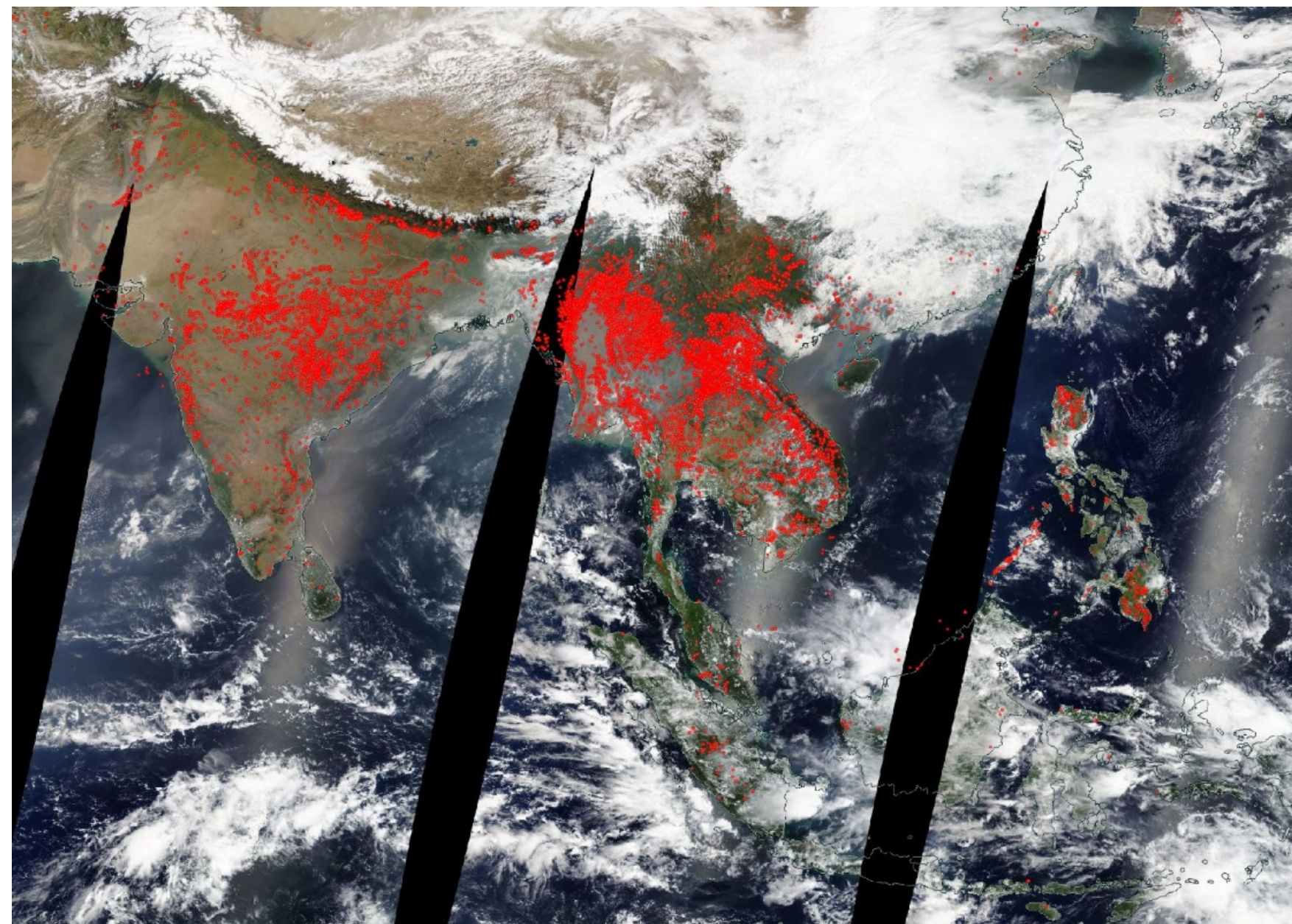


# Trends in Vegetation Fires in South/Southeast Asia

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# Fires in South/Southeast Asia are a recurrent problem



