



# Earthquake Emergency Response

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IE 482 - Humanitarian Logistics

# Introduction



## Earthquakes

expected location

great effects (during & after)

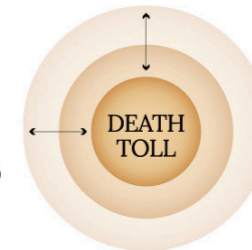
- tsunami
- flood
- fire
- landslide
- collapsed buildings

unknown time

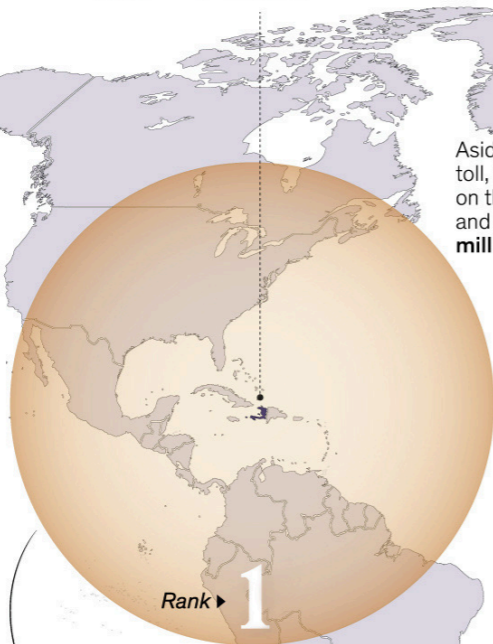
# Recent Earthquakes (World)

## VISUALIZING THE WORLD'S DEADLIEST EARTHQUAKES of the 21st Century

In the last 23 years, the world has witnessed 58 earthquakes that have killed more than 100 people. Here are those that shook the world.



Location ▶ HAITI  
 Death toll ▶ 316,000 +7.0  
 When ▶ JAN 2010



HAITI  
 CARIBBEAN SEA  
 EPICENTER

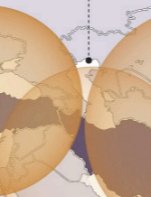
The Haiti earthquake occurred only 13 km (6 miles) below the earth, and its shallow epicenter caused extensive damage on the surface.

Aside from its high death toll, the 2023 earthquake on the border of Türkiye and Syria left close to 1.5 million without homes.

TÜRKIYE & SYRIA  
 50,132 +7.8  
 FEB 2023



IRAN  
 50,000 +6.6  
 DEC 2003



NEPAL  
 8,800 +7.8  
 APR 2015

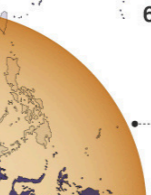


CHINA  
 87,500 +7.9  
 MAY 2008



JAPAN  
 20,000 +9.0  
 MAR 2011

In the aftermath of the Fukushima disaster caused by the Honshu earthquake, uranium prices dropped 60% in the next 3 years.



