Dengue Case Count Predictions and Cost Benefit Analysis of Island-wide Wolbachia Deployment vs Population Level Vaccination with Dengvaxia®

Contents

Problem Statement

- Given Historical Dengue Case Counts and other Relevant Variables, what is the Predicted Number of Dengue Cases up to 16 Weeks into the Future?
- Is Island-wide Wolbachia Deployment Cost Effective when Compared to a Population Level Vaccination Programme using Dengvaxia®?

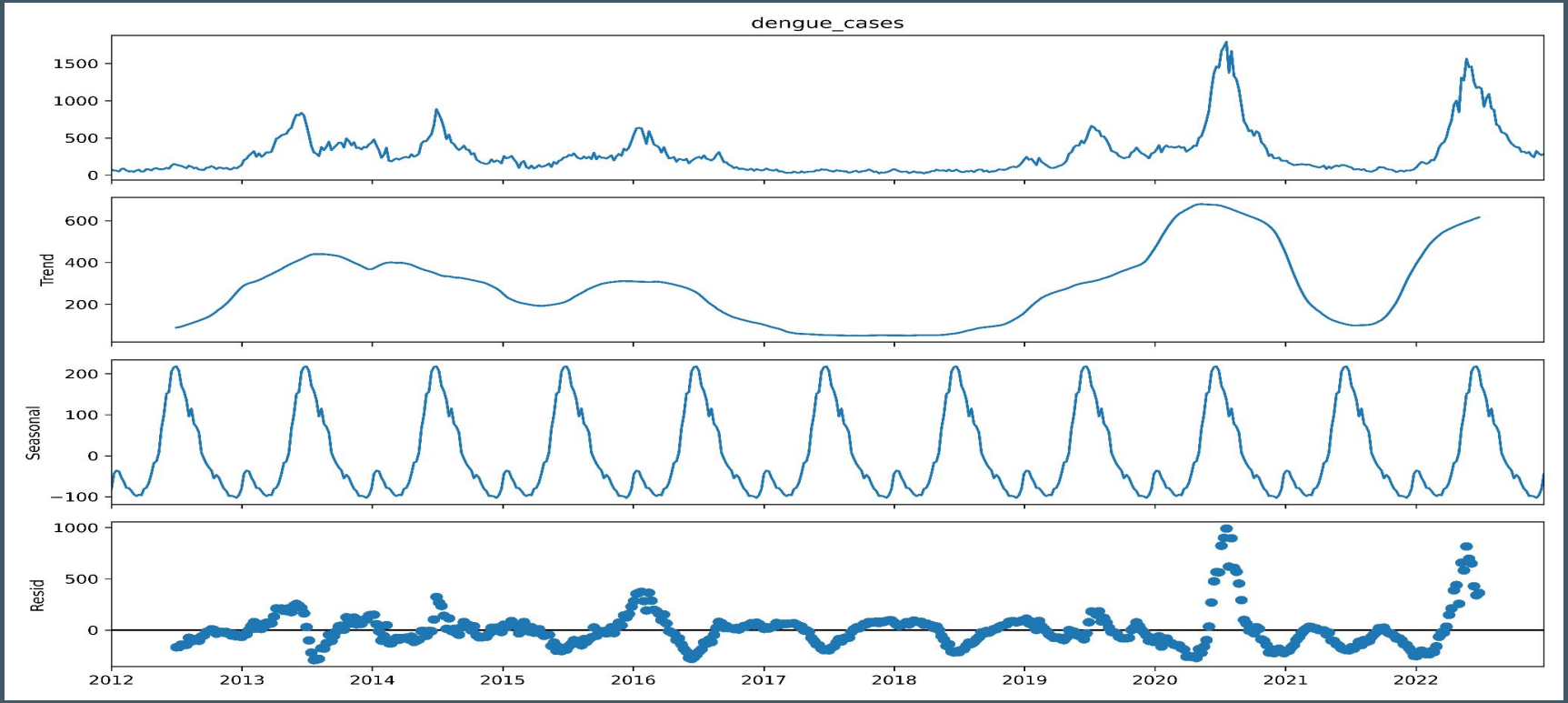
Highlight

- Prophet model has the best MAPE of 0.0867
- Island-wide deployment of Wolbachia is more cost effective than population level vaccination using Dengvaxia®
- With a cost per (DALY) averted at 60,039 USD vs 360,876 USD respectively

