Remote Sensing of wildfires in the North Africa and Middle East*

Presented by: George Mitri, Ph.D.
University of Balamand - Lebanon

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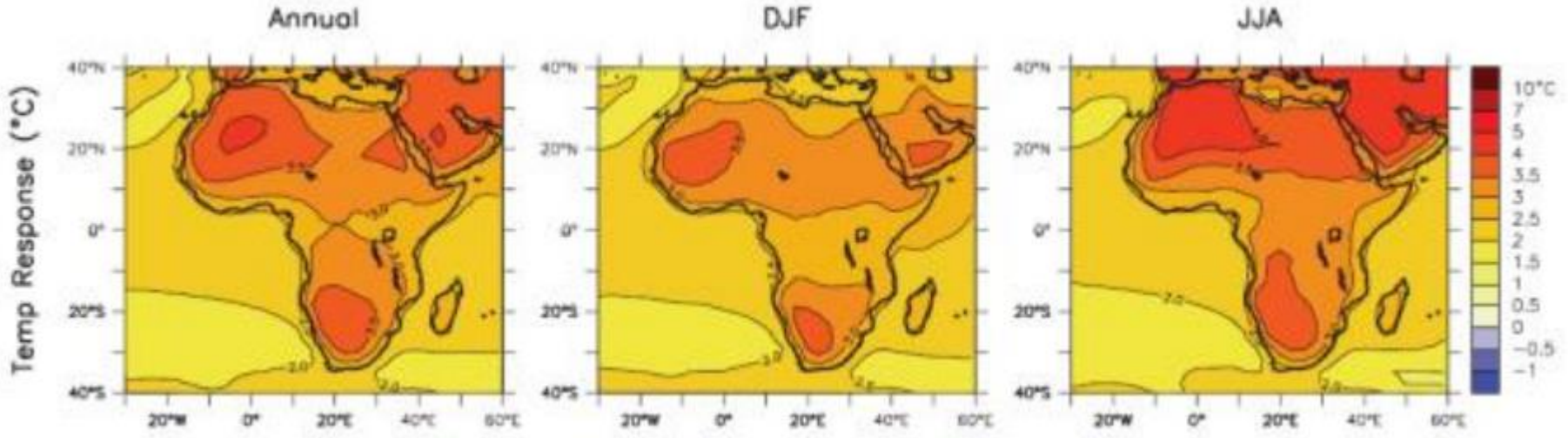
INTRODUCTION

OVERVIEW

- **Climate Change Impact**: Rising temperatures and prolonged droughts are leading to higher wildfire risks.
- **Vegetation Changes**: Increased aridity leads to more dry vegetation, which serves as fuel for fires.
- **Urban Expansion**: Encroachment of urban areas into wildland regions increases the potential for human-caused fires.



NOTABLE INCIDENTS

- **Lebanon Wildfires (2019 and 2021**): A series of devastating wildfires impacted vast areas, driven by extreme heat and strong winds and affecting forests in high mountains lands.

- **Algeria Wildfires (2021 and 2023):** Ones of the worst fire seasons in recent history, with numerous casualties and significant forest loss.

- **Tunisia wildfires (2023**): Fires near its border with Algeria have forced at least 300 people to be evacuated by sea and by land, with temperatures nearing 50C.

- **Morocco (2022):** Large areas of forests were consumed by the flames, which damaged many homes, and killed one person. Hundred of people were evacuated.

- **Syria Wildfires (2019, 2020 and 2021**): Fires consumed vast swathes of forests. Up to 140,000 people were affected by the 2020 fires one UN report said.

Smoke rises from a wildfire in Tabarka, Tunisia, 24 July. SAMMOUD HAITHEM/REUTERS

AIMS & OBJECTIVES

AIMS AND OBJECTIVES

The topic of fires in North African and Middle East Arab countries remains under-researched until present

This study **aims** to analyze and compare the occurrence of wildfires (hotspots) in relation to weather variability in Arab countries in the Mediterranean. Specific

Objectives among others:

- Conduct a **correlation analysis** between the number of wildfires and the FWI for each country, and model the relationship between FWI and wildfire occurrences.
- Examine **trends in wildfires and FWI** over time, identifying whether there is an increasing or decreasing pattern, and pinpoint the periods when forest fires are more likely to occur.
- **Assess fire risk** taking into the probability of fire occurrence under various FWI conditions, offering a practical resource for fire management.

