Poverty Estimation using Earth Observation Data for Inter-survey Periods of Bangladesh

Project Objectives

- To strengthen the ability of national statistical systems to produce better and more timely data to inform policies and monitor progress towards achieving the SDGs
- For Bangladesh--focused on country's priorities: *SDG indicator 1.2.1*
- Leveraging data innovations and better integration of geospatial and statistical operations

Project Coordination /Implementation

Under the technical supervision of the **SDG Coordinator's Office**, the **Bangladesh Bureau of Statistics** implemented the project with support from **A2i & UN Data Group**

UN Resident Coordinator's Office, Bangladesh coordinated with the project partners and supported its implementation

Key Initiatives

- Inception workshop held in 2020
- In April 2021, a Working Team was formed under the leadership of the HIES Project Director, which was composed of 15 members from BBS, Bangladesh Bank, Finance Division, General Economics Division, BTRC, SID, A2i, and RCO.
- First meeting of the Poverty Estimation Working team in September
- Two Resident Workshops organized in October December 2021 with Int'l and National technical experts –
- SDG Coordinator and DG, BBS inaugurated both workshops and
- **30 officials including 15+ BBS officials participated**

Capacity development Training workshops

Area covered

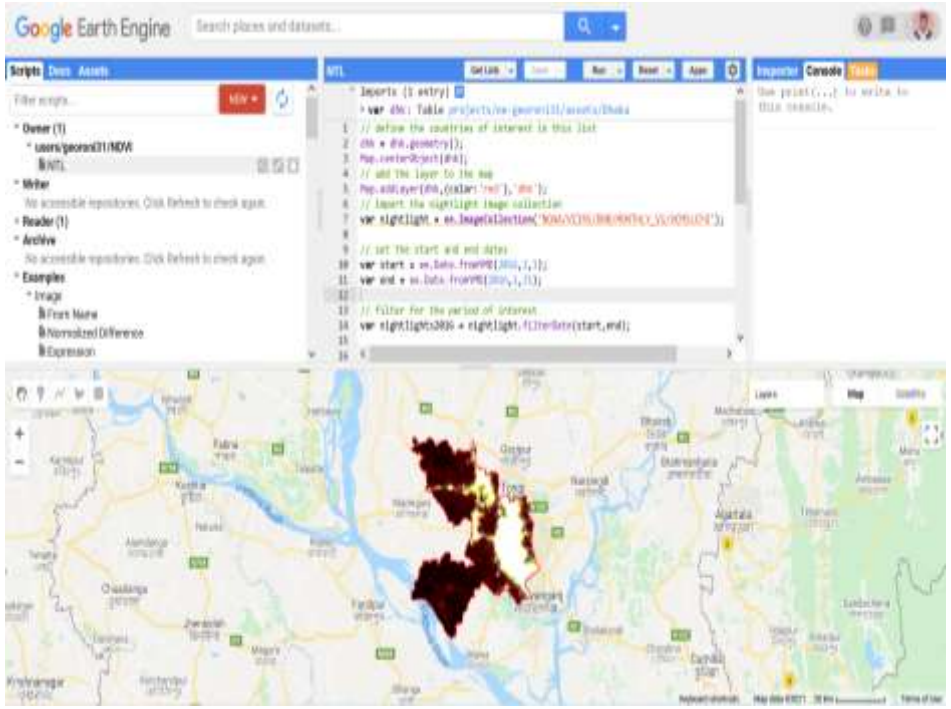
- Big Data for Poverty Estimation, Non-conventional data,
- Country Practices of Poverty Mapping, Mobile data for poverty estimate
- Hands on training on Model