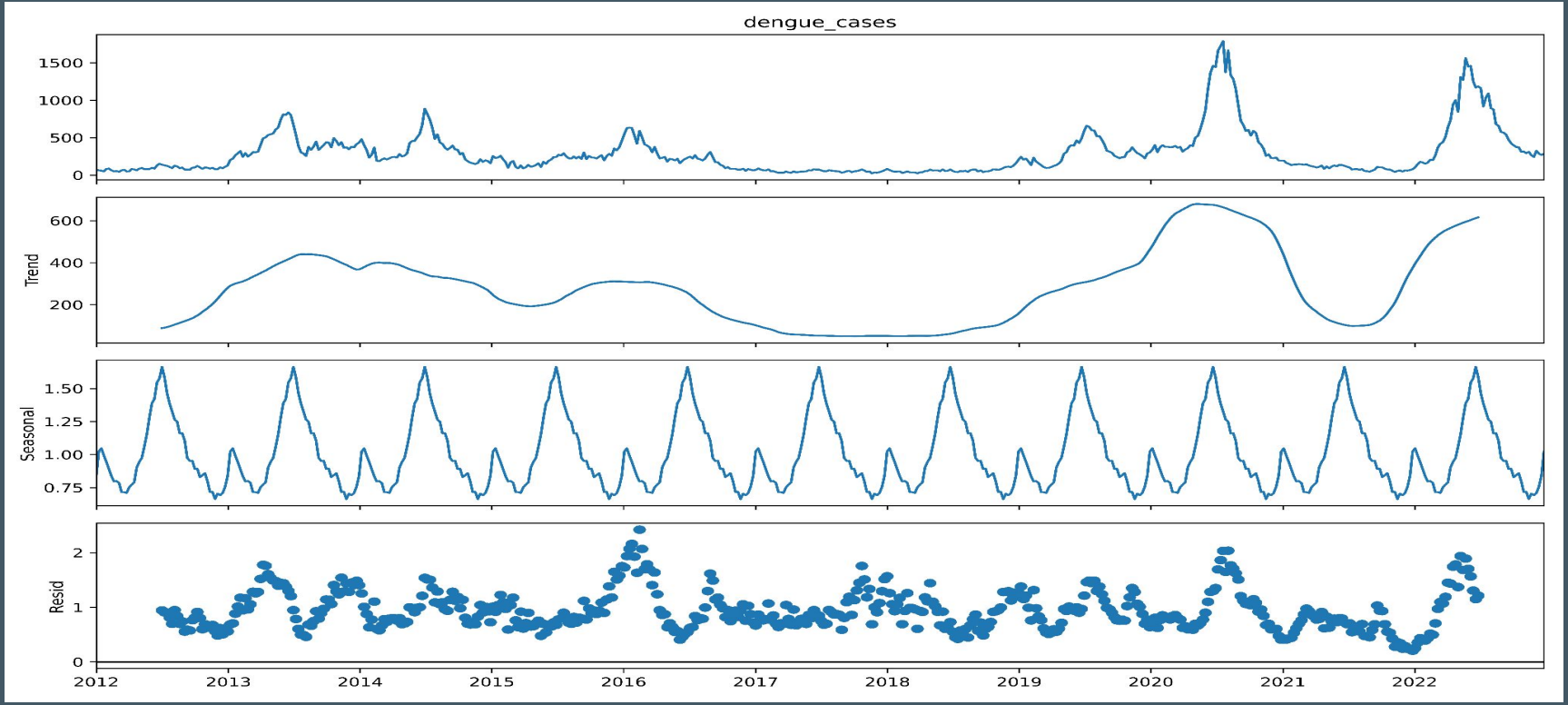
Datasets & Methodology

- Google Trends: Search Term (‘Dengue Fever’)
  - Monthly from Jan-2012 to Dec-2012
  - Converted (‘asfreq’) to weekly
  - Assumed constant throughout the month
- Total Population (Resident & Non-Resident)
  - Yearly from 2012 to 2022
  - Converted (‘asfreq’) to weekly
  - Assumed constant throughout the year
- Weather Data (Min temp, Max temp, Mean temp, Relative Humidity, Precipitation and Precipitation Cover)
  - Daily from 01-Jan-2012 to 31-Dec-2022
  - Resampled to weekly mean
- Dengue Fever Cases
  - Weekly From W1-Jan-2012 to W52-Dec-2022