STUDY AREA

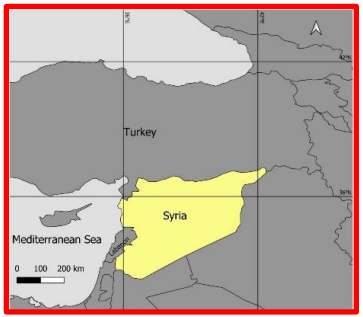
The study area includes **Lebanon**, **Syria**, **Morocco**, **Algeria**, and **Tunisia.**

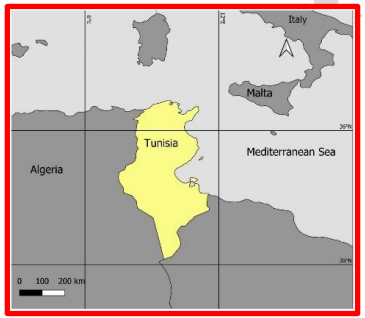
STUDY AREA DESCRIPTION (1)

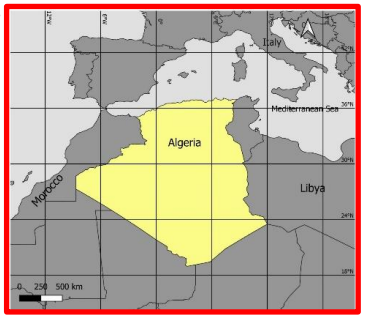
- The **Arab region** covers 10 million square kilometers of semi-arid and arid regions
- It is composed of 22 states
- It comprises an overall population of 370,989,000
- Recorded population growth rate in past 20 years ~ 2.6%

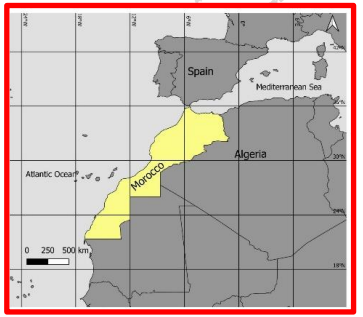
STUDY AREA DESCRIPTION (2)

The study area included **Lebanon**, **Syria**, **Morocco**, **Algeria**, and **Tunisia**, situated around the **Mediterranean Sea**. These countries feature diverse climates from Mediterranean to arid, influencing wildfire behavior. The region's varied land cover types, from forests to barren areas, further shape wildfire occurrence.





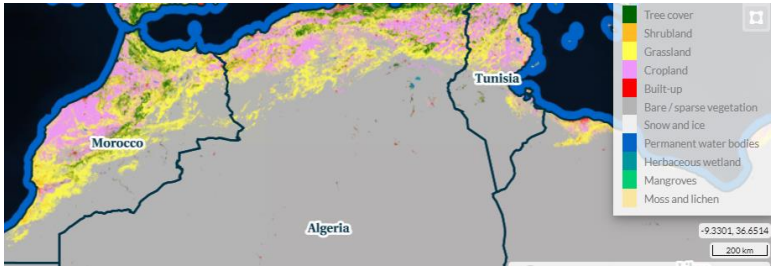


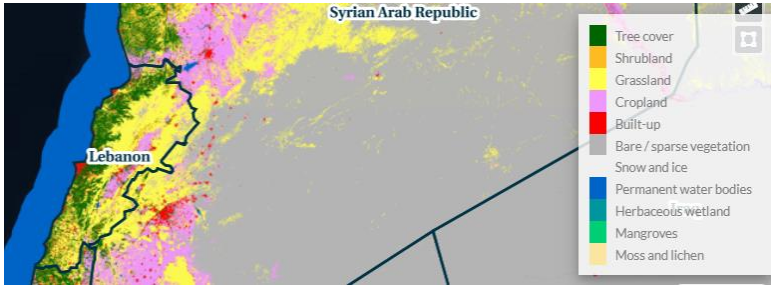


METHODOLOGY

DATASET DESCRIPTION (LC)

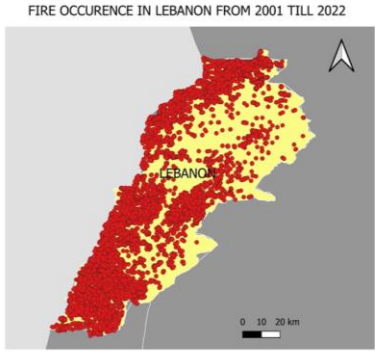
- The **land cover information** was gathered from the ESA WorldCover map, which offers comprehensive global coverage (ESA WorldCover, 2023).
- WorldCover provides the first global land cover products for 2021 at 10 m resolution, developed and validated in near-real time based on Sentinel-1 and Sentinel-2 data.
- This dataset was employed to delineate natural regions such as grasslands, forests, and shrublands, crucial for understanding the geographical context of fire incidents

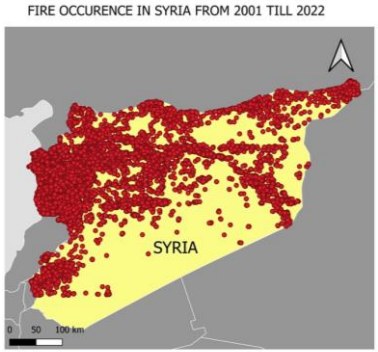


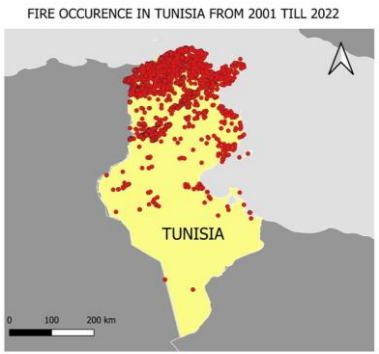


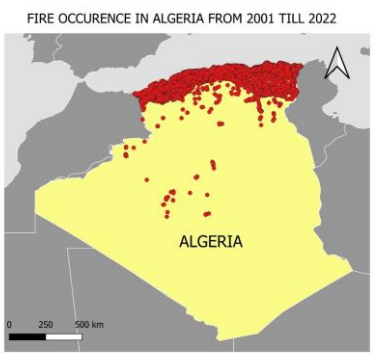
DATASET DESCRIPTION (FIRE HOTSPOTS)