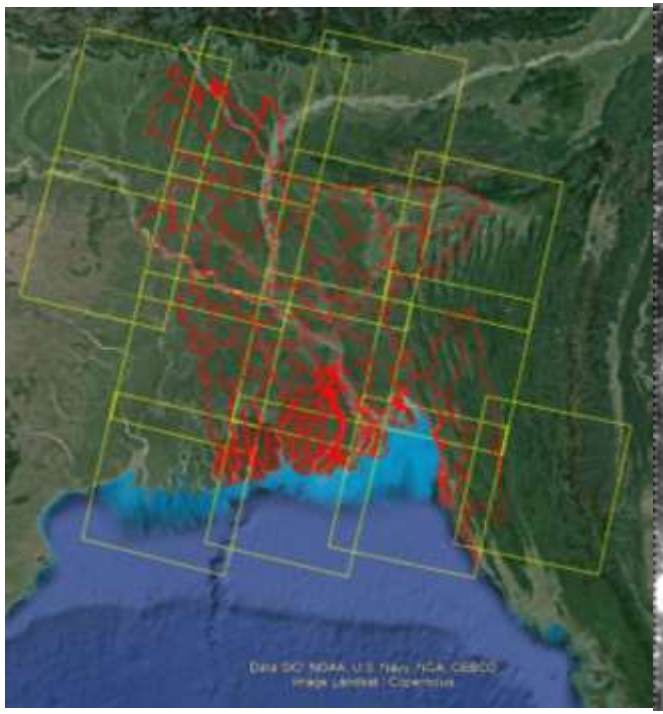
Platforms Used

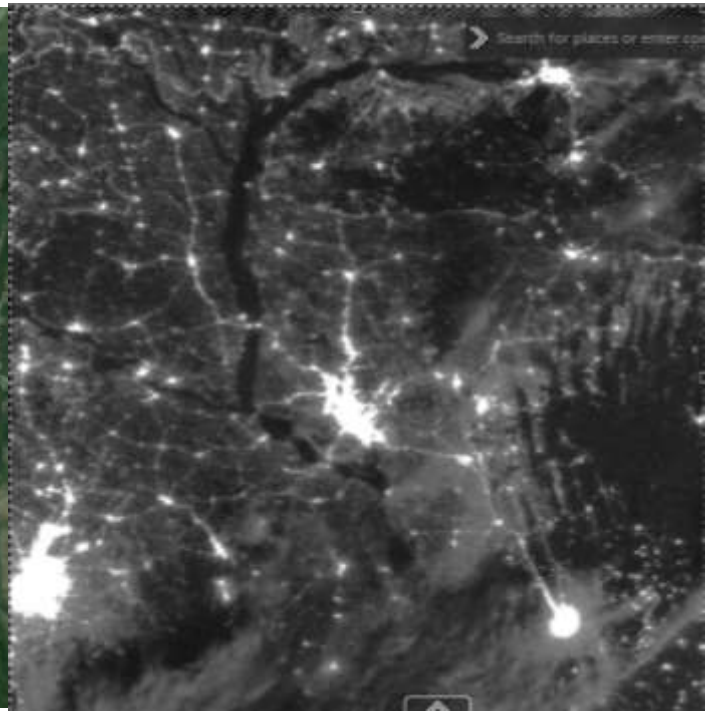
- Google Earth Engine (GEE),
- Geographic Information System (GIS) and
- Programming language R.