PAKISTAN  
 80,000 +7.6  
 OCT 2005



INDIA  
 20,000 +7.7  
 JAN 2001



INDONESIA  
 230,000 +9.1  
 DEC 2004

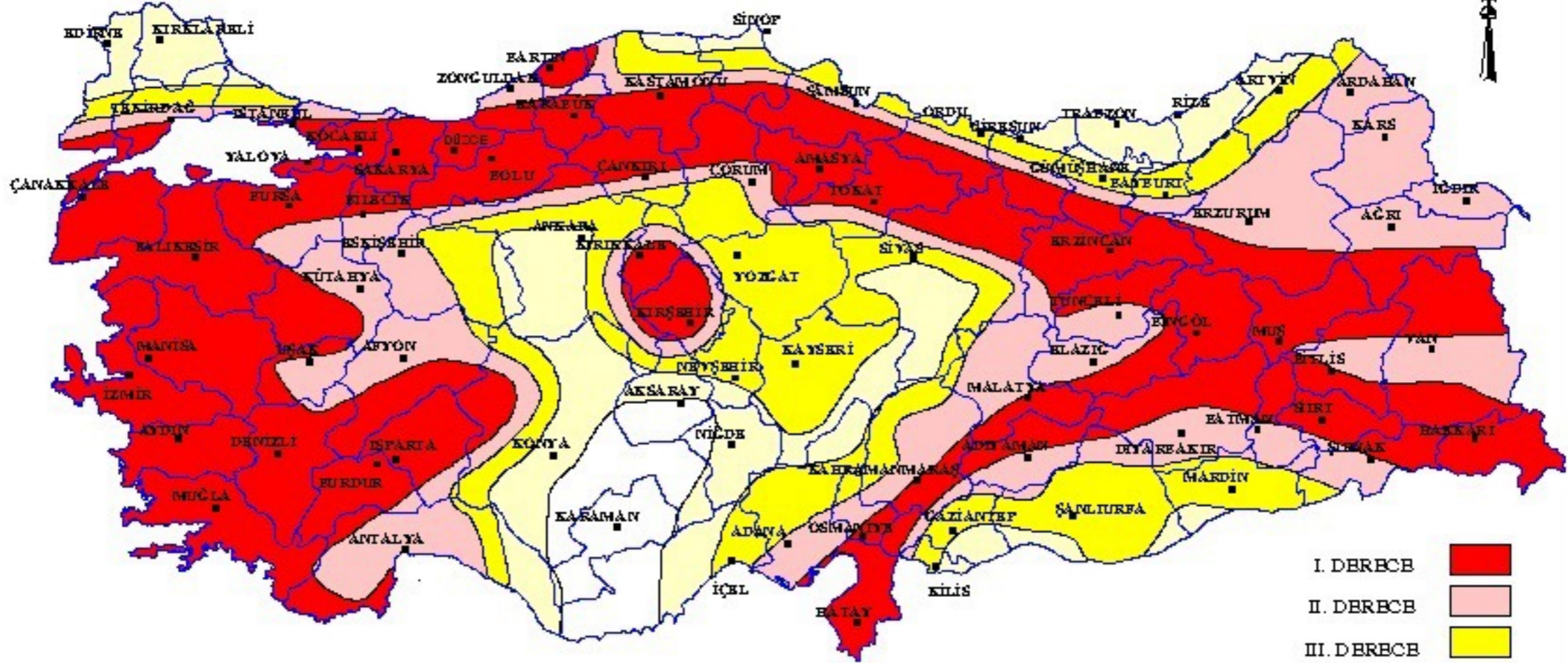


FAULT RUPTURE ZONES  
 EPICENTER  
 INDONESIA  
 INDIAN OCEAN

The 2004 earthquake off the coast of Indonesia triggered the Boxing Day Tsunami that was responsible for most of the disaster's death toll.

Earthquakes ranked by the total deaths caused, including those from secondary events like tsunamis that occurred after the earthquake. Source: NCEI

# Seismic Zone Map of Turkey



- I. DERECE
- II. DERECE
- III. DERECE
- IV. DERECE
- V. DERECE
- İl merkezi
- İl sınırı