Anthropogenic fires dominate in the region

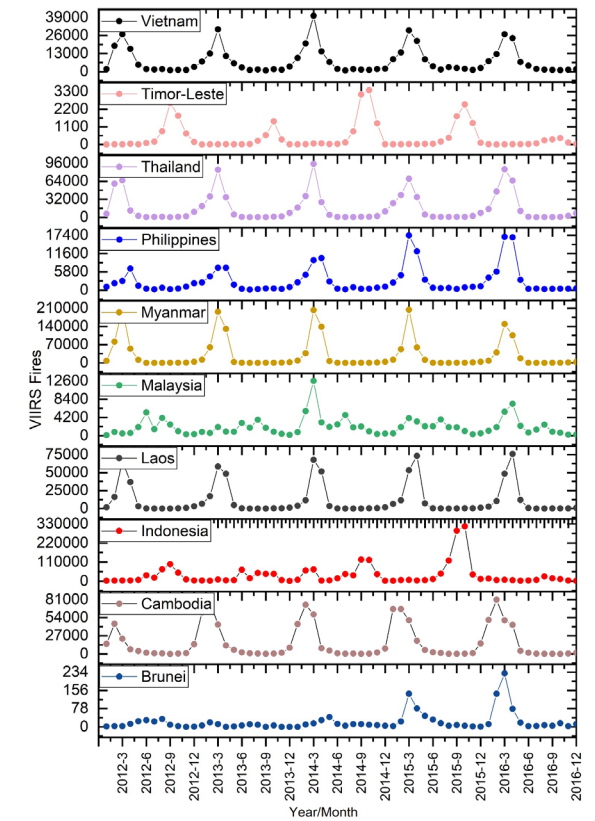
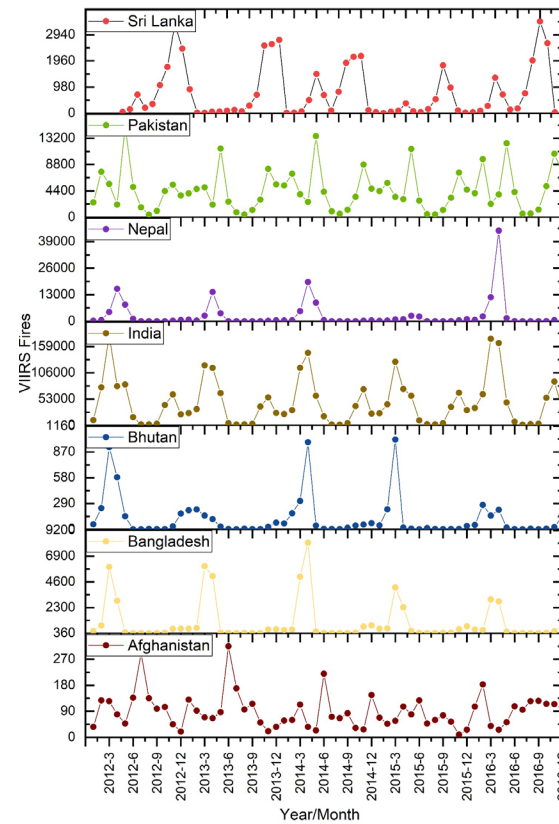
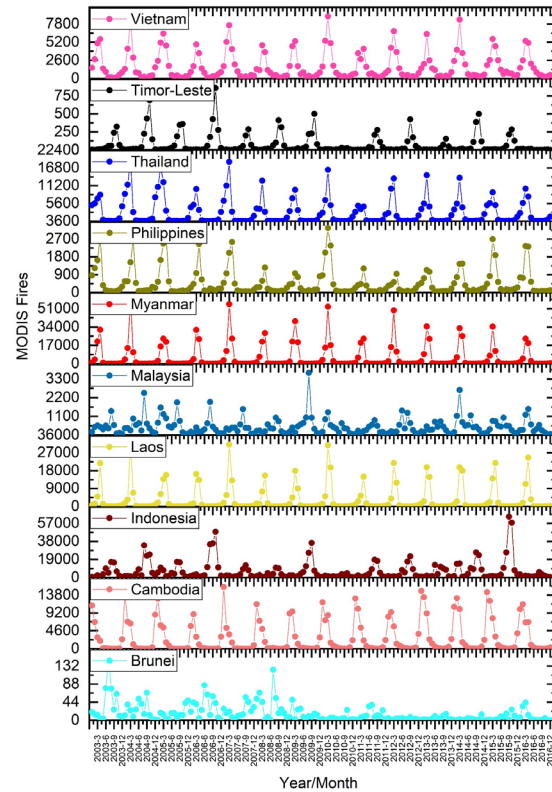
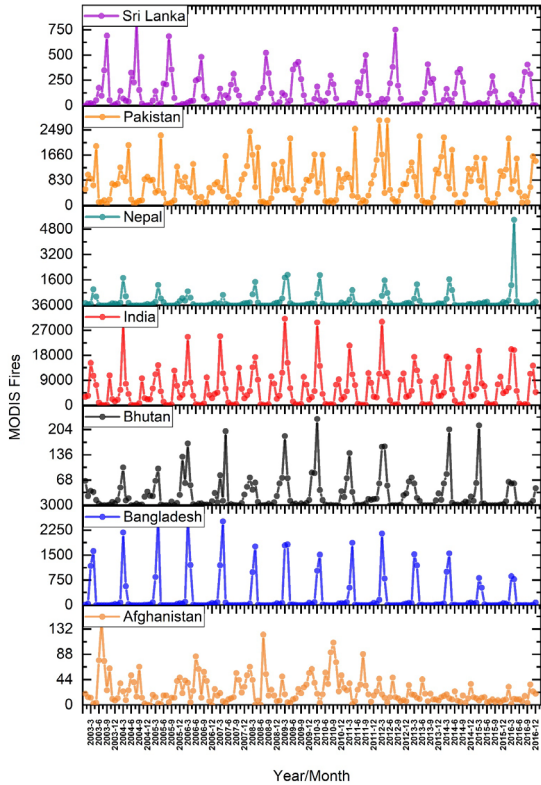
Climate influence is relatively less compared to the human component

# Trends in Vegetation Fires in South/Southeast Asia

- Are vegetation fires increasing or decreasing in Asian countries?
- Which of those countries show the highest vegetation fire concentration?
- Are the vegetation fire trends consistent between the MODIS and VIIRS data?
- How do fire trends vary across land cover types (agriculture, forests, grasslands, and shrublands?)