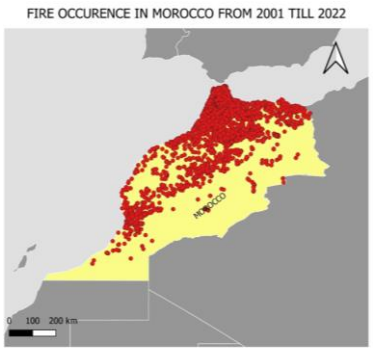
- The **Fire hotspot** data were obtained from the Fire Information for Resource Management System (FIRMS).
- The data, covering the years 2001 to 2022 (with focus on years 2012-2022 for specific analyses), were derived from MODIS and VIIRS sensors
- Fire hotspot locations were pre-processes and derived for areas of natural land cover





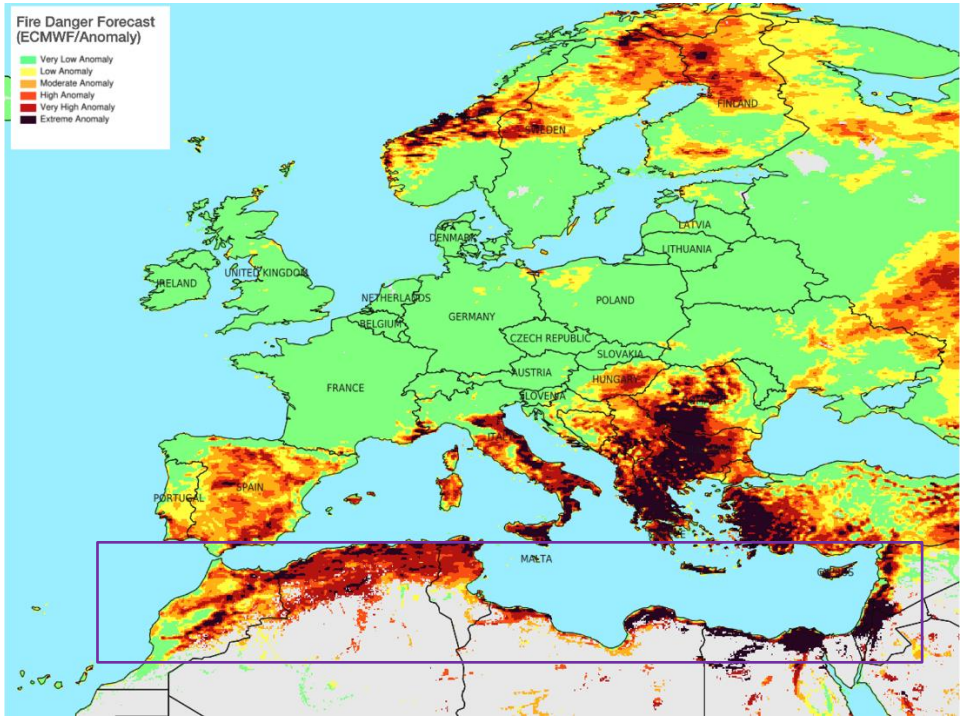




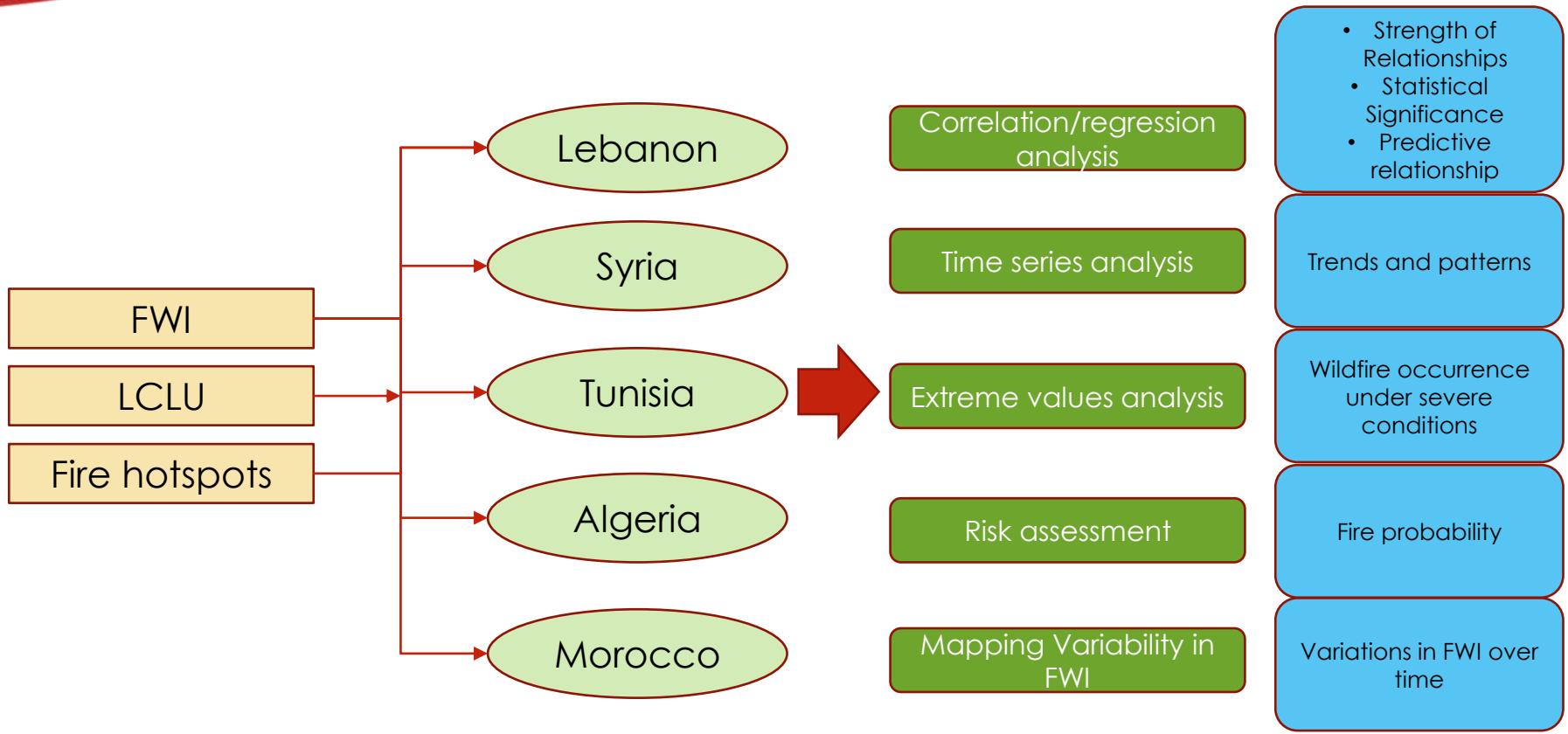


DATASET DESCRIPTION (FWI)

- The collected **FWI data** was sourced from the Copernicus Fire and Emergency Monitoring Service (EMS).
- The dataset spans from January 1, 2001, to July 31, 2022, and includes daily data in netCDF (Network Common Data Form) for the five countries under study
- Intersection of FWI data with fire hotspots