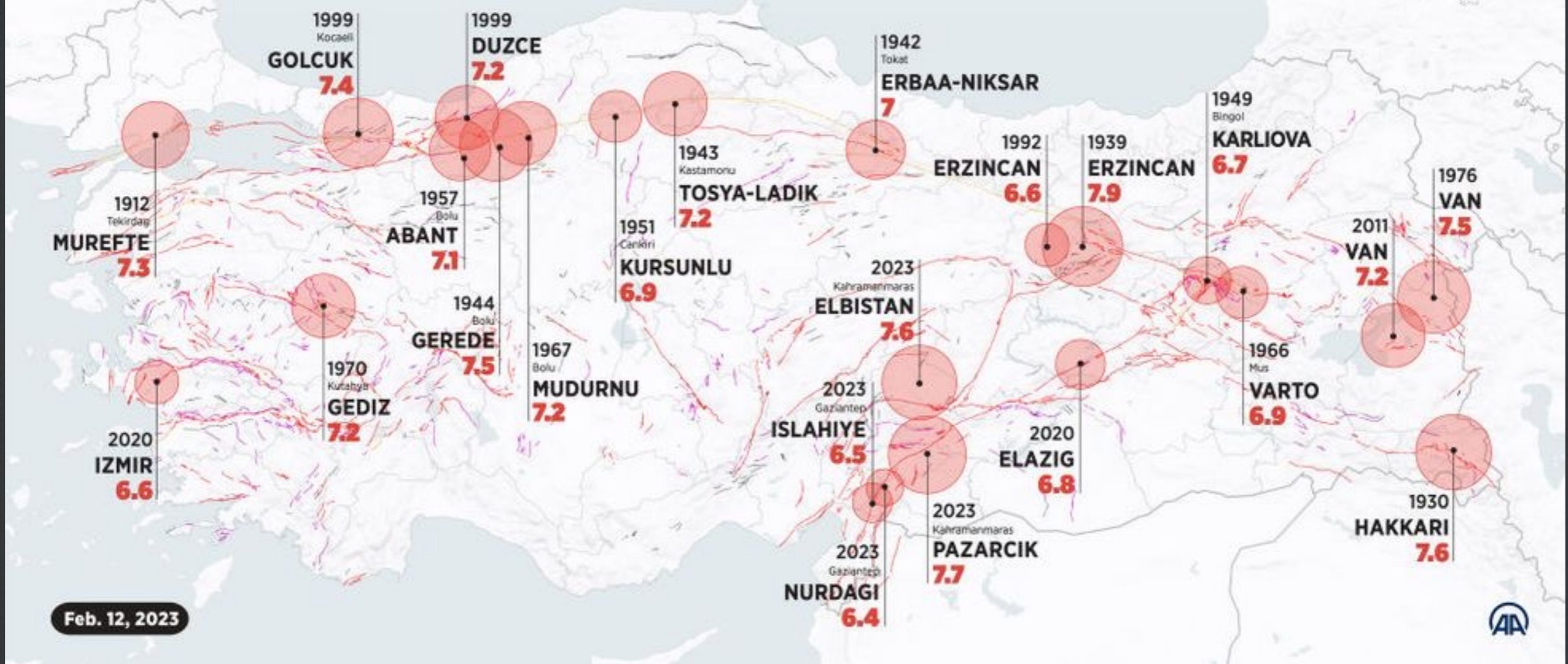
0 120 Kilometre

AFET İŞLERİ GENEL MÜDÜRLÜĞÜ  
DEPREM ARAŞTIRMA DAİRESİ  
ANKARA - TÜRKİYE

# Recent Earthquakes (Turkey)

## Earthquakes of magnitude 6 or above rocked Türkiye over last 125 years

- Earthquake magnitude
- Earthquake surface rupture
- Active fault lines
- Quaternary fault



Feb. 12, 2023



# Recent Earthquakes (Turkey)

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- 1999 İzmit, one of the most destructive earthquakes in Turkey:  
32,700 fatalities
- Organizations were not well prepared.
- TRC and municipalities were out of stock.
- S&R operations were not organized.  
(AKUT & Turkish Army)

# Recent Earthquakes (Turkey)

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- **6 February 2023, Kahramanmaraş Earthquakes**
- **7.7 and 7.6 magnitude**
- **South-east of Türkiye and parts of Syria**
- **11 cities were affected**
- **A large scale disaster**
- **Total Number of Urgent + Severely Damaged + Collapsed Houses > 500000**

# Recent Earthquakes (Turkey)

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- **Support groups were also affected**
- **Local resources are damaged**
- **Aftershocks and secondary disasters**
  - **floods, fires, etc.**
- **Complications regarding the implementation of TAMP**
- **Problems regarding**
  - **Facility utilization**
  - **Personnel experience**
  - **Collaboration among central and local public institutions and non-public actors**



# S&R Operations are not well organized

IN TURKEY!