Vadrevu et al., 2019, Nature Scientific Reports

# Trends Analyzed Using MODIS (2003-2016) and VIIRS (2012-2016)

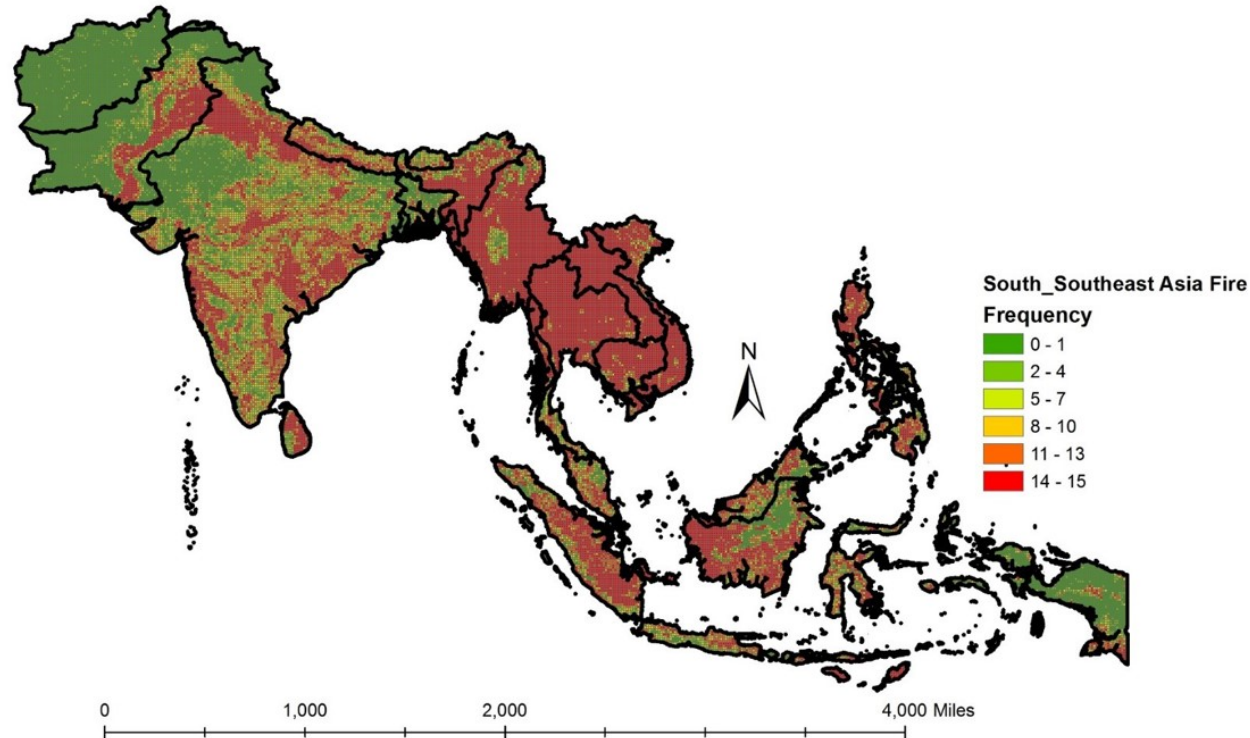


MODIS Collection 6 Fire product and VIIRS 375m I-Band fire product  
Mann Kendall Trend Test with Sen's slope estimator

# VIIRS detects more fires than MODIS

Country	MODIS	VIIRS	Factor
Afghanistan	298	1075	3.60
Bangladesh	3029	10972	3.62
Bhutan	347	1411	4.07
India	73836	551649	7.47
Nepal	3049	53998	17.71
Pakistan	8761	32018	3.65
Sri Lanka	1417	9185	6.48
South Asia Average	12962	94330	7.28
Brunei	75	253	3.37
Cambodia	32806	199646	6.09
Indonesia	79476	412080	5.18
Laos	39666	142354	3.59
Malaysia	6068	24470	4.03
Myanmar	70084	368533	5.26
Philippines	5977	35038	5.86
Singapore	7	32	4.63
Thailand	32533	194262	5.97
Timor-Leste	857	5118	5.97
Vietnam	20346	90917	4.47
Southeast Asia Average	26172	133882	5.12

# Fire Frequency Analysis (10km grid cells)



Country	Total 10m Grid cells	Cells with a fire frequency of 15	% of grid cells
India	9555	1701	17.802
Bangladesh	323	37	11.455
Bhutan	101	7	6.931
Myanmar	1849	1389	75.122
Cambodia	471	371	78.769
Indonesia	4572	974	21.304
Laos	575	551	95.826
Malaysia	785	124	15.796
Nepal	410	64	15.610
Pakistan	2747	397	14.452
Philippines	577	208	36.049
Srilanka	178	80	44.944
Thailand	1345	1009	75.019
Vietnam	792	494	62.374
Total	24280	7406	30.502

Laos had the highest recurrent fires followed by Cambodia, Myanmar, Thailand, Vietnam, etc.