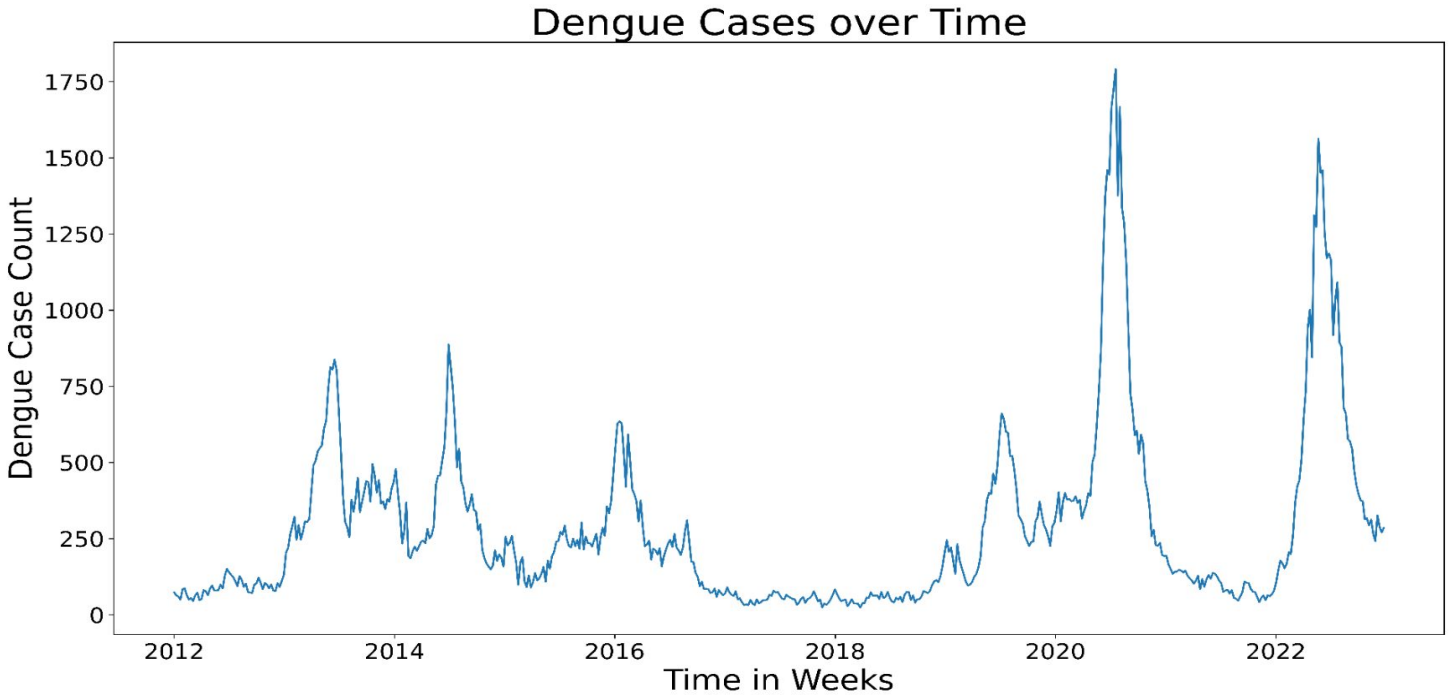
EDA - Additive Seasonal Decomposition



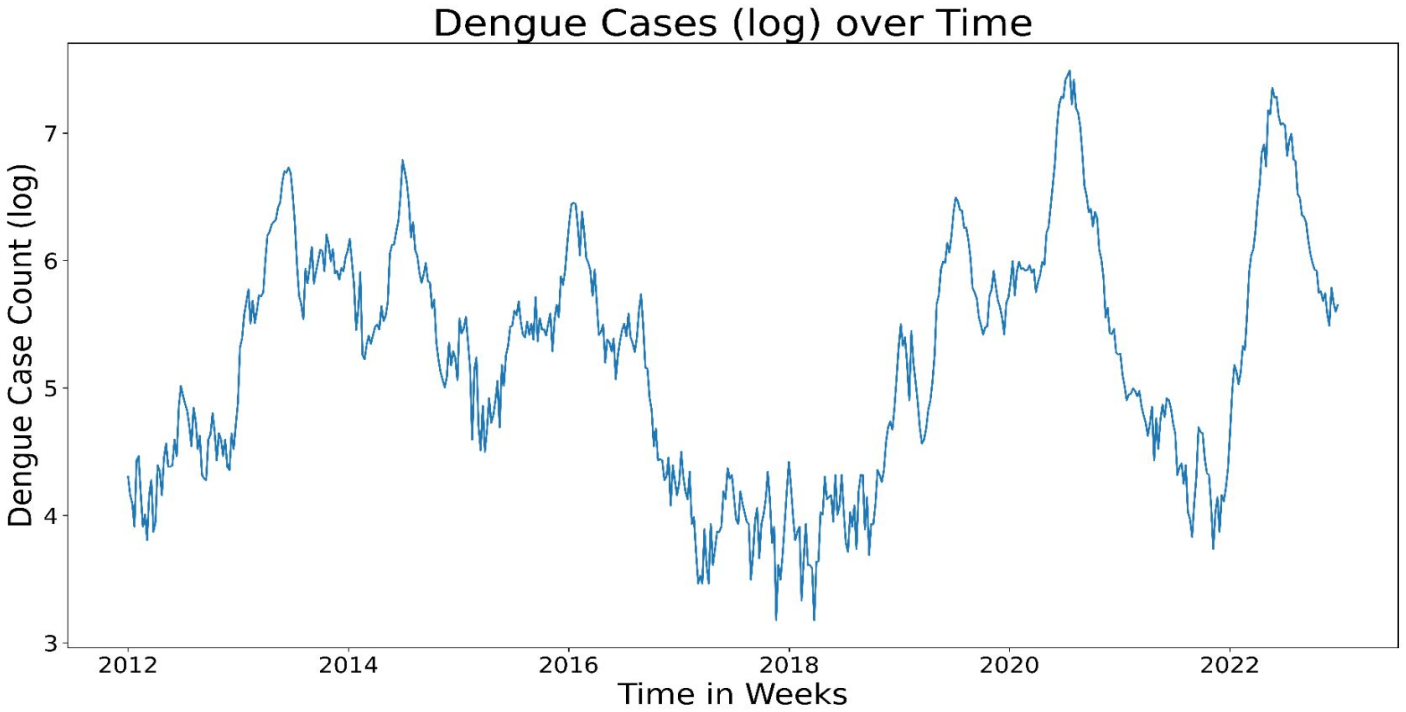
EDA - Multiplicative Seasonal Decomposition