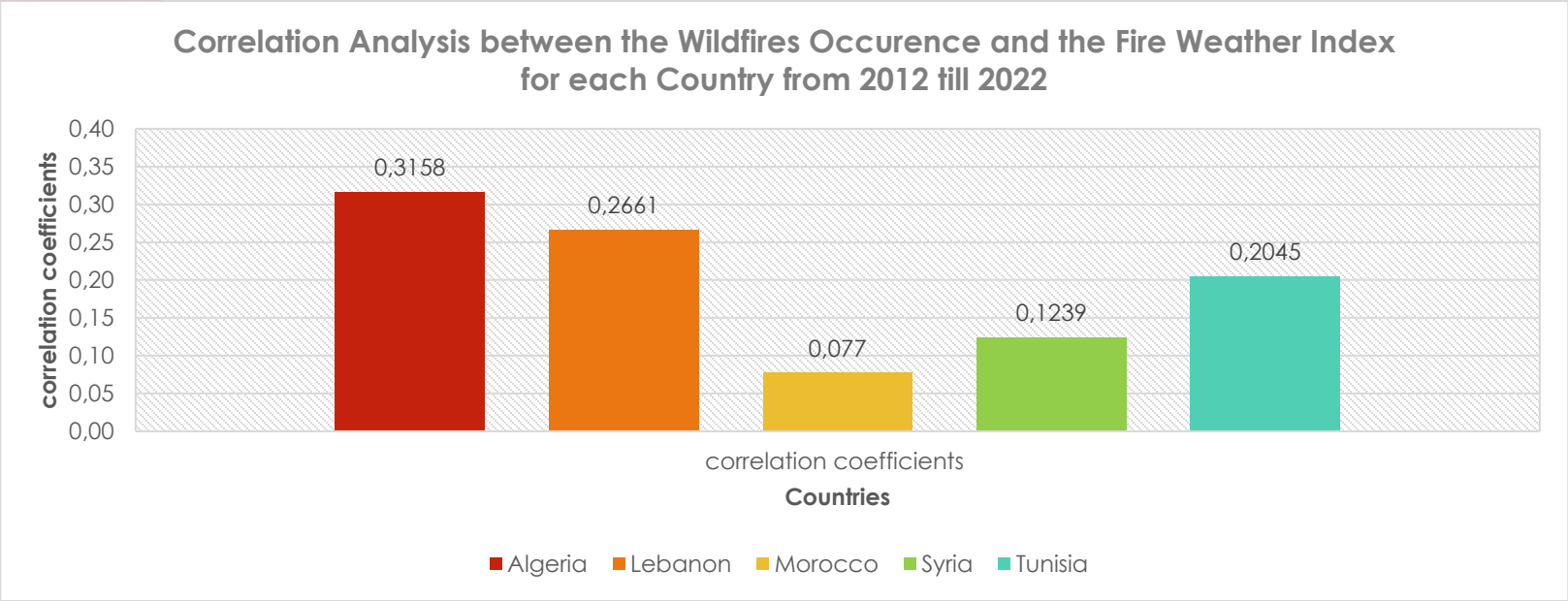


GEO-STATISTICAL ANALYSES



RESULTS & DISCUSSIONS

COMPARATIVE CORRELATION ANALYSIS

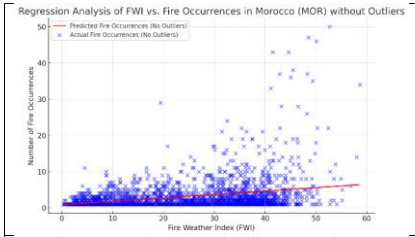


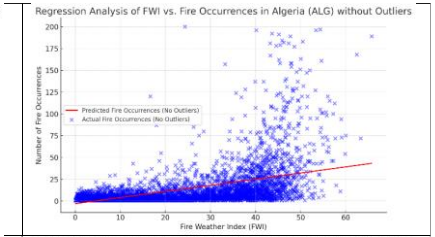
Low p-values (<0.05) recorded across all countries indicating statistically significant correlations

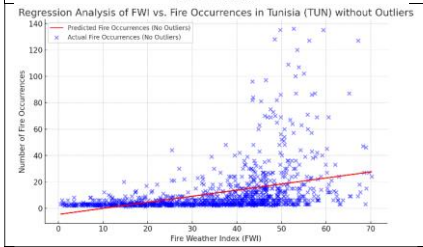
Countries	Algeria	Lebanon	Morocco	Syria	Tunisia
P-Value	2.2×10^{-16}	1.04×10^{-11}	0.008	1.62×10^{-6}	1.49×10^{-10}

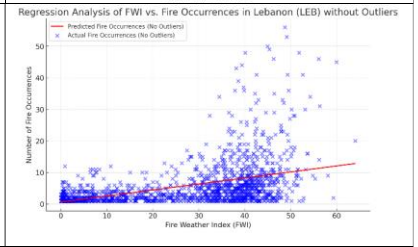
COMPARATIVE REGRESSION ANALYSIS

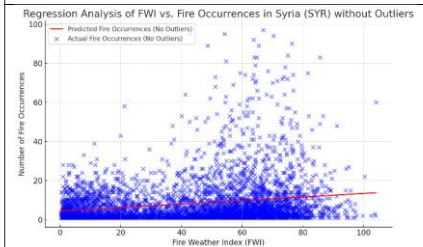
- Positive slope for each country indicating a positive relationship between FWI and fire occurrences.