HOWEVER,

Time	Survival Percentage
First 30 mins	%93
1. day	%81
2. day	%36
3. day	%33
4. day	%19
5. day	%7

**Mitigation**

**Preparation**

**International  
Disaster  
Management**

**Response**

**Recovery**



# Disaster Timeline

Pre-disaster

Disaster

Post-disaster

## Mitigation & Preparedness

- Assessment
  - Risk Factors
  - Vulnerability
- Planning
  - Infrastructure
  - Policy Making
  - Capacity building
  - Pre-positioning resources
  - Scenario studies
- Training / Education
- Technology development

## Response

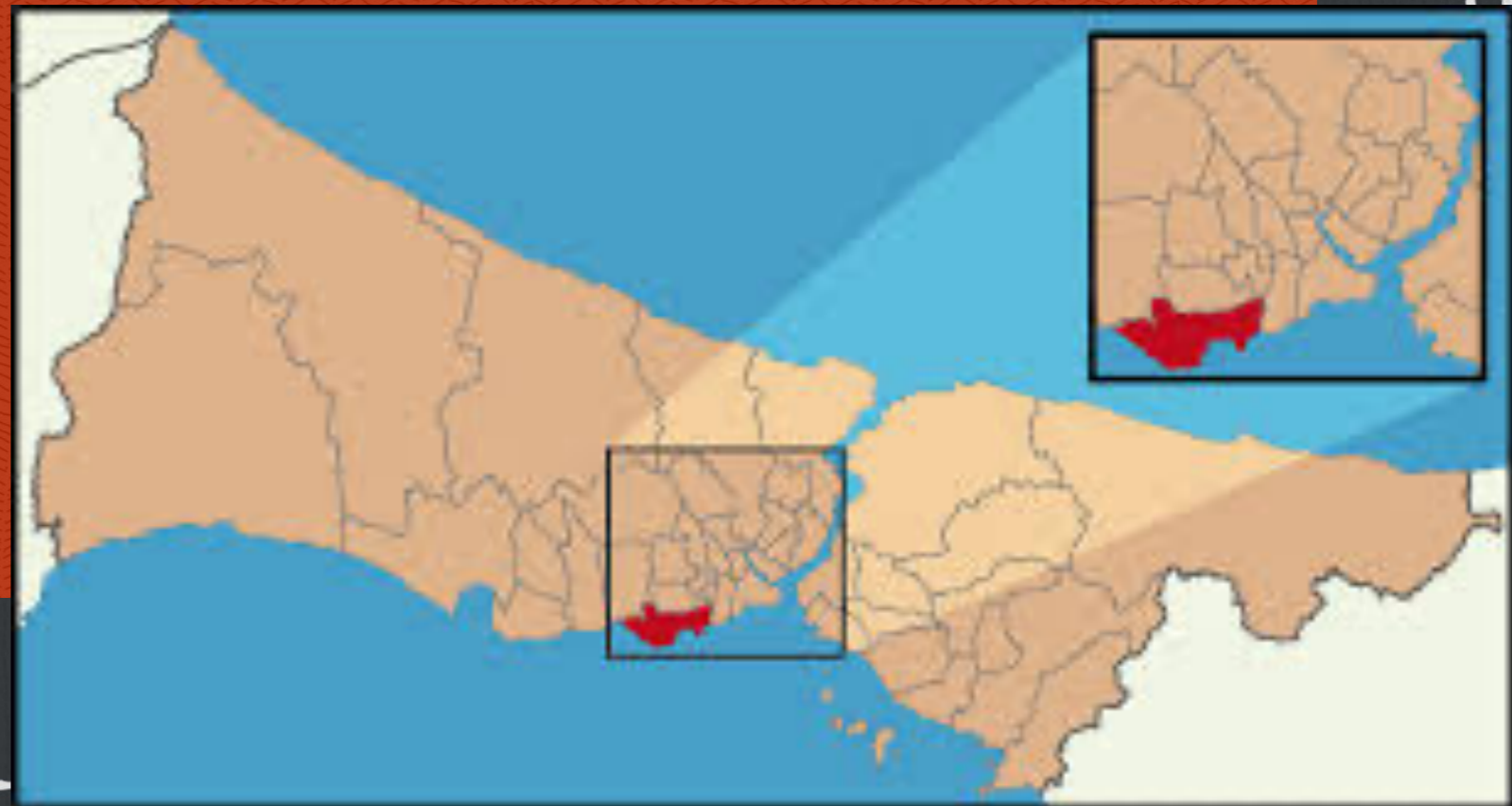
- Relief Operations:
- Acute phase
    - Medics, food, shelter
  - Then
    - Housing
    - Food supply chain building
- Logistics stages:
- Mobilization and procurement,
  - Long haul
  - The last mile