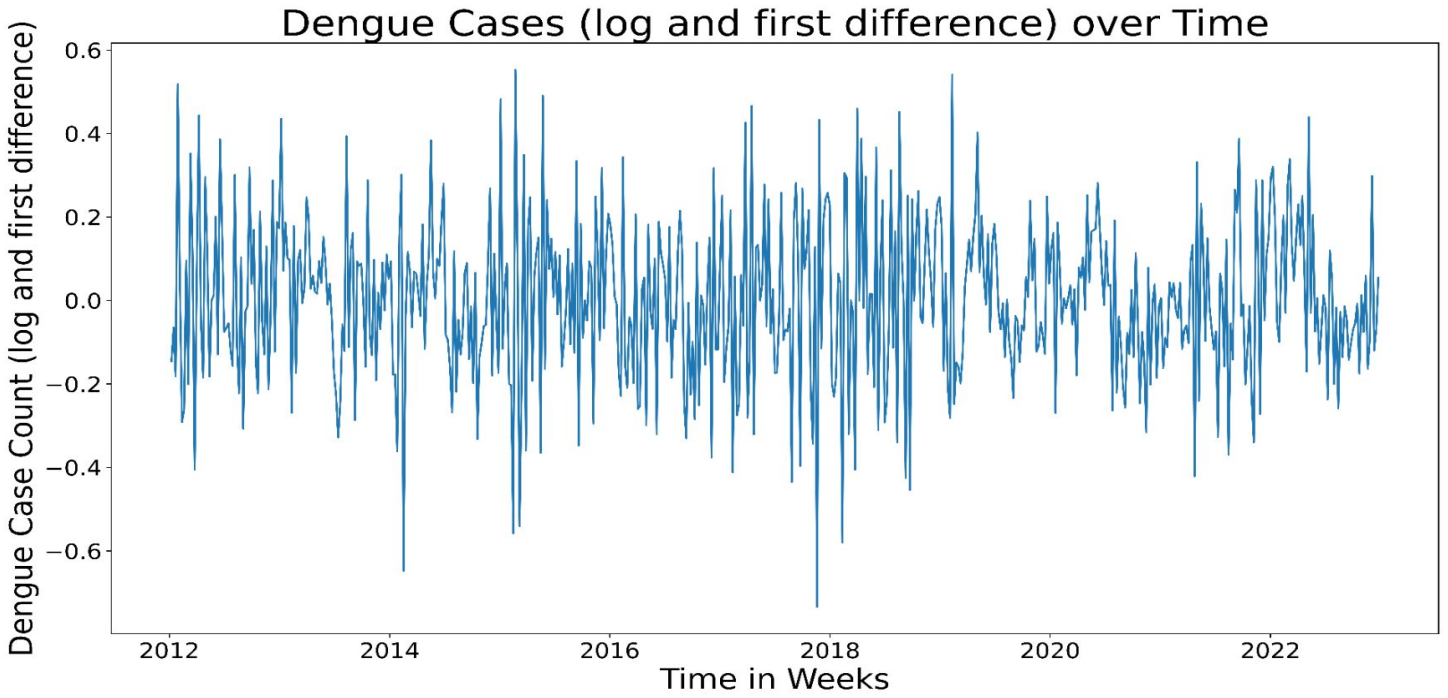
EDA - Dengue Cases