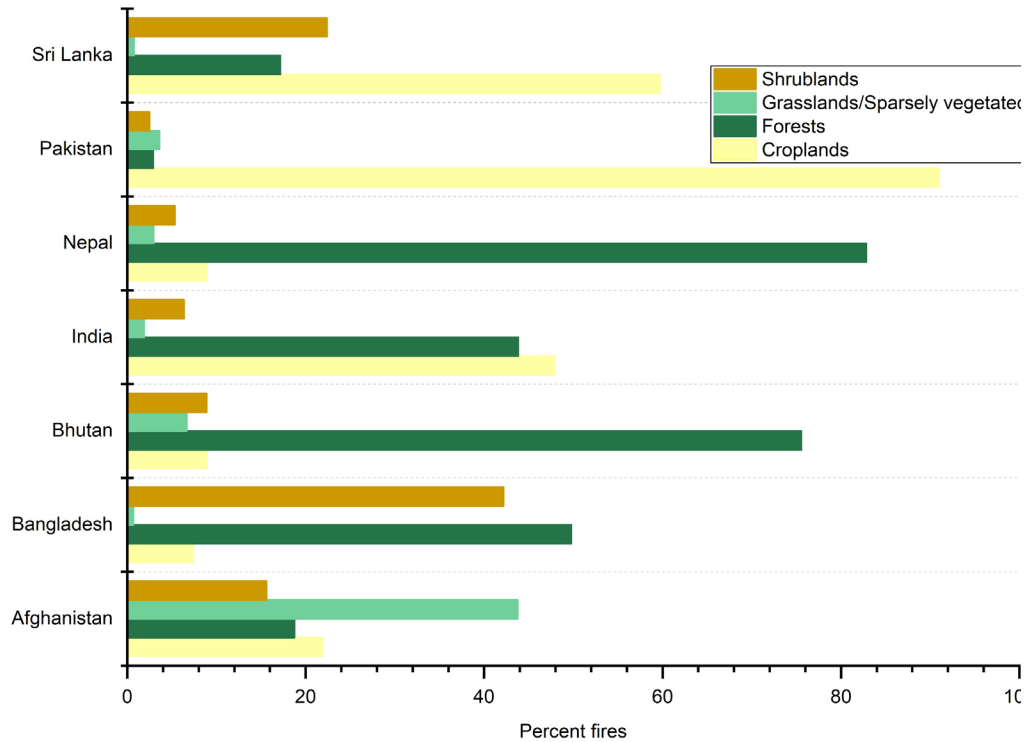
How many times each 10-km grid cell is impacted by fires over a 15-year time period?

# Increasing Trends in Fires for India, Cambodia and Vietnam

Country	FC Seasonal Kendall Test	FC Sens slope Estimator	FRP Seasonal Kendall Test	FRP Sens Slope Estimator
Cambodia	426 (0.001)	19.733	340 (0.005)	307.4
Indonesia	28 (0.8)	9.92	-44.0 (0.695)	-449
Laos	15 (0.773)	0	22 (0.688)	22.0
Malaysia	-59 (0.455)	-3.0	-42.0 (0.515)	-58.19
Maldives	-86 (0.251)	0	-112 (0.183)	-0.743
Myanmar	23 (0.736)	0.127	-14 (0.817)	-2.906
Philippines	-75 (0.435)	-1.917	-82 (0.429)	-39
Thailand	-69 (0.224)	-2.667	-100 (0.254)	-48.86
Timor Leste	-163 (0.004)	-0.40	-169 (0.99)	-6.844
Vietnam	126 (0.050)	12.8	30 (0.597)	68.64
Afghanistan	-103 (0.214)	-0.5	-116 (0.041)	-15.77
Bangladesh	145 (0.078)	0.222	57 (0.446)	0.747
Bhutan	-22.0 (0.685)	0.724	-22.0 (0.638)	0
India	218 (0.004)	20.857	102 (0.039)	131.49
Nepal	21 (0.714)	0	-12.0 (0.841)	0
Pakistan	136 (0.074)	6.417	130 (0.066)	116.09
Sri Lanka	-153 (0.072)	-0.50	-166 (0.049)	-10.54

