Road Crashes Analysis in Greek Islands

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Background (1/2)

- Greece ranks among the top countries worldwide in number of inhabited islands (over 200).
- Many of these islands are important tourist destinations, attracting both domestic and international visitors every year.
- During the summer months, populations often double or even triple, creating intense seasonal pressure on transport systems.
- Municipalities must adapt annually to deal with the increased traffic demand, temporary congestion, and mobility challenges.
- Although islands usually record fewer crashes compared to mainland Greece (narrower roads, less permanent traffic), the summer surge leads to sharp increases in road crashes and fatalities.

Background (2/2)

- Tourist crashes are preventable, but limited cooperation between health, tourism, and transport stakeholders hinders action (Page & Meyer, 1996).
- Scotland: Foreign drivers caused 28% of crashes, often severe; risks peak in summer and on main roads due to unfamiliarity (Walker & Page, 2004).
- Greece (2011–2015): Crashes rise sharply June–September; key factors: alcohol use, poor signage, and lack of adaptation measures (Bellos et al., 2020).
- Greece (2011–2015): Victims are mainly younger individuals (15–44 years) and two-wheeler users (Nikolaou et al., 2019).
- A large-scale association rule mining analysis (~41,500 crashes) showed that island and mainland crash patterns are broadly similar, reinforcing the role of seasonality as the key crash risk factor (Ziakopoulos et al., 2023).

Motivation

- Tourism is a pillar of the Greek economy, but it creates seasonal road safety challenges on the islands.
- Visitors and residents must share limited, often rural road networks not designed for large tourist volumes.
- Foreign drivers face added risks: traffic rule unfamiliarity, driving orientation differences (e.g., left vs right), and difficulty interpreting signs.
- Research on Greek islands is less extensive compared to national-level studies; data gaps exist in understanding the island-specific dynamics.
- This study aims to address this gap by providing a comprehensive, decade-long analysis of road crashes on 38 islands.

Objective

- Analyze the relationship between tourist arrivals and road crashes on Greek islands.
- Specific focus:
  - To determine how seasonal surges in arrivals contribute to injury crashes.
  - To test whether the same surges are linked to fatal crashes.
- Approach:
  - Build Generalized Linear Models (GLMs) and Random Forest models to capture correlations.
  - Assess both statistical significance and predictive accuracy.
- Research value: Provides quantitative evidence for policymakers on how tourism shapes seasonal road safety outcomes.

Data Collection

- Geographical scope: 38 islands categorized into 4 groups: Dodecanese, Cyclades, Ionian, and Central/Northern Aegean.

- Tourism arrivals:
  - Port data → Hellenic Statistical Authority.
  - Airport data → Institute of Greek Tourism Enterprises.
  - Combined totals per island and per month (yacht arrivals excluded).

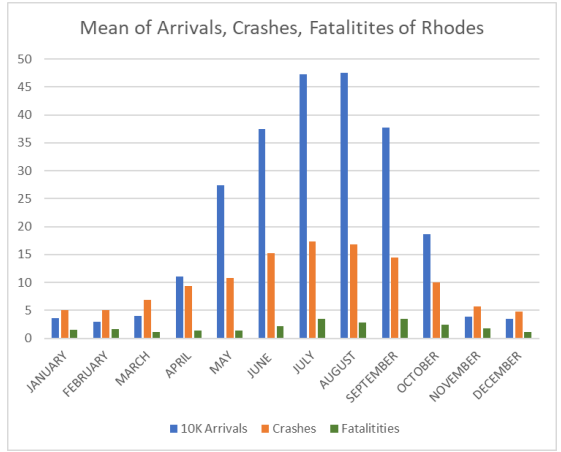
- Crash data: Monthly records of road crashes with injuries and fatalities from ELSTAT.

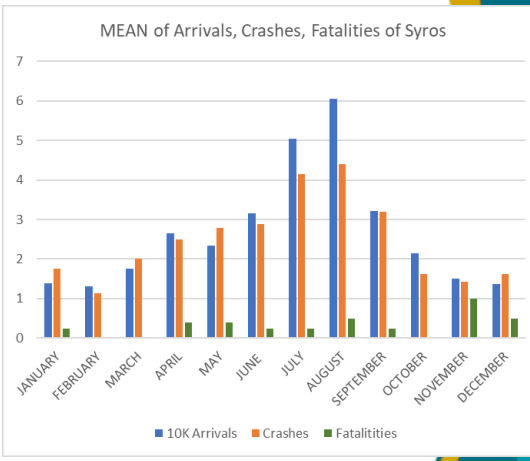
- The combined dataset covers 10 years (2009–2018), capturing both long-term trends and short-term seasonal variation.

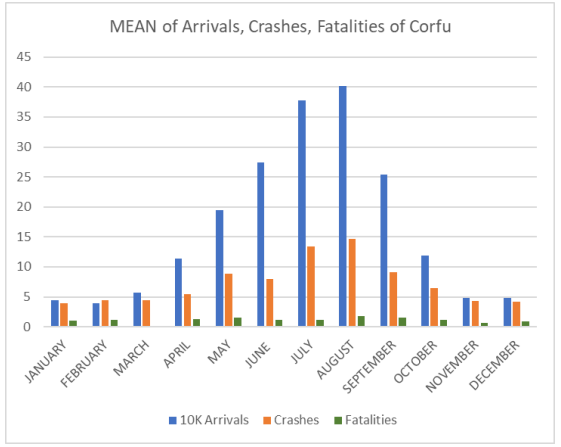
- Processing workflow:
  - Initial dataset formatting in Excel.
  - Statistical analysis and modeling conducted in R.