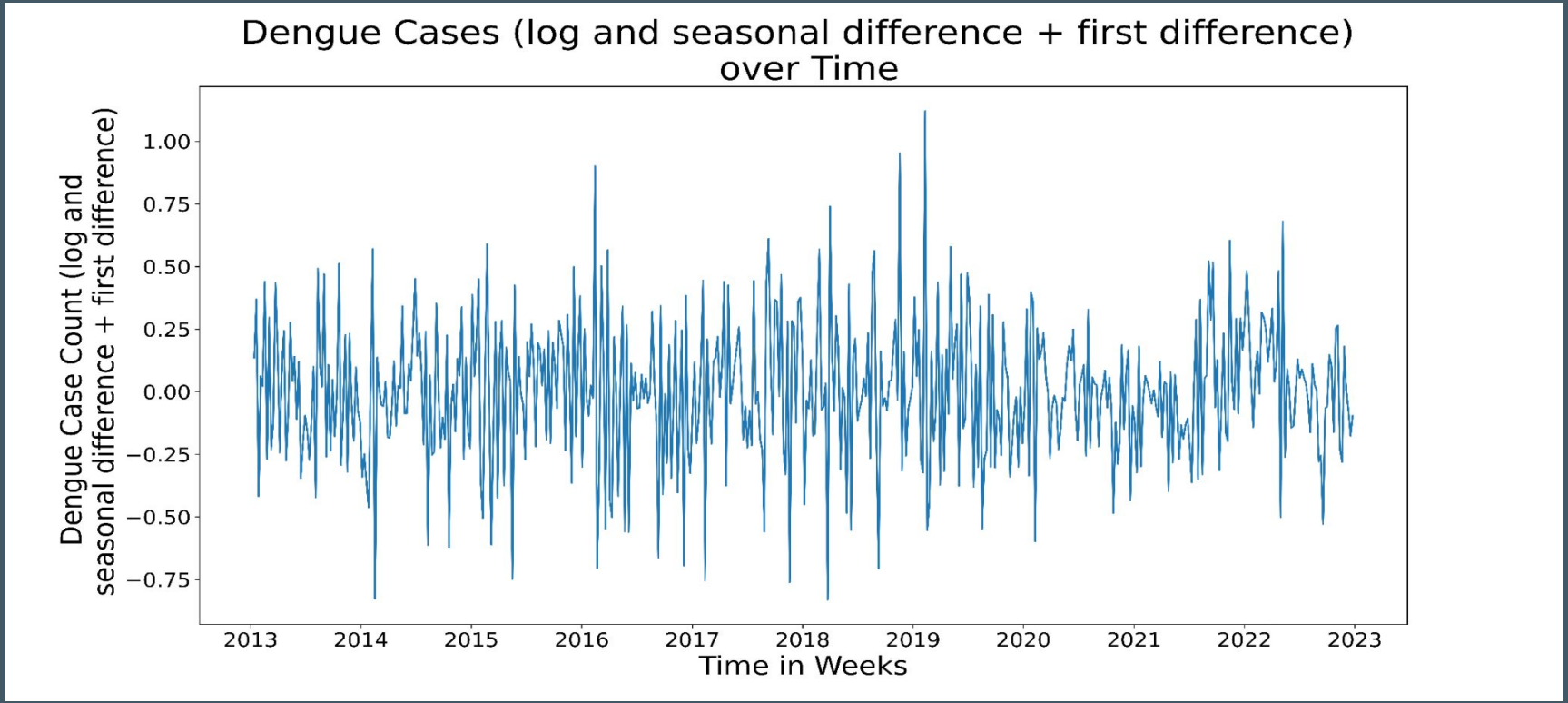
EDA - Dengue Cases (Natural Log)



