risk. The closer the color shifts to red, the higher the risk level, and the closer it shifts to green, the lower the risk level.

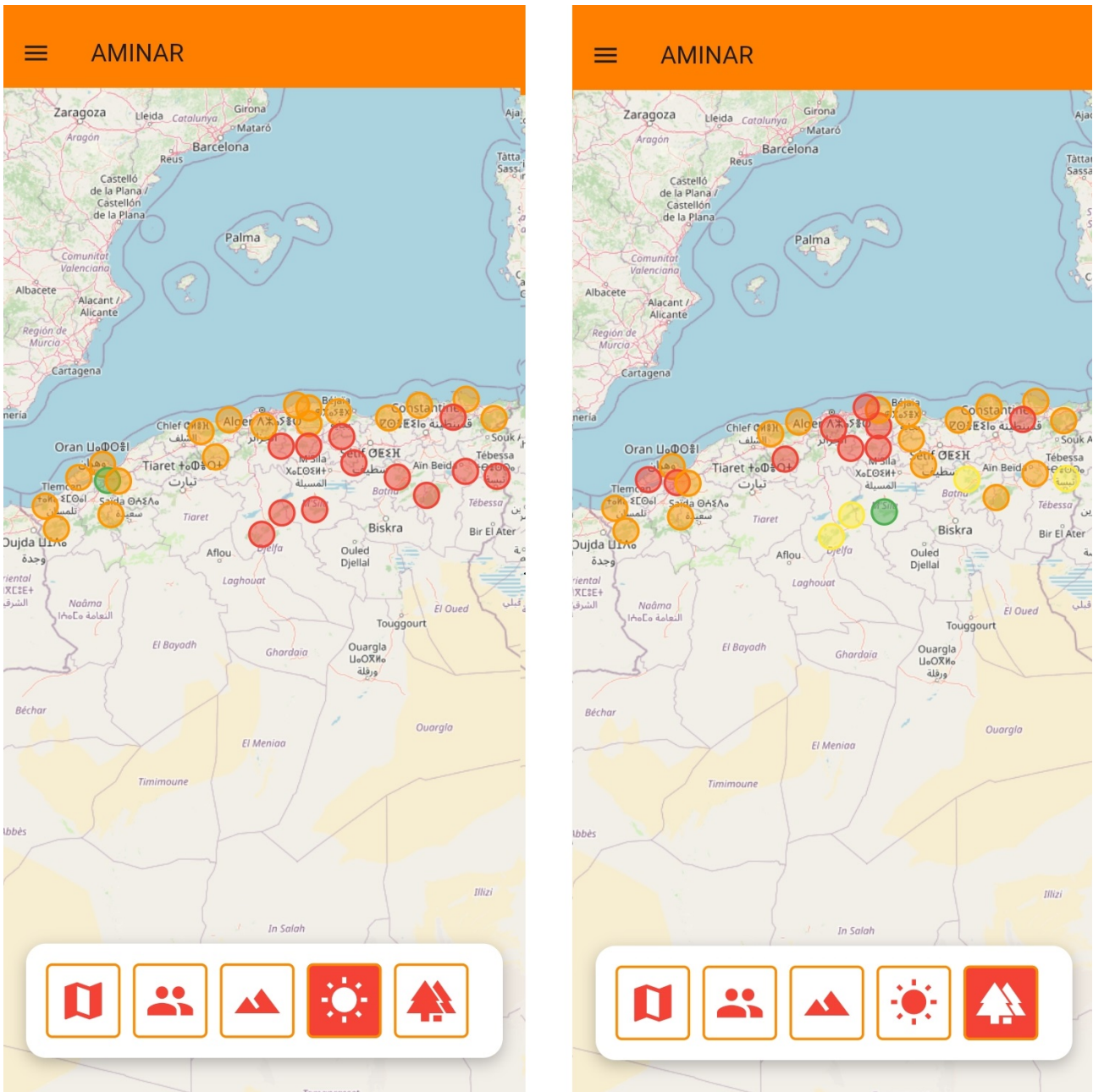


Figure 5.5: Risk Analysis Details

The Figure 5.5 illustrates the impact of plants on fire risk, as shown on the right, while on the left, it depicts the impact of weather on fire risk. The closer the color shifts to red, the higher the risk level, and the closer it shifts to green, the lower the risk level.