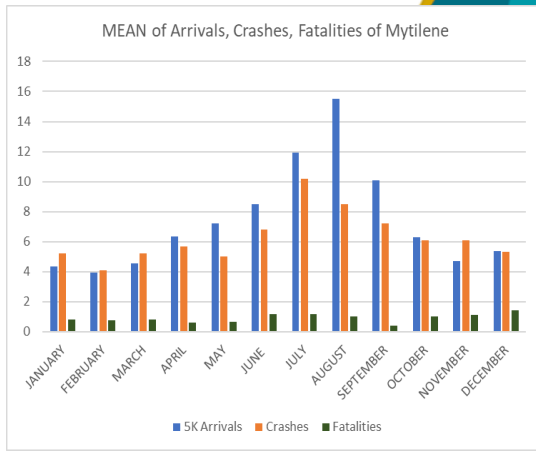
Descriptive Statistics

- **Rhodes**: Arrivals rise sharply May–October, peak July–August. Crashes and fatalities mirror this curve, showing a clear seasonal link.
- **Syros**: Tourist inflows increase March–August, followed by decline; road crashes track this rise and fall closely.
- **Corfu**: Gradual increase April–August, drop September–November. Monthly crashes follow same trend.
- **Mytilene**: July–September is peak season for both arrivals and crashes.
- Overall descriptive insight: Across all studied islands, **seasonality is the dominant factor shaping crash trends**. Tourist flows and crashes move together over time, strongly suggesting a causal link.









Methodological Background

- **Generalized Linear Models (GLMs):**
  - Extension of linear regression for non-normal, heteroscedastic data.
  - Include distribution, linear predictor, link function (log, logit)
  - Can model count data such as crash frequencies.
  - Enables testing the strength and significance of associations between arrivals and crashes.
  - Limitation: assumes linear relationships, may not fully capture complexity.

- **Random Forests:**
  - Ensemble machine learning method using multiple decision trees.
  - Each tree trained on a random subset of data → prevents overfitting.
  - Handles non-linear relationships and interactions better than GLMs.

- **Model Evaluation:**
  - McFadden R^2 → fit quality
  - AICc → balances fit vs complexity
  - MAE & RMSE → prediction accuracy (lower = better)

Results

- Tourist arrivals positively correlated with fatalities in most regions.
- However, fatal crashes are relatively rare events and their statistical modeling is limited by low absolute counts, reducing reliability.
- Clear positive correlation between arrivals and crashes across all island groups.
- Central/Northern Aegean: highest coefficient, Cyclades: second highest, Dodecanese: moderate, Ionian: weakest relationship.
- Crashes are frequent enough to produce robust GLM models, confirming that seasonal traffic volumes strongly drive crash frequencies.
- RF consistently produced lower MAE & RMSE, showing stronger predictive capacity.
- Interpretation: Non-linear methods capture the complexity of crash dynamics better than linear statistical models.

	Generalized Linear Model (GLM)					
	Fatalities			Crashes		
Island Groups	Συντελεστής	McFadden R^2	AICc	Συντελεστής	McFadden R^2	AICc
Dodecanese	0.00909 < p = 0.001	0.16	954.66	0.0123	0.1193	2638.03
Kyklades	0.01122 < p = 0.001	0.11	628.61	0.0182	0.1081	2491.14
Ionio	0.00714 < p = 0.001	0.10	634.42	0.0095	0.1062	1853.99
Central/ North Aegean	0.03354 < p = 0.001	0.06	708.54	0.0574	0.100	2227.65

Island Groups	Fatalities MAE	Fatalities RMSE	Crashes MAE	Crashes RMSE
Dodecanese	0.64	2.42	15.40	87.42
Kyklades	0.16	0.34	3.40	15.83
Ionio	0.59	1.07	5.78	18.60
Central/ North Aegean	0.27	0.51	4.35	17.52

	Random Forest			
	Fatalities		Crashes	
Island Groups	Mean of Squared Residual	% of Var explained	Mean of Squared Residual	% of Var explained
Dodecanese	0.454	23.16	5.977	63.15
Kyklades	0.099	-26.53	2.185	16.53
Ionio	0.471	2.84	8.015	53.14
Central/ North Aegean	0.245	-21.47	4.658	15.18

Island Groups	Fatalities MAE	Fatalities RMSE	Crashes MAE	Crashes RMSE
Dodecanese	0.29	0.65	1.06	2.10
Kyklades	0.16	0.40	0.96	1.91
Ionio	0.40	0.72	1.92	3.42
Central/ North Aegean	0.24	0.50	1.73	3.26

Conclusions

- Tourist arrivals are strongly linked to increased road crashes on Greek islands.
- Fatalities show weaker or inconsistent correlation due to low numbers and other contributing factors.
- Strongest crash-arrival relationship found in Central/Northern Aegean.
- Many crashes involve tourists unfamiliar with local conditions, leading to accidents even without extreme risk-taking.

Implications & Future Work

- **Policy implications**:
  - Install clear, multilingual signage in tourist areas.
  - Improve road surface quality and lighting in high-risk zones.
  - Strengthen traffic enforcement during peak tourist months (alcohol checks, speed control).

- **Future research**:
  - Incorporate severe injury data alongside fatalities.
  - Conduct timeseries analysis (ARIMA etc.)

- **Takeaway message**: Seasonal tourism strongly affects road safety on Greek islands, and targeted interventions can reduce risk for both tourists and residents.

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