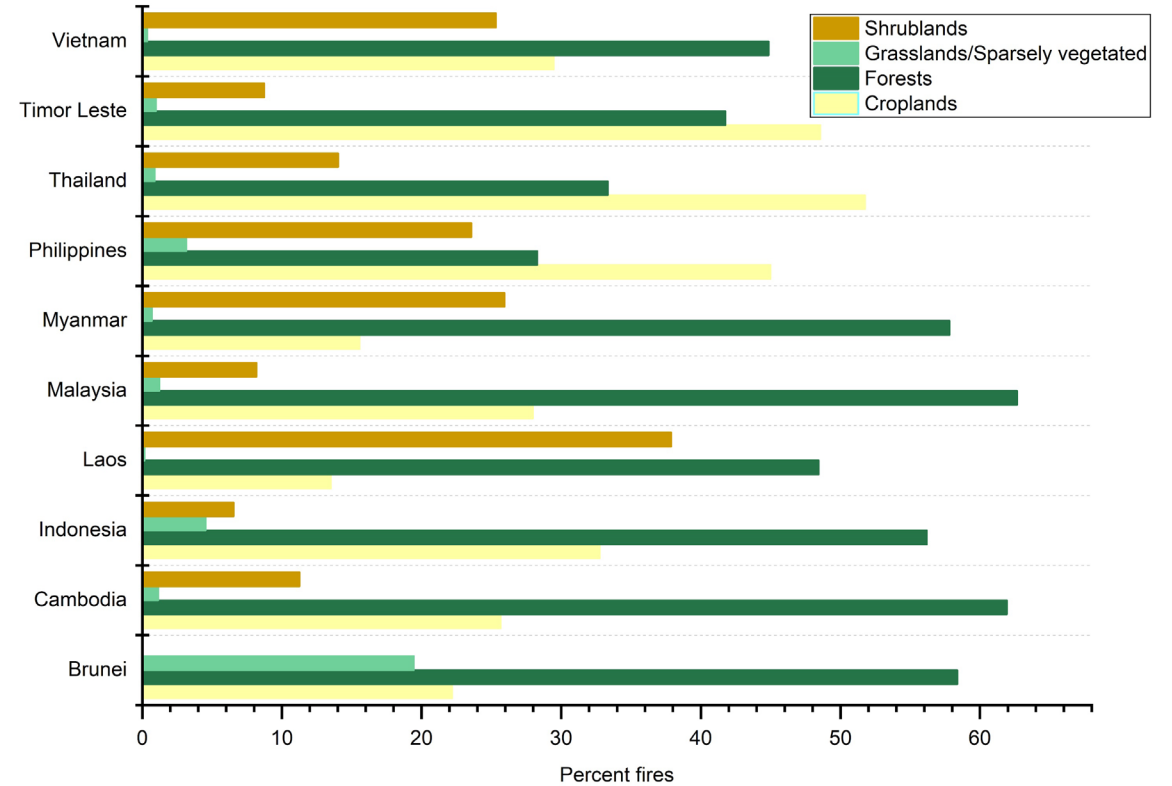
Of the different countries, increasing trend in fires were found for India ( $p=0.004$ ), Cambodia ( $p=0.001$ ), and Vietnam ( $p=0.050$ ) and decreasing trend for Timor Leste ( $p=0.004$ ). Thiel's Sen's slope which indicates the magnitude in trend was relatively high for countries with increasing fires, i.e., India, Cambodia and Vietnam.