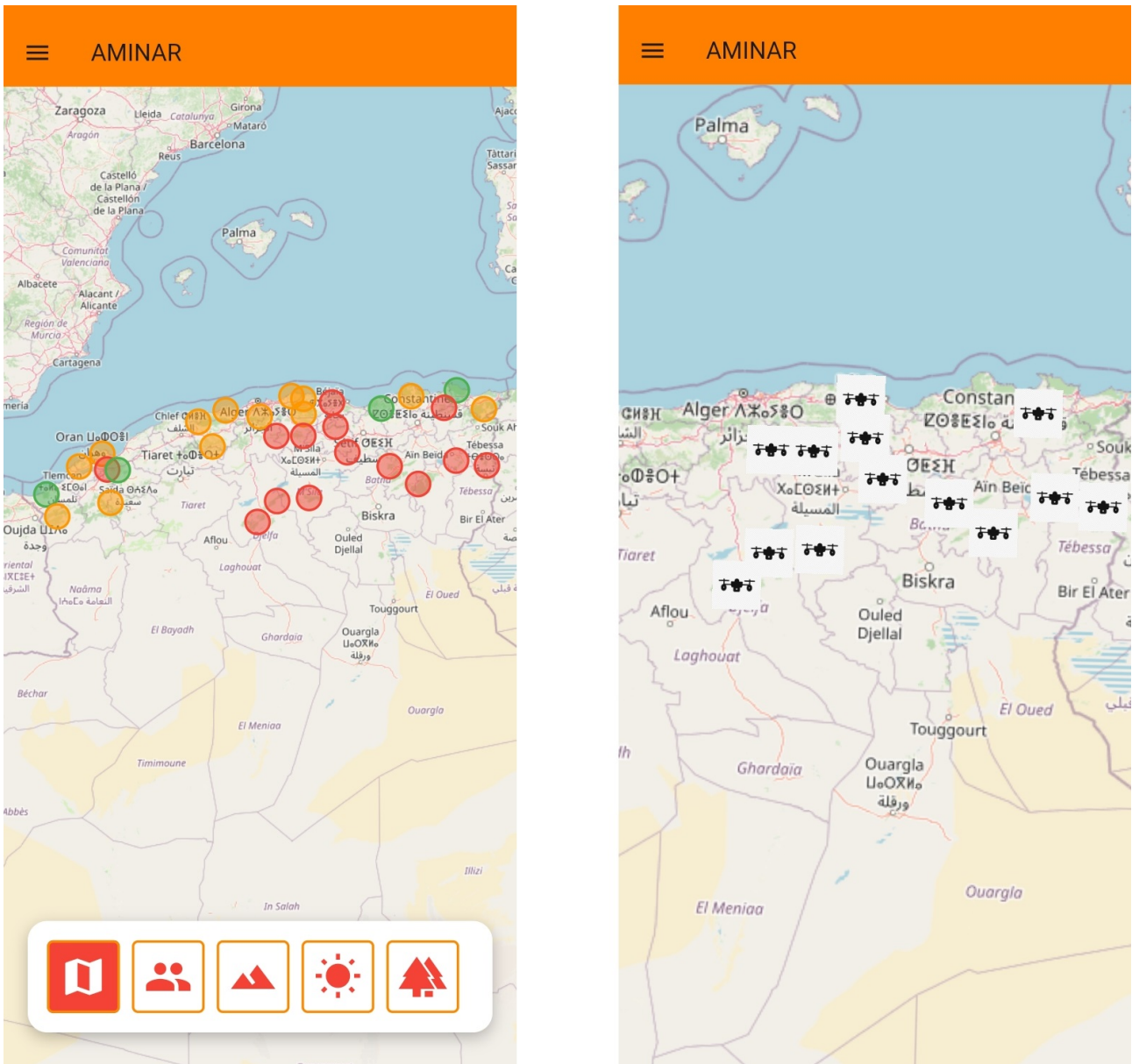


Figure 5.6: Analytic Hierarchy Process Interface and canadires Distribution

The Figure 5.6 shows the final risk assessment using the AHP method on the left, while on the right, it illustrates the locations for deploying canadires, which are distributed across the most hazardous areas.