## Recovery

- Debris cleaning
- Infrastructure rebuilding
- Re-establishing communities
- Measure the effects of
  - Infrastructure
    - Planning
    - Response
      - Short and long term
- Lessons learned
- Feedback to planning & response

# Bakırköy Municipality

- **Close to North Anatolian Fault Line**
- **BAKOM (Bakırköy Disaster Coordination Center)**
- **Population  
210,000**



# **Bakırköy Municipality**

**You, as a team will handle several problems under three main concepts:**

- 1. In advance action planning**
- 2. Status Detection**
- 3. Resource Assignment**

# Important Dates

- Due date: April 30<sup>th</sup>, 2024
- Latex format required
- Questions via e-mail:

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## **Question 1:**

- **93 districts (demand nodes)**
- **Inputs**
  - distances between districts**
  - population of each district**
  - risk coefficient of arcs in the network**

**The municipality plans to open distribution centers (DCs) for basic aid. Since the roads may be damaged, people may walk to those distribution centers from districts.**

a) Assume the municipality will open 5 DCs.

Give a mathematical model that

- determines the locations of DC's
- while minimizing the longest distance( $R$ ) that a person needs to travel to reach a DC.

b) Now assume the municipality decides that each district should be covered by at least two DCs within a range ( $R$ ) with at most  $p$  DCs.

- Use the  $R$  value that you have found in part a).

How do you model this situation?



**c) Conduct a sensitivity analysis on the number of distribution centers for part b) and give your results (corresponding R values).**

**d) Consider part a) again. But, this time assume the municipality also wants to consider the risk of destruction of the roads**

- **(1=remains perfectly, 0=totally demolished)**

**So, they want each district to be able to access the DC that they are assigned to, using a link with a risk coefficient greater than 0,7.**

**Again minimize the longest distance(R) that a person needs to travel to reach a DC.**

## Question 2:

a) Emergency Response Center (ERC) considers using motorcycles right after an earthquake in order to have an idea about the status of districts in Bakırköy after the earthquake within 2 hours time. So that, they can send the Rescue Teams more efficiently.

According to the plan, each node should be visited by a motorcycle right after the earthquake.

Assume the motorcycles are located in ERC (node #1 of the data set) and they can travel 30 km/h on average.

How many motorcycles do the ERC should purchase at minimum?

Report the route for each motorcycle.

**b) Now conduct a sensitivity analysis on part a.  
Decrease the total visit time from 2 hours to 1 hour  
with increments 0.25 hrs.**

**Note the # of motorcycles needed for each step.**

**c) Now the authorities want to relocate the ERC.**

**Among the distribution centers that you open in Q1 part a,  
where do you move ERC?**

**Use the number of motorcycles that you have found in Q2  
part a.**

**d) Now assume we can locate the motorcycles in more than one DC's.**

**(Still you will choose the motorcycle locations from Q1 part a)**

**How many motorcycles should locate in which DC's, in order to visit all districts in 1 hour this time?**