# Trends Analyzed Using MODIS (2003-2016) and VIIRS (2012-2016)



India, Pakistan and Sri Lanka – most agricultural fires

Nepal and Bhutan – Mostly Forest fires



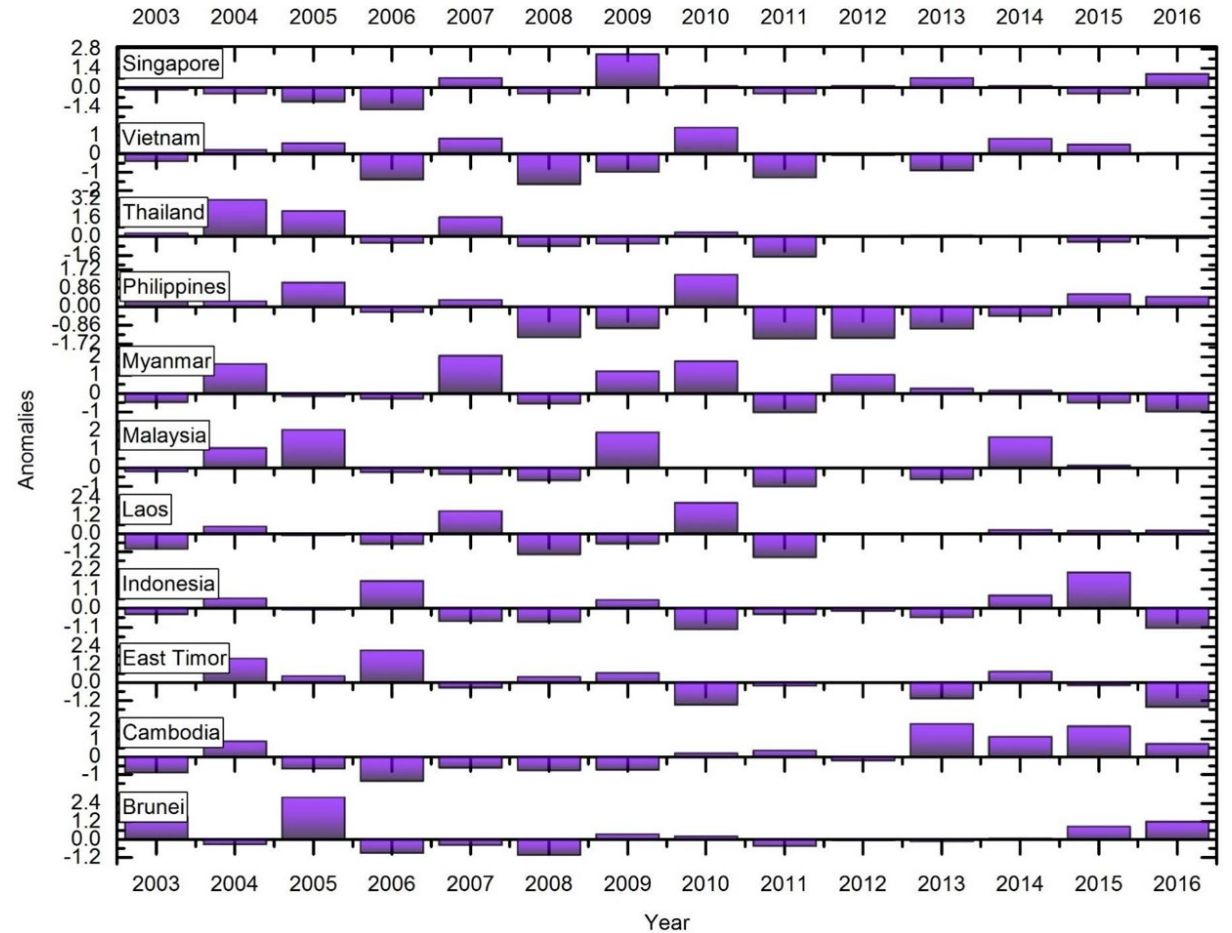
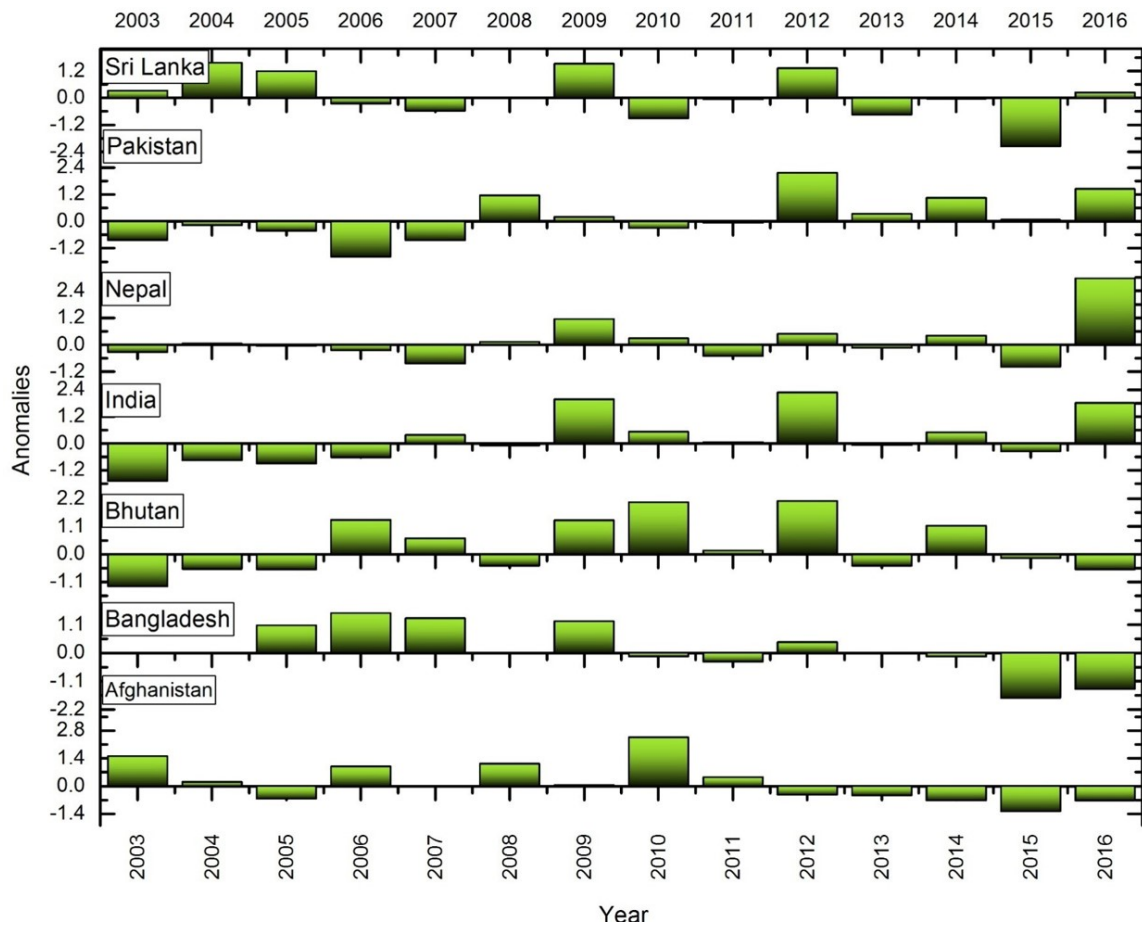
Thailand, Timor Leste, Philippines - most agricultural fires