As for the user database, it contains variable data such as temperature and wind speed using specify API

<https://www.weatherapi.com/api-explorer.aspx#current>

5.5.3 AI and Decision Making

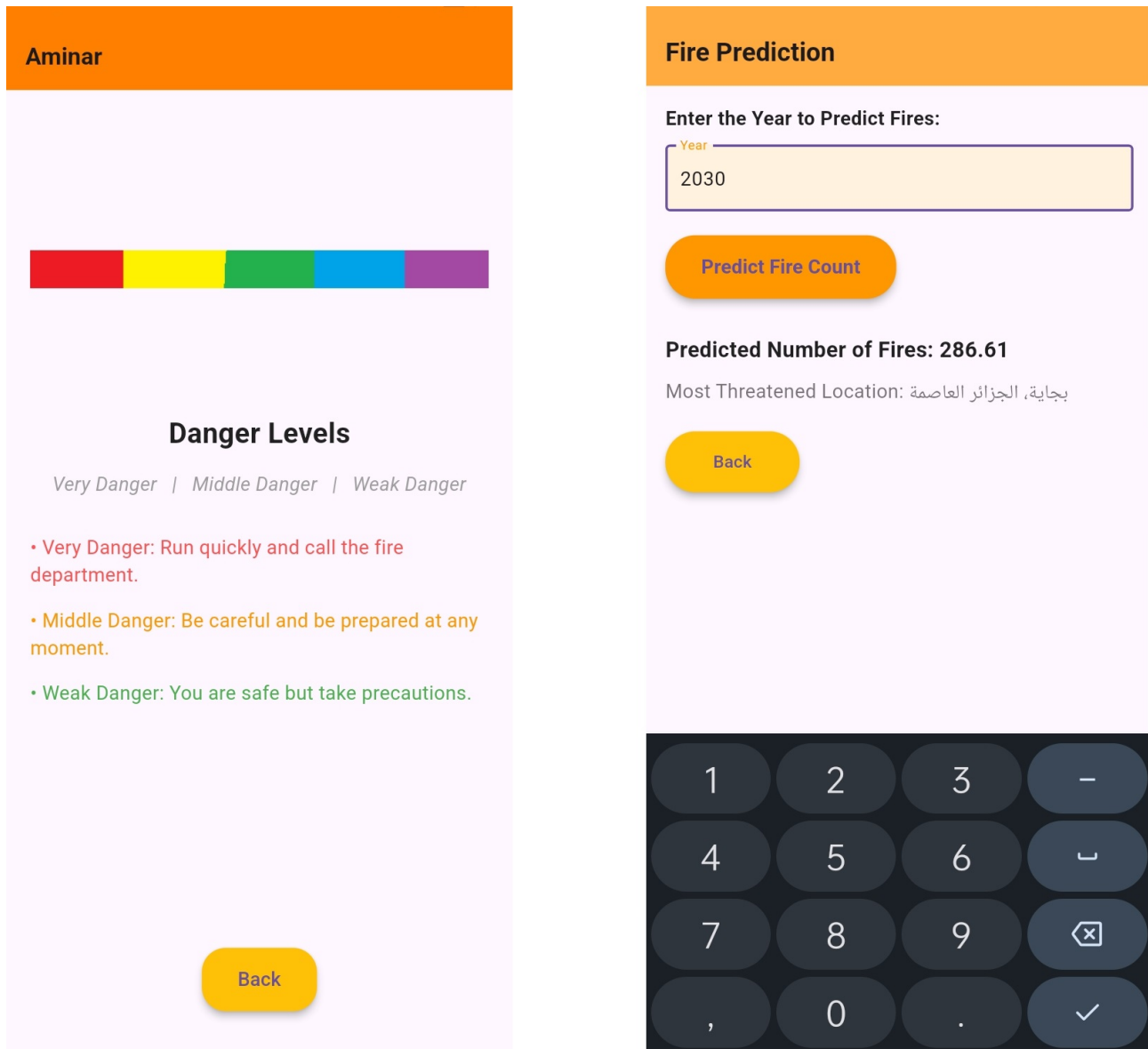


Figure 5.7: AI Model for Decision Making

The figure 5.7 illustrates the artificial intelligence model used in the application, which predicts the number of fires and the most affected areas based on the linear regression method, as shown on the left. On the right, it presents the measures to be taken to avoid fire risks and explains the meaning of the colors used.