- Steeper slopes recorded for ALG and TUN indicating a stronger impact of FWI on the number of fire occurrences











MOR: y = 0.0935.x+0.8809
R^2 = 0.082

ALG: y = 0.7031.x –2.9994
R^2 = 0.271

TUN: y = 0.4602.x – 4.7226
R^2 = 0.159

LEB: y = 0.1908.x +0.6386
R^2 = 0.190

SYR: y= 0.0908.x +4.3640
R^2 = 0.041

COMPARATIVE TIME SERIES ANALYSIS

Algeria
•**Wildfire Occurrence**: Peaks in frequency observed.
•**FWI**: Consistently high during summer months.

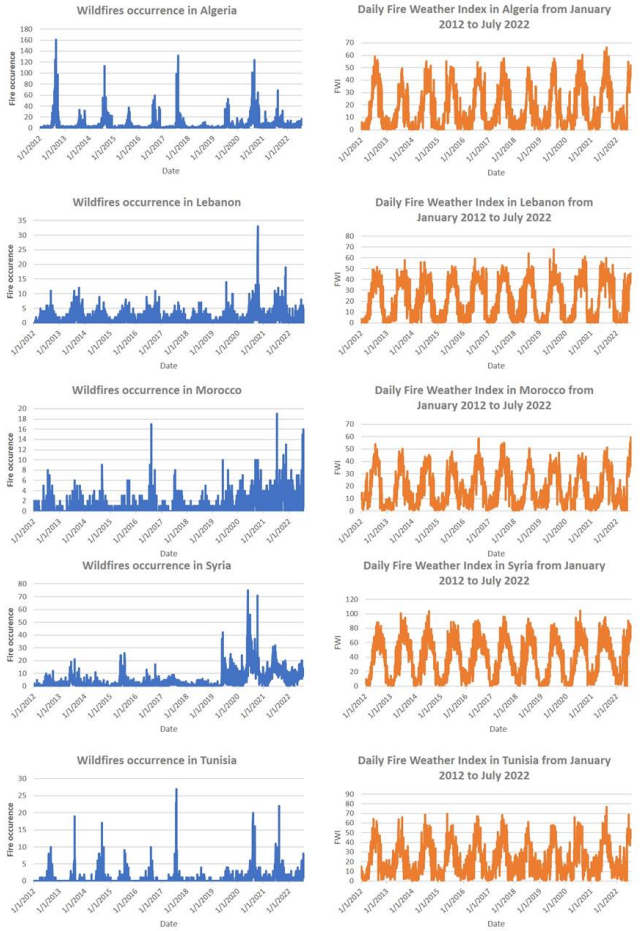
Lebanon
•**Wildfire Occurrence**: Steady increase over the years.
•**FWI**: Regular peaks correlating with wildfire occurrences.