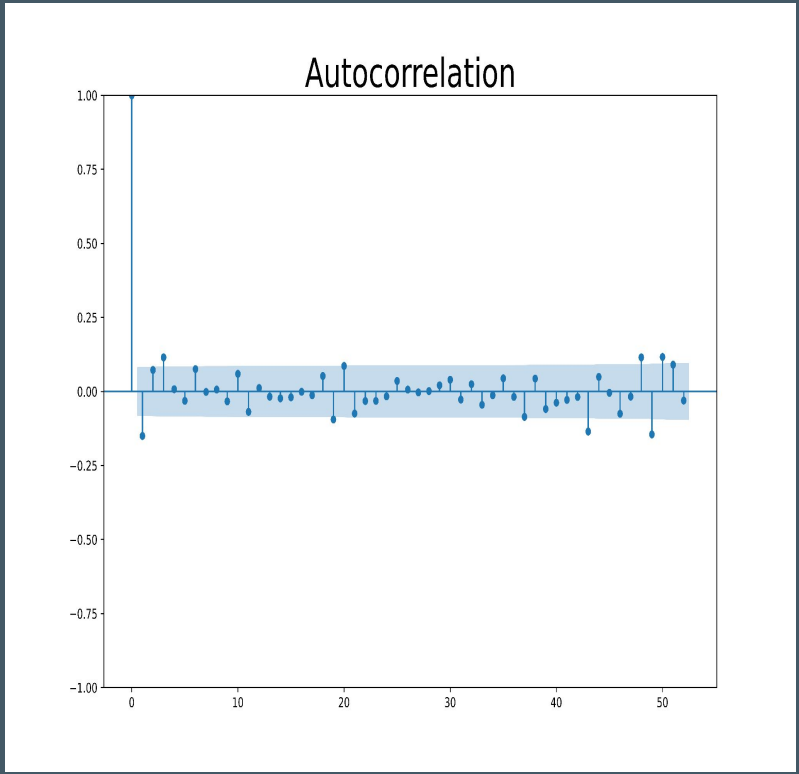
EDA - Dengue Cases (Log) with 1st Differencing