5.5.4 Application User Guide

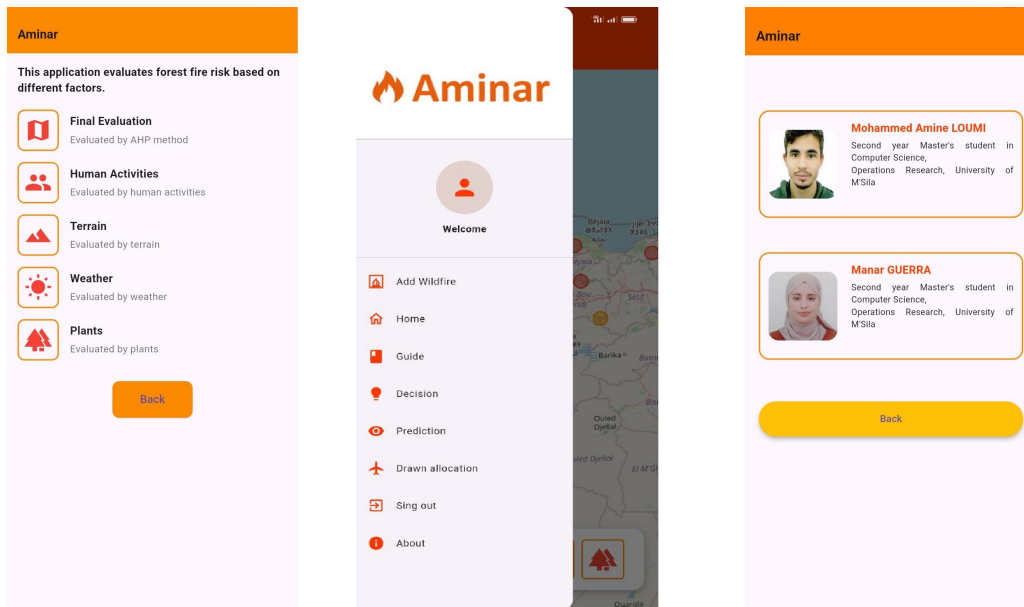


Figure 5.8: Application User Guide

The figure 5.8 illustrates the interfaces explaining the application. In the center, we find the application’s features, on the right, the meaning of the icons used, and on the left, information about the application’s developers.

5.5.5 Dashboard

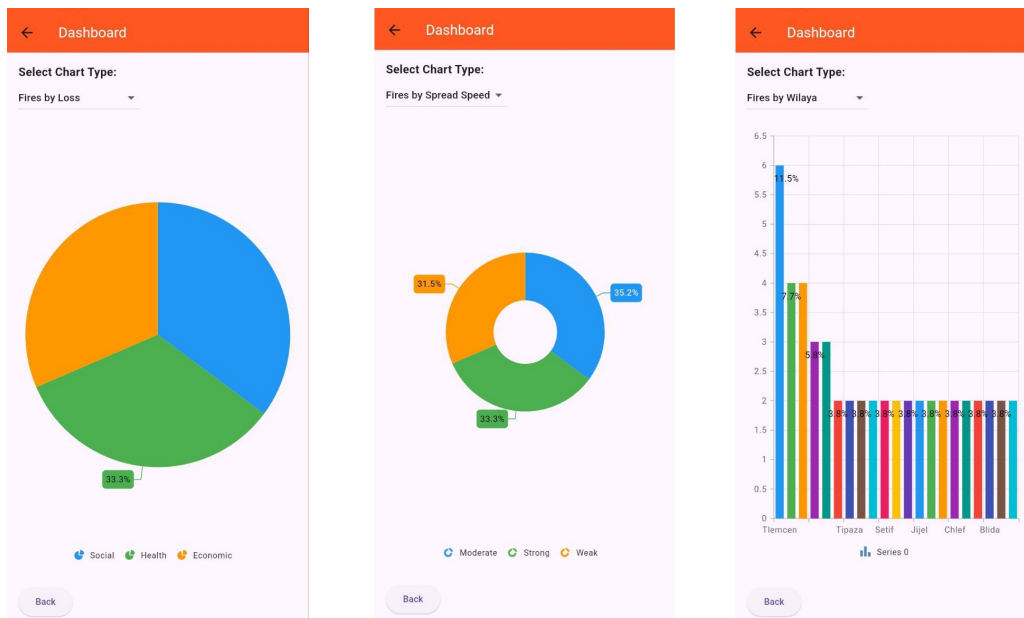


Figure 5.9: Dashbaord

The figure 5.9 illustrates the dashboard of fires in Algeria by regions , speed and loss , it uses to decision making .