Morocco
•**Wildfire Occurrence**: Increasing trend with notable spikes.
•**FWI**: High during dry seasons, contributing to wildfire risk.

Syria
•**Wildfire Occurrence**: Significant peaks observed, particularly in recent years.
•**FWI**: High values during summer months.

Tunisia
•**Wildfire Occurrence**: Noticeable increase over time.
•**FWI**: Regular high values in summer, indicating increased risk.

Key Takeaway: Rising temperatures and changing weather patterns are increasing wildfire risks across these regions.



SEASONALITY ANALYSIS

Algeria (ALG)
•**Fire Occurrence Peaks**: August - **FWI Peaks**: July
•**Observation**: High correlation between FWI and fire occurrences during summer months.

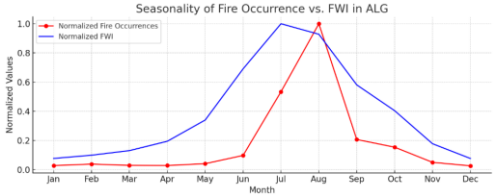
Lebanon (LEB)
•**Fire Occurrence Peaks**: August to September - **FWI Peaks**: July to August
•**Observation**: Fire occurrences align closely with high FWI periods, indicating increased risk during late summer.

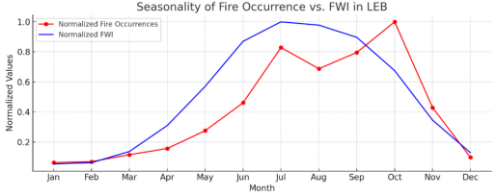
Morocco (MOR)
•**Fire Occurrence Peaks**: August - **FWI Peaks**: July
•**Observation**: Strong seasonal pattern with fire occurrences closely following high FWI values.

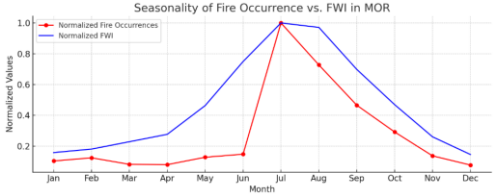
Syria (SYR)
•**Fire Occurrence Peaks**: July to August - **FWI Peaks**: July
•**Observation**: Notable alignment of fire occurrences with high FWI, indicating increased risk during mid-summer.

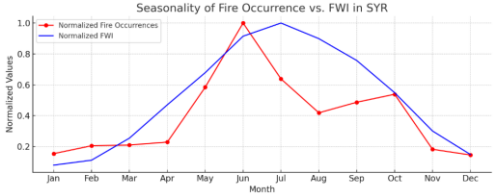
Tunisia (TUN)
•**Fire Occurrence Peaks**: August - **Fire Weather Index (FWI) Peaks**: July
•**Observation**: Clear correlation between high FWI and fire occurrences, highlighting the critical fire season in late summer.

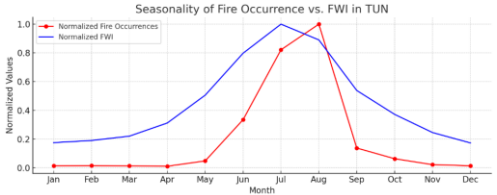
Key Takeaway: All countries show a clear seasonal pattern where fire occurrences peak shortly after the highest FWI values, underscoring the importance of targeted fire prevention efforts during these critical periods.











EXTREME VALUES AND RISK ASSESSMENT

Algeria

•**95th Percentile Thresholds**: 40 fire occurrences, FWI of 45.27
•**99th Percentile**: 164 occurrences, FWI of 52.65
•**Example**: July 19, 2001 – 75 fire occurrences, FWI of 60.03

Lebanon
•**95th Percentile Thresholds**: 7 fire occurrences, FWI of 44.95
•**99th Percentile**: 20 occurrences, FWI of 51.25
•**Observation**: High FWI doesn't always lead to high fire occurrences (e.g., June 7, 2001, FWI of 55.86, but no significant fires)

Morocco
•**95th Percentile Thresholds**: 5 fire occurrences, FWI of 40.92
•**99th Percentile**: 12 occurrences, FWI of 46.90
•**Example**: August 13, 2003 – 13 fire occurrences, FWI of 33.77