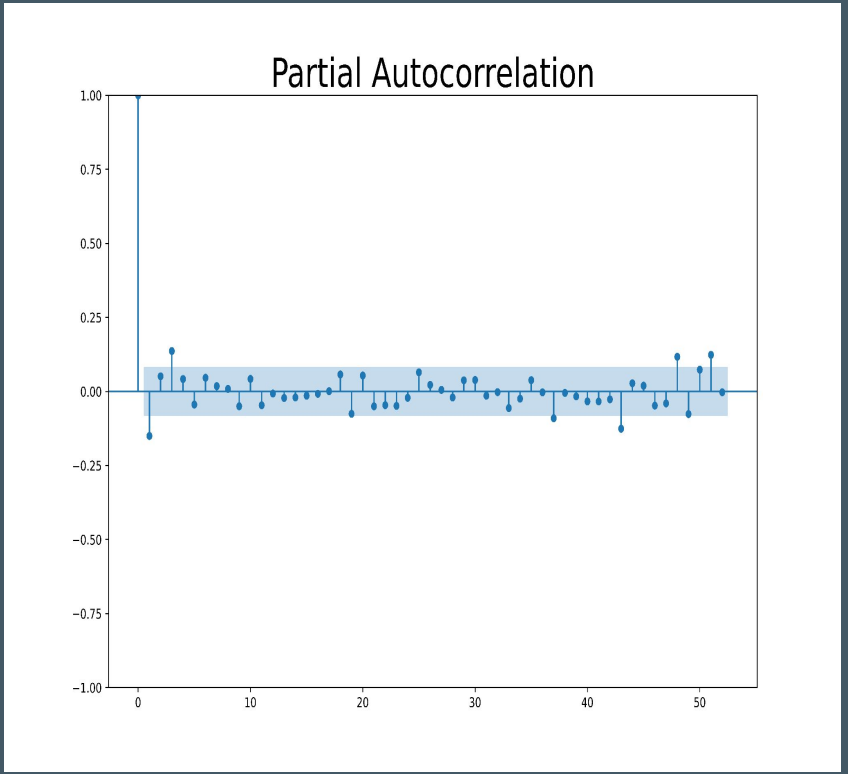


EDA - Dengue Cases (Log) with Seasonal and 1st Differencing



EDA - ACF & PACF with log 1st Differencing





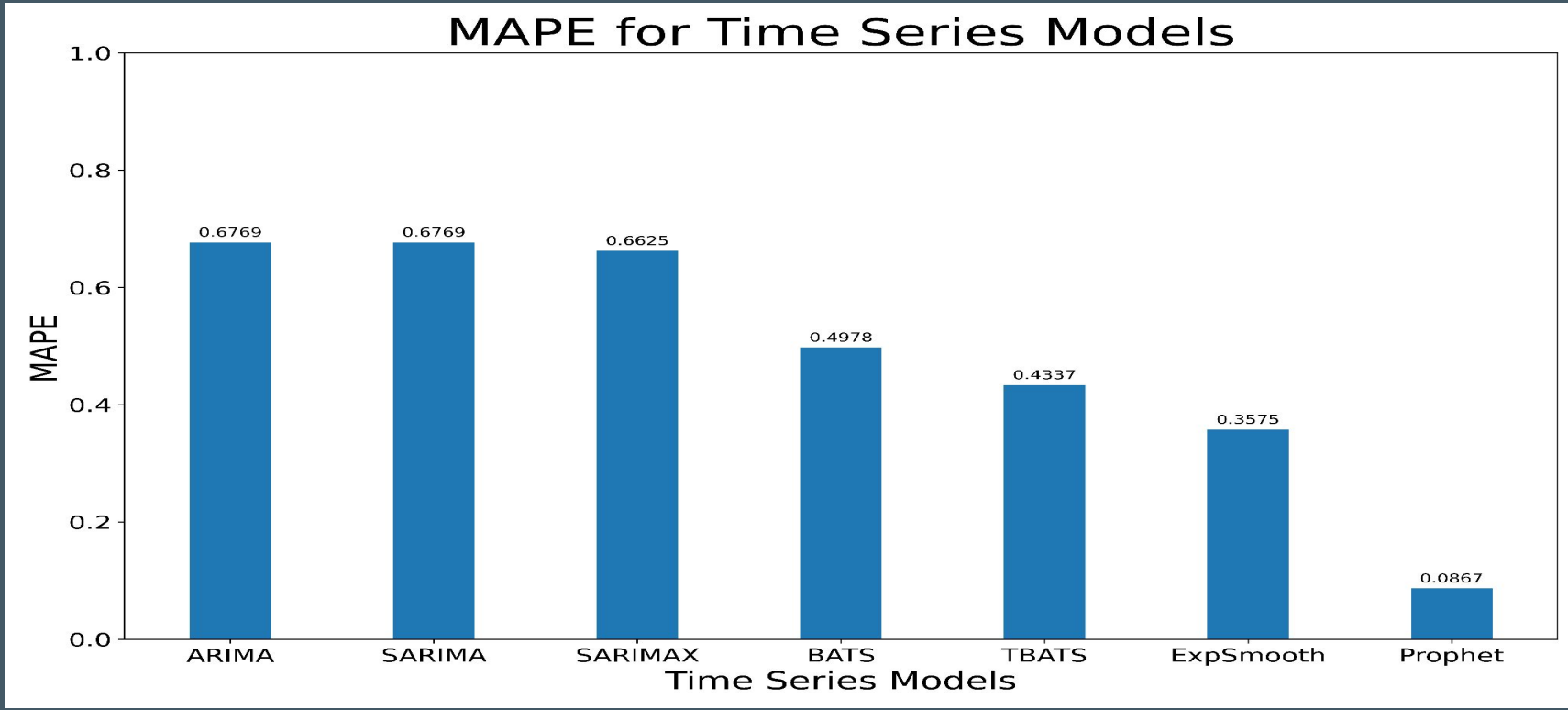
Statistical Results

Test	Value	Action
ADF Test	0.0037	P-value < 0.05, hence Stationary
KPSS Test	0.1000	P-value > 0.05, hence Non-Stationary
Seasonal Strength(F_S Test)	0.5678	F_S value < 0.64, hence no seasonal differencing required