5.5.6 Data Entry

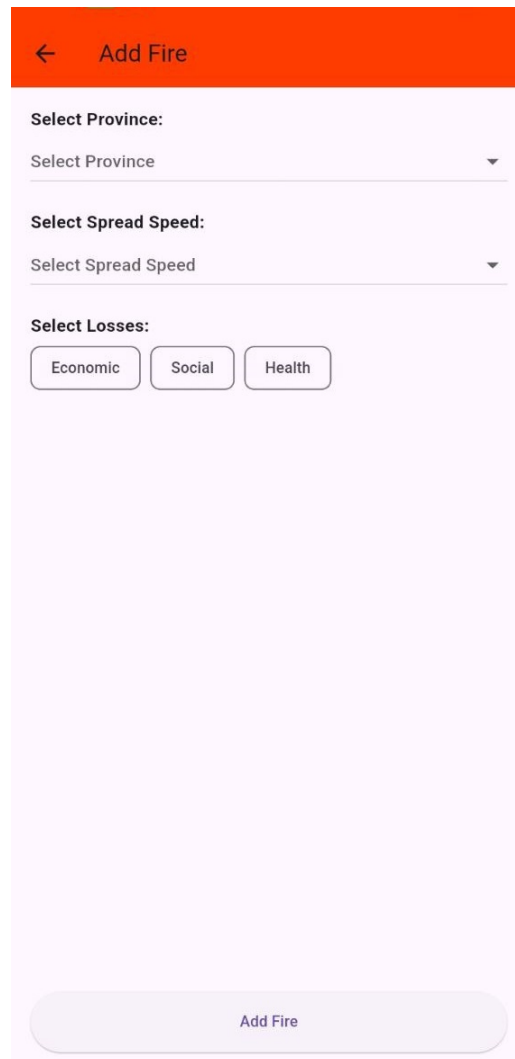


Figure 5.10: Data Entry

The figure 5.10 illustrates the interface of insertion of Fire data like region , speed (week,middle,strong) and loss (health,economy,social) in real time.

5.6 Conclusion

This chapter has provided a comprehensive look into the technical foundation of our mobile application. By exploring the development tools, programming languages, geographical database implementation, and user interface design, we have demonstrated how each component contributes to creating an efficient, user-friendly system.

General Conclusion

Forest fires are among the most serious environmental threats affecting ecosystems and biodiversity, especially in the context of accelerating climate change. This project aims to develop a mobile application for assessing forest fire risks in Algeria using the GIS-AHP methodology. By integrating Geographic Information Systems (GIS) with the Analytic Hierarchy Process (AHP), the project seeks to identify high-risk areas and support proactive strategies to mitigate this phenomenon. The results demonstrated that the developed application can serve as an effective tool for risk analysis, providing accurate insights into fire-prone areas by incorporating multiple data factors, including climatic conditions, topography, and vegetation types. This analysis enables decision makers to enhance fire prevention planning by optimizing resource allocation and prioritizing rapid intervention. Additionally, the use of interactive geographic technologies contributes to improving the efficiency of prevention strategies and reducing the negative impacts of forest fires. Despite the positive outcomes achieved, there are still opportunities for further improvement and development. Integrating artificial intelligence and machine learning techniques could enhance the accuracy of fire risk predictions, while incorporating real-time spatial data could allow for more dynamic analysis. Moreover, the application could be expanded to include additional features such as real-time alerts and advanced field data analysis. In conclusion, this project highlights the importance of leveraging modern technology to address environmental challenges and represents a significant step toward developing intelligent tools that help reduce forest fire risks and promote ecosystem sustainability. We hope this work will contribute effectively to national and international efforts to protect forests and ensure their sustainability for future generations.

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Abstract

Forest fires are among the most dangerous environmental phenomena affecting ecosystems and biodiversity, especially in Algeria, where their intensity increases due to climatic and human factors. This study aims to develop a mobile application for mapping forest fire risks in Algeria using Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP), with the goal of identifying high-risk areas and analyzing the factors influencing their spread.