Malaysia, Cambodia, Brunei and Myanmar (57.82%) had the highest percentage of fires in forests

Laos, Myanmar, Vietnam and the Philippines had the highest percentage of fires in the shrublands category.

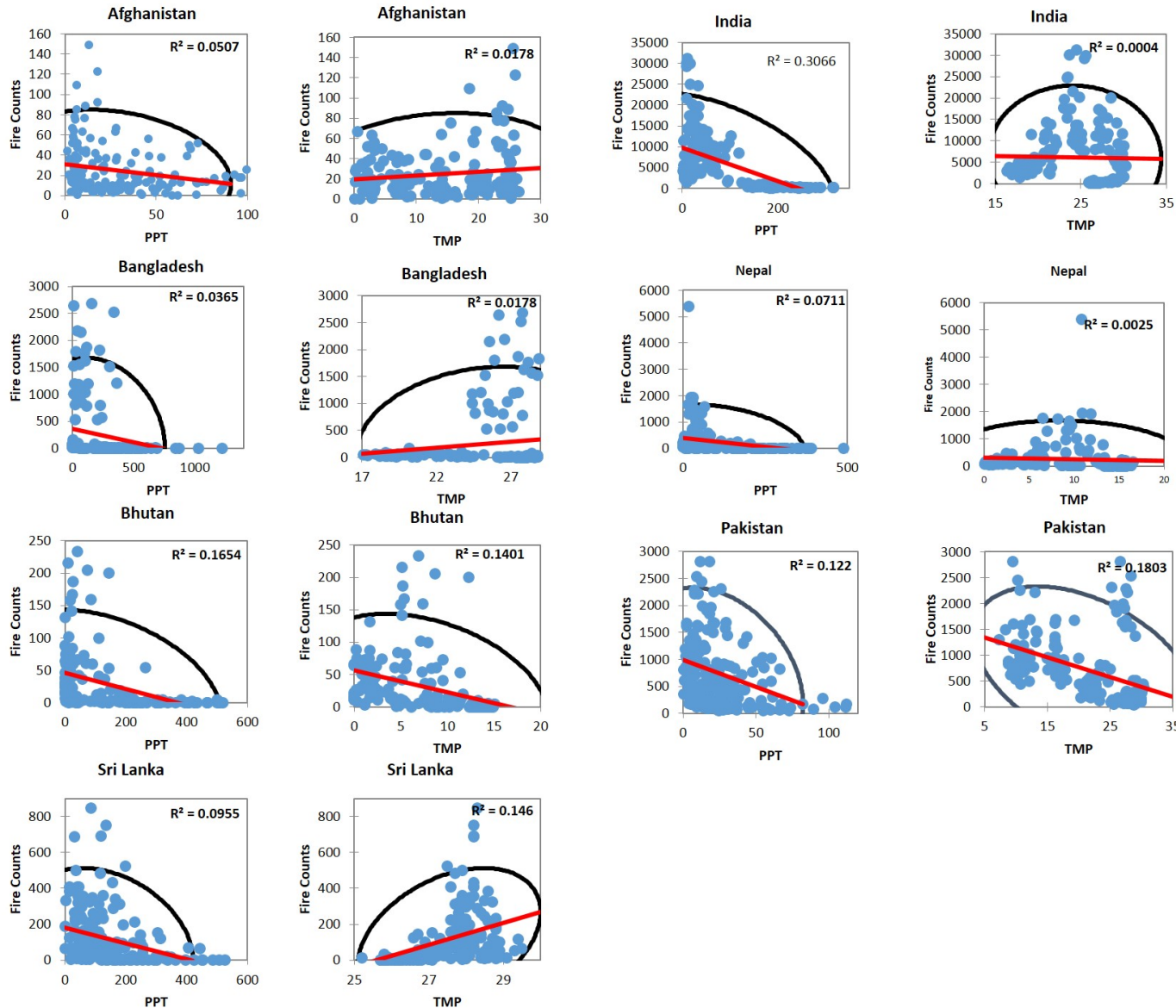


# Fire Anomalies



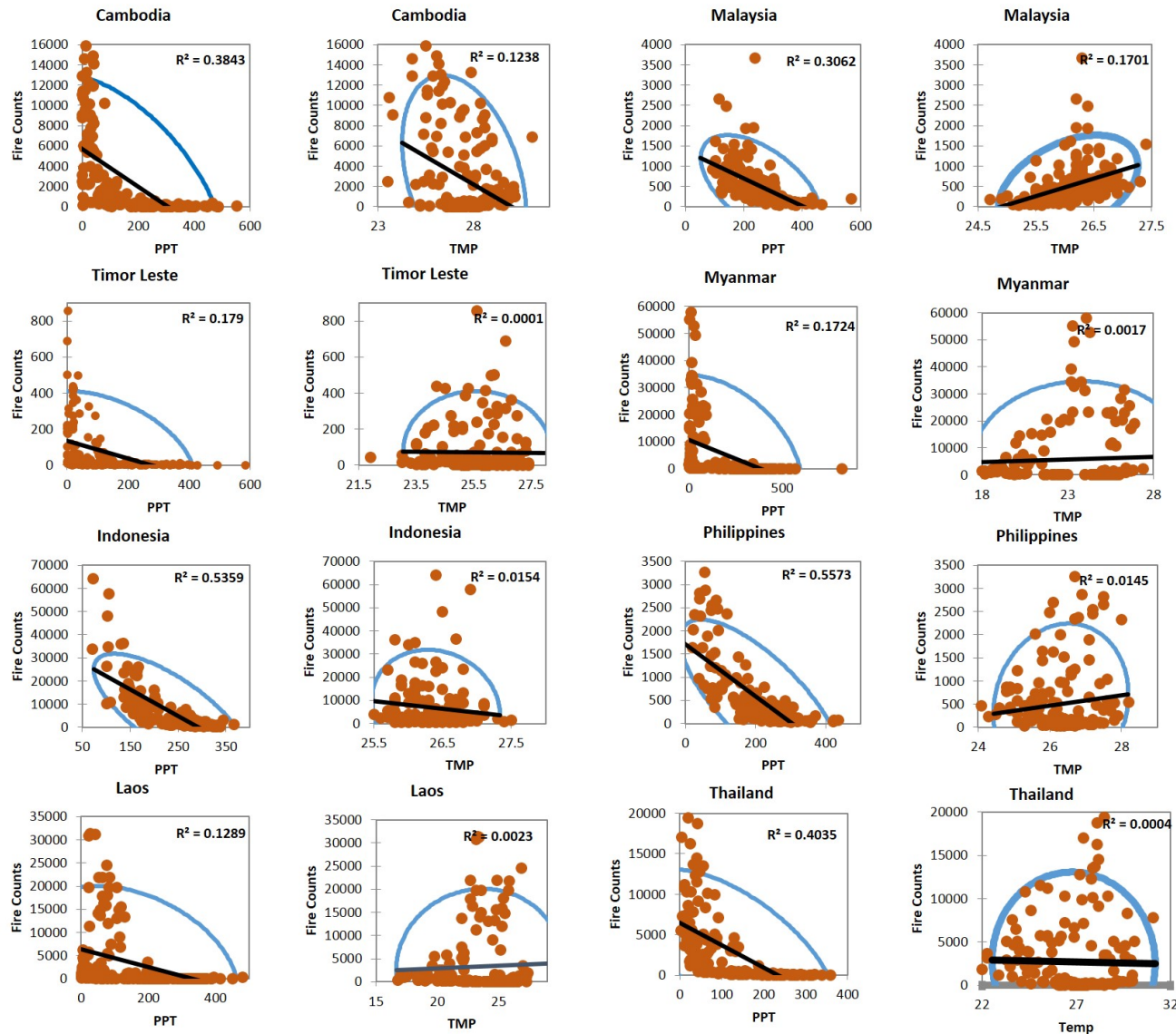
In the case of Indonesia, the positive fire anomalies found during 2006 and 2015 can be related to the El Nino induced droughts due to abnormal warming

# Precipitation – Temperature Controls of Fires



- Most of the countries in South Asia showed a negative slope with decrease in fire counts with an increase in precipitation, however, the  $r^2$  values were not strong except for India and Bhutan where precipitation could explain 30% and 16% of the variation in fires.
- Mean monthly temperature showed poor correlations and, in some cases, had no relationship as in Nepal or negative slope as in Pakistan.

# Trends Analyzed Using MODIS (2003-2016) and VIIRS (2012-2016)



- Relatively, in Southeast Asian countries, precipitation showed strong negative correlations with fire counts. For example, in the Philippines, 55% of variations in fires could be explained by the precipitation; similarly, 53% in Indonesia, 40% in Thailand, 41% in Vietnam, 38% percent in Cambodia, and 17% in Timor Leste
- Similar to South Asian countries, correlations between the fire counts and temperature were poor.

**Managing Fires will  
be the Key**