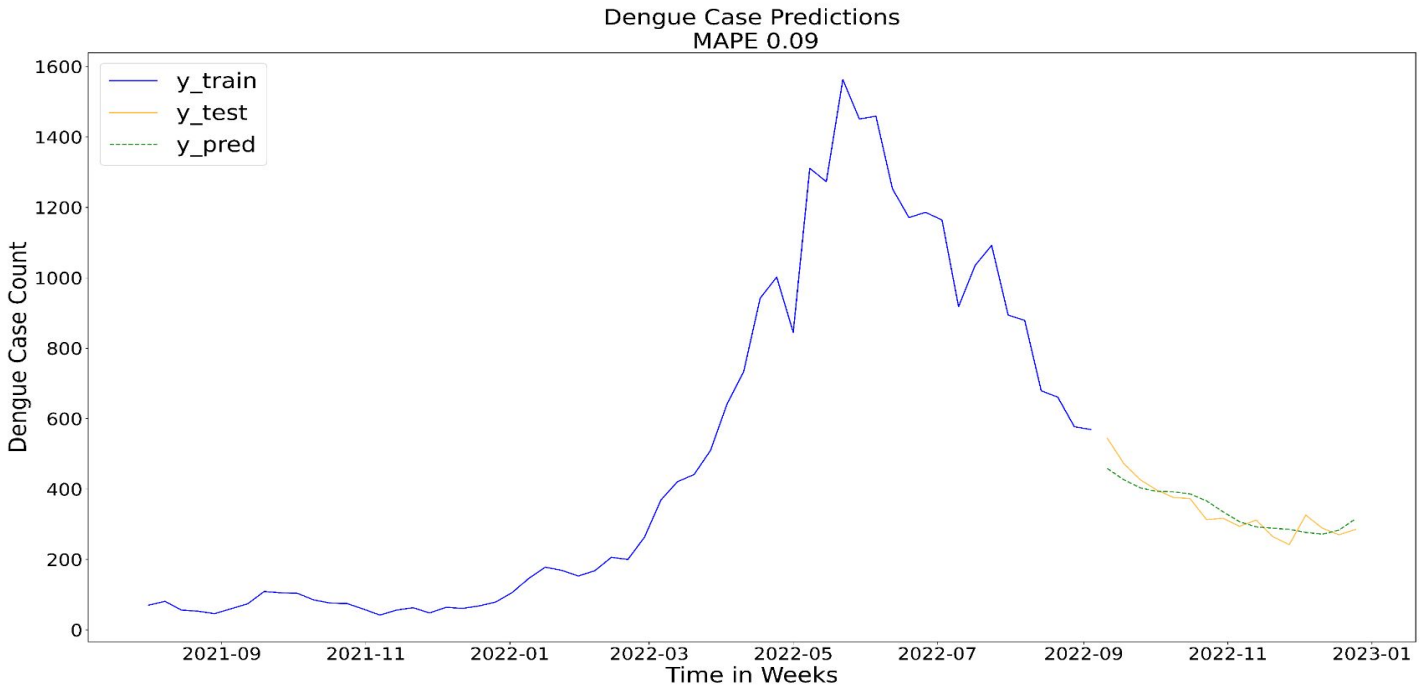
Modeling

1. ARIMA
2. SARIMA
3. SARIMAX
4. BATS & TBATS
5. Holt-Winters exponential smoothing
6. Prophet

Model MAPE Comparisons



Best Model Predictions



Cost Benefit Analysis

	Vietnam	Jakarta	Singapore
Cost of Wolbachia Deployment per year	17.13 Mn USD	13.73Mn USD	27.00Mn USD
Benefit of Wolbachia Deployment per year	15.95 Mn USD	27.90Mn USD	78.40Mn USD
Benefit Cost Ratio	1.86	4.06	2.90
Cost per disability-adjusted life year (DALY) averted	1,048 USD	1,100 USD	60,039 USD
0.5 x GDP per Capita	1,760 USD	4,487 USD	30,364 USD

Cost Benefit Analysis (continued)

Population (estimated from 2022)	5,637,022
3 Doses of Dengvaxia® at Raffles Medical	391 USD
Cost per year to vaccinate Singapore at a population level assuming vaccine confers immunity for 10 years at 80% efficacy	220,711,959 USD
Disability-adjusted life year (DALY) averted due to vaccination	611.6 DALYs
Cost per disability-adjusted life year (DALY) averted	360,876 USD
3 x GNI per capita	166,255 USD
Cost per disability-adjusted life year (DALY) averted using Wolbachia	60,039 USD

Conclusion

- Again... as shown earlier...
- Prophet model has the best MAPE of 0.0867
- Island-wide deployment of Wolbachia is more cost effective than population level vaccination using Dengvaxia®
- With a cost per (DALY) averted at 60,039 USD vs 360,876 USD respectively

Recommendations

- Use 16 week predictions to inform timing of annual dengue awareness and control campaign and specific site Wolbachia deployment
- Progressively rollout Wolbachia deployment in view of better cost effectiveness compared to population level vaccination
- Vaccination may become cost effective depending on availability of newer vaccines