The application integrates and analyzes various data, primarily climate factors such as temperature and humidity, as well as population density, allowing for the creation of interactive maps that accurately display risk levels. This approach helps decision-makers and relevant authorities improve prevention strategies and resource management effectively, thereby reducing the losses caused by wildfires.

The study results showed that combining GIS and AHP provides a precise and effective tool for assessing forest fire risks. Spatial geographic analysis enables the prioritization of interventions and directs efforts towards the most threatened areas. This application proves to be a valuable tool in supporting planning and decision-making processes, making it an essential asset for environmental risk management and forest protection in Algeria.

Key Words :Geographic Information Systems (GIS), Analytic Hierarchy Process (AHP), Risk Management . Forest Fires, Mobile Application, Interactive Maps.

الملخص

تعتبر حرائق الغابات من أخطر الظواهر البيئية التي تؤثر على النظم البيئية والتنوع الحيوية خاصة في الجزائر، حيث تزداد حدتها نتيجة العوامل المناخية والبشرية، تهدف هذه الدراسة إلى تطوير تطبيق هاتف لرسم خريطة لمخاطر حرائق الغابات في الجزائر باستخدام نظم المعلومات الجغرافية (GIS) وطريقة التحليل الهرمي (AHP)، وذلك بهدف تحديد المناطق الأكثر عرضة للحرائق وتحليل العوامل المؤثرة في انتشارها.

يعتمد التطبيق على دمج وتحليل بيانات مختلفة، تشمل بصفة عامة المناخ خاصة درجة الحرارة والرطوبة ويعتمد أيضا على الكثافة السكانية مما يتيح إنشاء خرائط تفاعلية تعرض مستويات الخطورة بدقة، يساعد هذا النهج في دعم متخذي القرار والجهات المختصة في تحسين استراتيجيات الوقاية وإدارة الموارد بفعالية، مما يساهم في تقليل الخسائر الناجمة عن الحرائق.

أظهرت نتائج الدراسة أن الجمع بين GIS وAHP يوفر أداة دقيقة وفعالة لتقييم مخاطر حرائق الغابات، حيث يتيح التحليل الجغرافي المكاني إمكانية تحديد أولويات التدخل وتوجيه الجهود نحو المناطق الأكثر تهديداً، يبرز هذا التطبيق أهميته في دعم عمليات التخطيط واتخاذ القرار، مما يجعله أداة قيمة في إدارة المخاطر البيئية وحماية الغابات في الجزائر.

الكلمات المفتاحية : نظم المعلومات الجغرافية (GIS)، عملية التحليل الهرمي (AHP)، حرائق الغابات ، تطبيق هاتف الخرائط التفاعلية ، ادارة المخاطر .

Résumé

Les incendies de forêt figurent parmi les phénomènes environnementaux les plus dangereux, affectant les écosystèmes et la biodiversité, notamment en Algérie, où leur intensité s'accroît en raison des facteurs climatiques et humains. Cette étude vise à développer une application mobile pour cartographier les risques d'incendies de forêt en Algérie en utilisant les Systèmes d'Information Géographique (SIG) et la Méthode d'Analyse Hiérarchique (AHP), dans le but d'identifier les zones à haut risque et d'analyser les facteurs influençant leur propagation.

L'application intègre et analyse diverses données, notamment les facteurs climatiques comme la température et l'humidité, ainsi que la densité de population, ce qui permet de générer des cartes interactives affichant avec précision les niveaux de risque. Cette approche aide les décideurs et les autorités compétentes à améliorer les stratégies de prévention et la gestion des ressources de manière efficace, réduisant ainsi les pertes causées par les incendies de forêt.

Les résultats de l'étude ont montré que la combinaison du SIG et de l'AHP offre un outil précis et efficace pour évaluer les risques d'incendies de forêt. L'analyse géospatiale permet de prioriser les interventions et d'orienter les efforts vers les zones les plus menacées. Cette application s'avère être un outil précieux pour soutenir les processus de planification et de prise de décision, constituant ainsi un atout essentiel pour la gestion des risques environnementaux et la protection des forêts en Algérie.

Mots Clés : Systèmes d'Information Géographique (SIG), Processus d'Analyse Hiérarchique (AHP), Incendies de Forêt, Application Mobile, Cartes Interactives, Gestion des Risks.