Data (non-conventional) Used during 1st Workshop

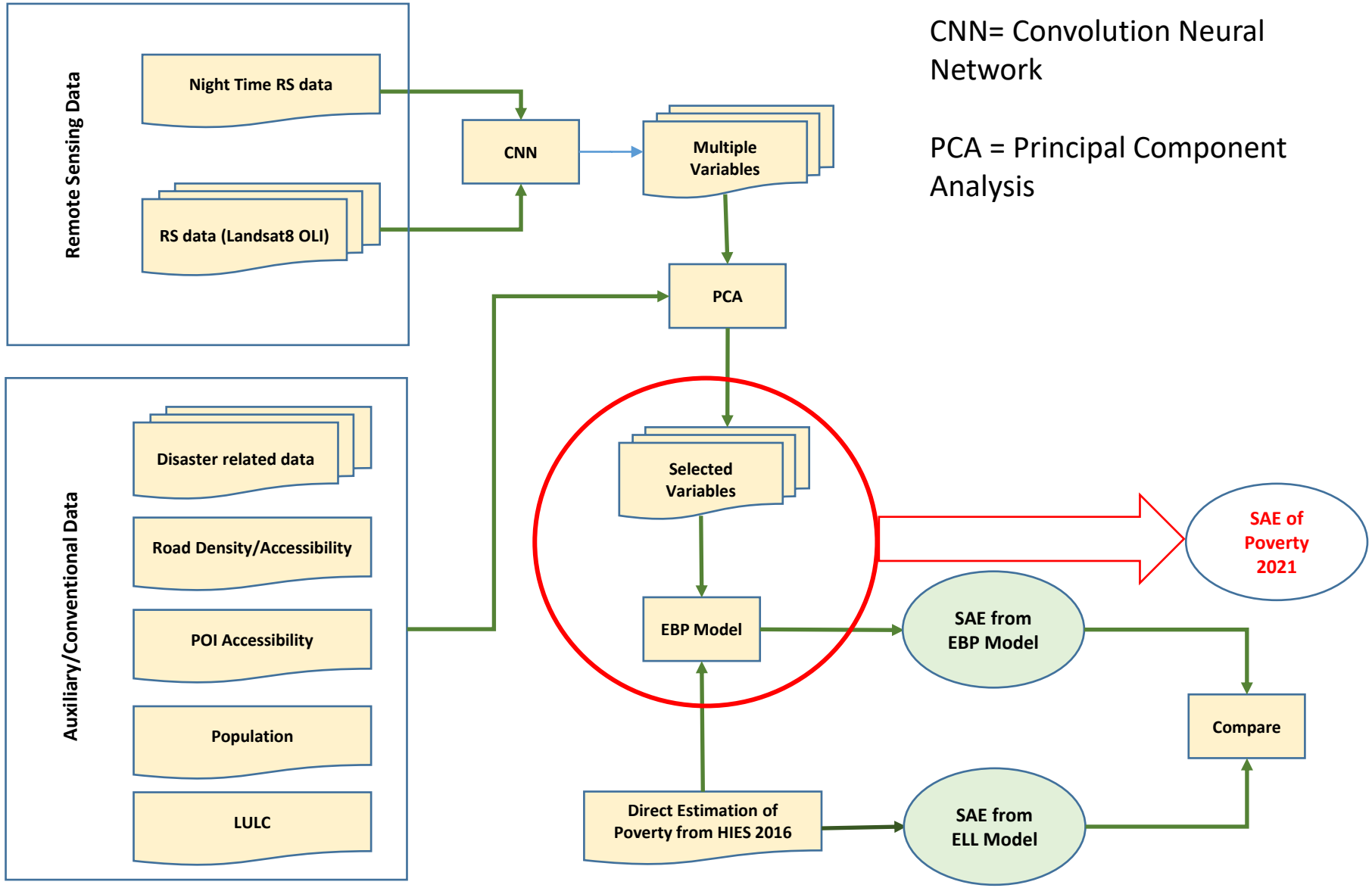
Data Type	Description	Platforms
Raster	Night Time Light (NTL) data	Google Earth Engine
Vector	Road Network, Educational Institutions, etc.	ArcMap
Tabular	Agriculture statistics 2016	Programming language R







Proposed Model shared
with Prof Nikos Tzavidis, University of Southampton



CNN= Convolution Neural Network

PCA = Principal Component Analysis

Key challenges:

Survey of Bangladesh data was not available for free

Mobile operator’s data was not available for 2016

Dept of Disaster Management data not regularly updated

Data resolution did not match each other

Poverty Mapping Methodology (Country Practice)

