

IE 479 Fall 2026 Project 1

Facility Planning for Forest Fire Observation and Response Infrastructure

Due Date: October 27, 23:59

General Information

Türkiye is one of the countries most severely affected by forest fires in the Mediterranean basin. Due to its geographic location, climate characteristics, and the increasing impact of climate change, forest fires have become one of the most destructive natural disasters in the country. Especially in the coastal regions of the Aegean and Mediterranean, including provinces such as Muğla, Antalya, İzmir, and Bodrum, large-scale fires have caused irreversible damage to ecosystems, wildlife habitats, agricultural land, and human settlements in recent years.

The primary institution responsible for forest fire prevention, detection, and suppression in Türkiye is the **General Directorate of Forestry** (*Orman Genel Müdürlüğü*, OGM), operating under the Ministry of Agriculture and Forestry. The OGM manages a nationwide network of watchtowers, fire stations, and aerial firefighting assets. Among the most critical components of fire management are:

- **Early detection:** Identifying fires at the earliest possible stage through observation posts and watchtowers positioned on elevated terrain or along forest roads.
- **Rapid intervention:** Deploying firefighting crews and equipment from fire stations to suppress fires before they spread beyond control.
- **Resource efficiency:** Allocating limited infrastructure resources (observation posts, stations, vehicles, and personnel) to maximize coverage across forest districts.

Despite existing infrastructure, recent fire seasons have demonstrated that coverage gaps remain, particularly in districts with limited road access or sparse observation networks. To address this, the OGM is undertaking a strategic facility planning effort to determine the optimal placement of new observation posts and fire stations across affected forest districts.¹

¹General Directorate of Forestry, Republic of Türkiye Ministry of Agriculture and Forestry, 2023.

Problem Definition

A series of devastating and large-scale forest fires has swept across multiple districts in recent years, causing extensive destruction of forested areas, wildlife habitats, and nearby settlements. Due to the vast scale of the fires and the limited number of observation and intervention resources, it is impossible to establish a dedicated response unit at every at-risk location.

Hence, to ensure that fire detection and suppression can still be delivered efficiently, the General Directorate of Forestry must establish a network of strategically located observation posts and fire stations. The observation posts will serve as early warning hubs where trained personnel monitor forest districts in rotating shifts, enabling rapid detection before fires spread beyond control. The fire stations will serve as intervention and equipment depot hubs where firefighting crews and suppression equipment are positioned, enabling rapid response once a fire is detected.

To maximize effectiveness, these facilities should:

- Be accessible via forest or major roads for fire vehicles and personnel,
- Cover all at-risk districts within a defined service radius, and
- Serve the largest possible at-risk population if resources are limited.

The planning problem is to determine where to locate observation posts and fire stations across the affected forest districts.

Case Questions

In light of the scenario above, the General Directorate of Forestry must develop a strategic plan for placing observation posts and fire stations. Using the provided dataset, you are asked to solve the following problems:

Question 1

Each observation post must be established near a forest road or a district center to ensure accessibility for personnel and monitoring vehicles. Considering the visual observation range of each post, determine the **minimum number and locations of observation posts** required to ensure that every at-risk district is within a certain observation radius.

Analyze the system for radii of **2 km, 3 km, 4 km, 5 km, and 6 km**.

- For each radius, where should observation posts be placed?
- How many posts are required to cover all districts?

Question 2

Suppose the OGM has limited resources and can establish a maximum of **4 fire stations** (4 is an upper limit as a result of budget and staffing constraints; you may reach the solution by establishing fewer stations). These stations also serve as equipment depots, storing firefighting vehicles, water tankers, and suppression gear. In this case, the goal is to cover as many people as possible within each service radius.

Analyze the system for the same radius values (**2 km, 3 km, 4 km, 5 km, 6 km**).

- Which 4 locations should be selected for each radius?
- What percentage of the total at-risk population can be served under each scenario?

Question 3

In addition to coverage, the OGM aims to minimize the overall travel distance between districts and their assigned fire stations, ensuring faster equipment deployment and improved suppression response times. As an alternative planning objective to Question 2, the goal is to select **4 fire stations** that minimize the total population-weighted distance while ensuring each district is within the specified service radius.

The population weight reflects the number of people living in or near each forest district who face evacuation risk or property damage in the event of a fire.

Analyze this for radii of **3 km, 4 km, 5 km, and 6 km**.

- Which station locations minimize the total population-weighted travel distance?
- What is the total population-weighted distance for each radius?

Some Useful Information About the Case and Reports

1. Some or all members of each group will be called for oral interviews about the case questions to ensure the material is fully understood. The outcome of these interviews will also affect your project grade.
2. In the provided dataset, you have three sheets named *District Population*, *District Distance*, and *Distance – 25x20*. The dataset includes **20 forest districts** at elevated fire risk:
 - The **first sheet** provides the population of each district. This represents the population living in or near the forest district — i.e., people at risk of damage or displacement in the event of a fire. You will use this in population-based optimization.
 - The **second sheet** shows the pairwise distances between districts (in meters).
 - The **third sheet** provides distances from districts to **25 major forest and ridge road locations**, which serve as the candidate sites for observation posts and fire stations.
3. You will be solving a **site selection problem**, not a site generation problem. This means you will choose locations for observation posts and fire stations from among the **candidate sites provided in the dataset** (districts or road locations), rather than generating new ones.
4. When writing your mathematical models:
 - Clearly state all assumptions,
 - Define parameters, decision variables, objective function, and constraints,
 - Provide the full mathematical formulation,
 - Include explanations for the objective function and each constraint.
5. Include an **Introduction / Executive Summary** in your report summarizing the purpose, data, and overall findings.
6. Structure your report into clear sections corresponding to each case question (Q1, Q2, Q3) for readability and logical flow.
7. Note that **Questions 2 and 3 represent two alternative planning objectives** for locating the same fire stations — one prioritizing maximum population coverage, the other prioritizing minimum population-weighted response distance. They are not sequential decisions; rather, the OGM will choose between them based on policy priorities.
8. Before starting your report, read the documentation titled *Report Format and Rules of Submission* available under the Projects page on the course website.
9. You do not need to include any code in your report (nor screenshots), unless you believe they are essential for understanding your approach.
10. Submit your project as a single ZIP file containing:
 - Your Report (PDF format),

- Your code(s),
- And any other materials you wish to include.

Ensure your code is runnable on other computers. If you use external data files (e.g., `.dat` for CPLEX), include them in the ZIP.

11. Name your ZIP and PDF files as `GroupName_Project1`. For example, if your group number is 13, name the files: `Group13_Project1.pdf` and `Group13_Project1.zip`. You can find your group number on the course website.
12. If you encounter any issues or have questions, do not hesitate to contact the Egehan Uğraş.