Syria

•**95th Percentile Thresholds**: 22 fire occurrences, FWI of 76.86
•**99th Percentile**: 59 occurrences, FWI of 87.90
•**Example**: July 11, 2001 – 16 fire occurrences, FWI of 88.42

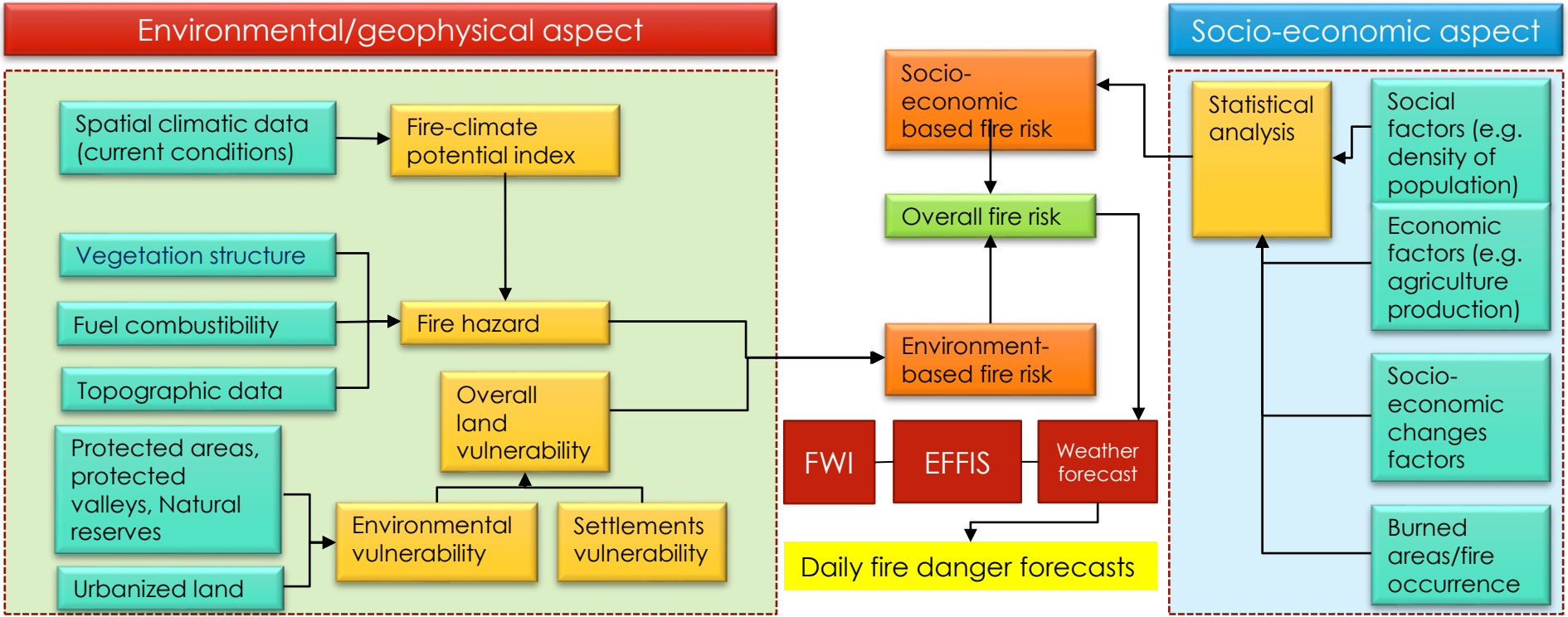
Tunisia

•**95th Percentile Thresholds**: 9 fire occurrences, FWI of 49.33
•**99th Percentile**: 44 occurrences, FWI of 58.13
•**Example**: July 1, 2002 – 18 fire occurrences, FWI of 67.47

