Towards an Integrated Surveillance for Lassa fever: Evidence from the Predictive Modeling of Lassa fever Incidence in Nigeria.

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Outline

# Dataset: Overview

Climate and Case Count Data **Data Overview:**

* Weekly Lassa fever case counts for Bauchi, Edo, and Ondo states (Nigeria)
* Time period: January 2018 – December 2024
* Corresponding weekly climate data collected over the same period

**Climate Variables (per week):**

* Minimum Temperature
* Maximum Temperature
* Average Temperature
* Precipitation
* Precipitation Coverage
* Average Humidity

Dataset: Plots image Observations - The data appears to exhibit characteristics of a stationary stochastic process.

Dataset **Data - Per State**

image

Data Split and Training Plan

**Data Split:**

* **Train:** 2018–2022 (per-state data)
* **Test:** 2023, 2024 (with prior context)

**Modeling Strategies:**

* LSTM
* MAR

**Experiment Variants:**

* **State-wise:** One model per state
  + 7D input → 7D output (climate + cases)
  + 7D input → 1D output ((climate , previous cases)→ cases)
* **Unified:** One model across all states

# Modeling Choices

## Non-linear: Long short-term memory recurrent neural network (LSTM)

Non-linear Model: Long Short-Term Memory (LSTM)

**Prediction Variants:**

* **Single-output (Lassa case count only):**
* **Multivariate output (case count + climate variables):**

**Where:**

LSTM Model: Training Loss Function **Given:** Training dataset (time index omitted for clarity)

**Loss Function:**

**Where:**

* : LSTM output for all targets
* : LSTM prediction of Lassa fever cases (scalar)
* : LSTM prediction of climate variables (multi-output case)
* : First-order difference (temporal smoothness)
* : Trainable LSTM parameters
* : Smoothness regularization weight (e.g., 0.3)

### One Model Per State - Climate + Cases Preditions

LSTM (Per-State Model) — Bauchi: Training Loss **Variant:** All Variables | One Model per State

**Training Loss Curve**

image

LSTM (Per-State Model) — Bauchi: Predictions **Variant:** All Variables | One Model per State

**Training and Test Predictions**

image

LSTM (Per-State Model) — Edo: Training Loss **Variant:** All Variables | One Model per State

**Training Loss Curve**

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LSTM (Per-State Model) — Edo: Predictions **Variant:** All Variables | One Model per State

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LSTM (Per-State Model) — Ondo: Training Loss **Variant:** All Variables | One Model per State

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### One Model Per State - Cases Only Preditions

LSTM (Per-State, One-Output) — Bauchi: Training Loss **Variant:** One Output | One Model per State

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### LSTM Model Per State Model Comparison

Per-State Model Comparison: All vs One – Bauchi Predictions **All vs One – Output: Bauchi Predictions**

image

Per-State Model Comparison: All vs One – Edo Predictions **All vs One – Output: Edo Predictions**

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Per-State Model Comparison: All vs One – Ondo Predictions **All vs One – Output: Ondo Predictions**

image

## Linear: Mutivariate Autoregressive Model (Mar)

MAR(4) Model for Climate and Lassa Fever Cases Let be the multivariate time series defined by:

The MAR(4) model is given by:

**Lassa fever dynamics** (7th component):

MAR(4) Model — One-Output Variant In the one-output version of the MAR(4) model, only Lassa fever cases are predicted based on the past values of climate variables:

**Where:**

* : vector of climate variables and the number of cases at time
* : autoregressive weight matrices
* : predicted number of Lassa fever cases at time

Training Objective

Let be the dataset, and let denote the model’s prediction. To reduce clutter, we omit the explicit time index .

**Training Loss Function:**

**Where:**

* : model coefficient matrices (e.g., MAR parameters)
* : regularization term penalizing negative outputs, enforcing for
* : regularization hyperparameter

### All Variable: One Mar Model Per State

MAR (Per-State Model) — Bauchi: Training Loss **Variant:** All Variables | One Mar Model per State

**Training Loss Curve**

image

MAR (Per-State Model) — Bauchi: Predictions **Variant:** All Variables | One MAR Model per State

**Training and Test Predictions**

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MAR (Per-State Model) — Edo: Training Loss **Variant:** All Variables | One MAR Model per State

**Training Loss Curve**

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MAR (Per-State Model) — Edo: Predictions **Variant:** All Variables | One MAR Model per State

**Training and Test Predictions**

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LSTM (Per-State Model) — Ondo: Training Loss **Variant:** All Variables | One Model per State

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MAR (Per-State Model) — Ondo: Predictions **Variant:** All Variables | One MAR Model per State

**Training and Test Predictions**

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### One Mar Model Per State - Cases Only Preditions

Mar (Per-State, One-Output) — Bauchi: Training Loss **Variant:** One Output | One Model per State

**Training Loss Curve**

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Mar (Per-State, One-Output) — Bauchi: Predictions **Variant:** One Output | One Mar Model per State

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### Mar Model Per State Model Comparison

Per-State Model Comparison: All vs One – Bauchi Predictions **All vs One – Output: Bauchi Predictions**

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Per-State Model Comparison: All vs One – Edo Predictions **All vs One – Output: Edo Predictions**

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Per-State Model Comparison: All vs One – Ondo Predictions **All vs One – Output: Ondo Predictions**

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