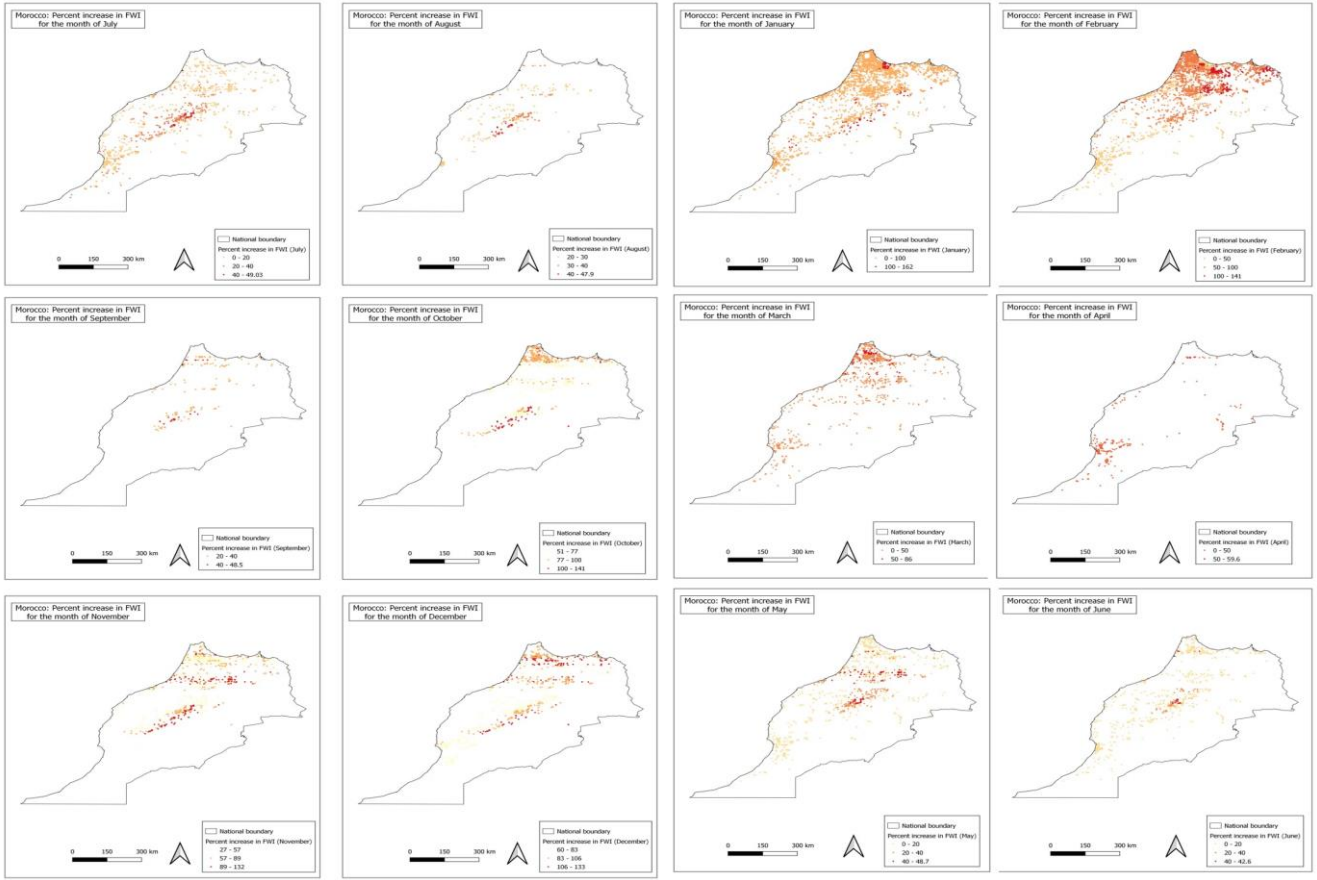
Key Takeaways
•**Monitoring Importance**: High FWI values indicate extreme fire weather conditions; actual fire occurrence influenced by multiple factors.
•**Risk Preparation**: Understanding FWI and fire dynamics aids in fire prevention and management strategies.
•**Future Research**: Including meteorological and biophysical data can provide deeper insights into extreme fire risks.

FWI supported by bio-physical and socio-economic data for improved fire danger forecast:
Case study from Lebanon https://firelab.balamand.edu.lb/firelabweb

Mitri, G., Saba, S., Nader, M., McWethy, D. (2017). Developing Lebanon's fire danger forecast, International Journal of Disaster Risk Reduction, 24, 332-339,



MAPPING MONTHLY PERCENT INCREASE IN FWI: EXAMPLE FROM MOROCCO



Significant monthly percent increase (observed in Algeria, Lebanon, Morocco, Syria, and Tunisia.

In MOR, there is a clear spatial pattern where certain regions, particularly in the northern parts of the country, consistently show higher percent increases in FWI.

CONCLUSION

Seasonal Patterns:
- Distinct seasonal increases in FWI align with traditional fire seasons (drier and hotter conditions).
- Climatic factors like temperature and aridity significantly influence wildfire potential.

Spatial Analysis:
- Higher FWI increases in coastal and northern regions indicate greater fire risk in these areas.
- Suggests the need for region-specific fire risk management and resource allocation.

Fire Occurrence vs. Burnt Area:
- Important to distinguish between fire occurrences and the extent of burnt areas.
- A decrease in fire numbers may still result in larger burnt areas, impacting resource allocation and management strategies.

FWI Predictive Power:
- Strongest correlation between FWI and fire occurrences in Algeria.
- Weaker correlations in Lebanon and Syria indicating the need for complementary data in these regions.
- Higher fire occurrence probabilities observed with 'Very High' and 'Extreme' FWI categories.

Regional Fire Management:
- Emphasizes the critical role of FWI in assessing wildfire risk.
- Highlights the need for flexible fire management strategies tailored to regional conditions and risks.
- Ongoing research needed to adapt to shifting climate patterns and improve understanding of wildfire dynamics.

Integration with Other Data:
- Advocates for combining FWI analysis with environmental and other bio-physical data.
- Improved regional forecasting models and targeted fire management approaches are essential.
- Validation through vegetation indices and actual fire events (e.g., case study of burnt areas) enhances understanding of fire risk

THANK YOU

george.mitri@balamand.edu.lb