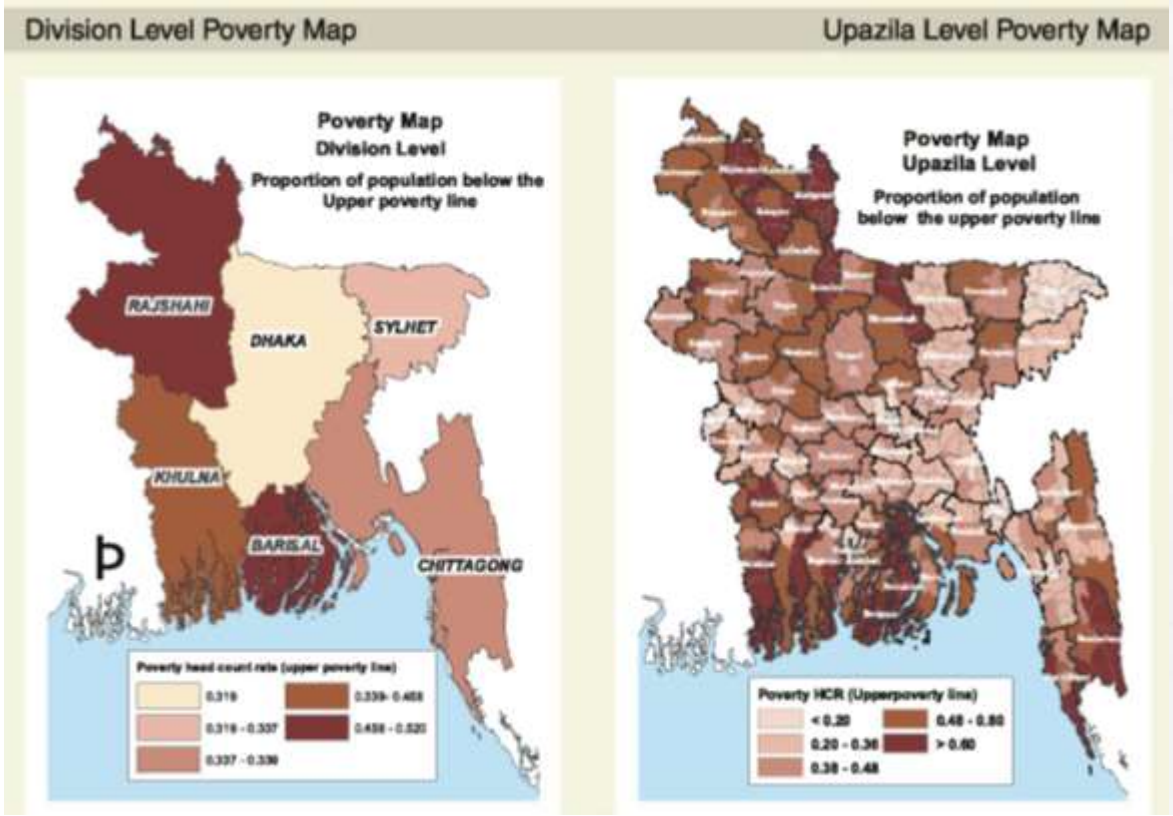
Poverty mapping methodology is the ELL method developed by Elbers et al. using Small Area Estimation (SAE) techniques. The ELL method, which has been widely tested and validated around the world, takes advantage of the strengths of both sources of data used in such exercises.

Primary data sources used in the Small Area Estimation method:

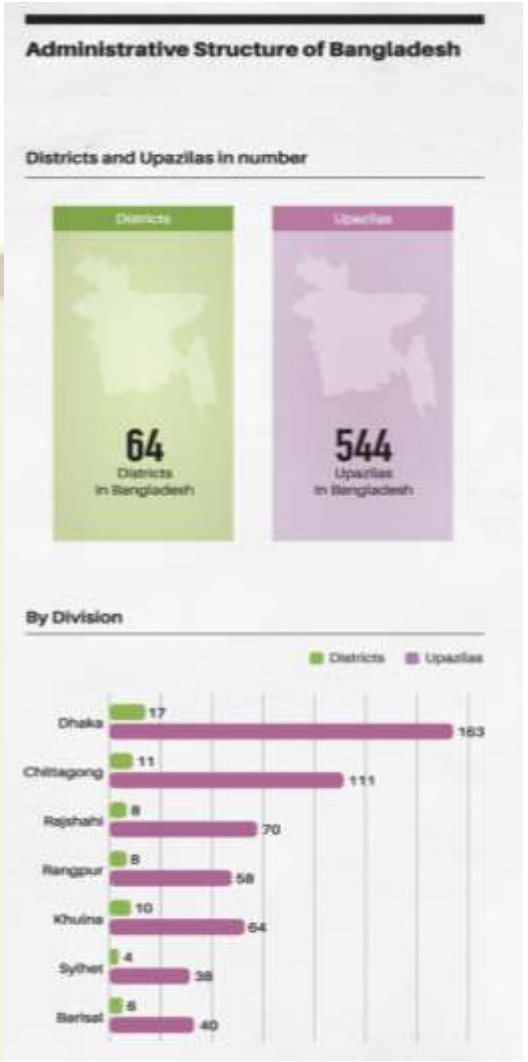
a) Population and Housing Census

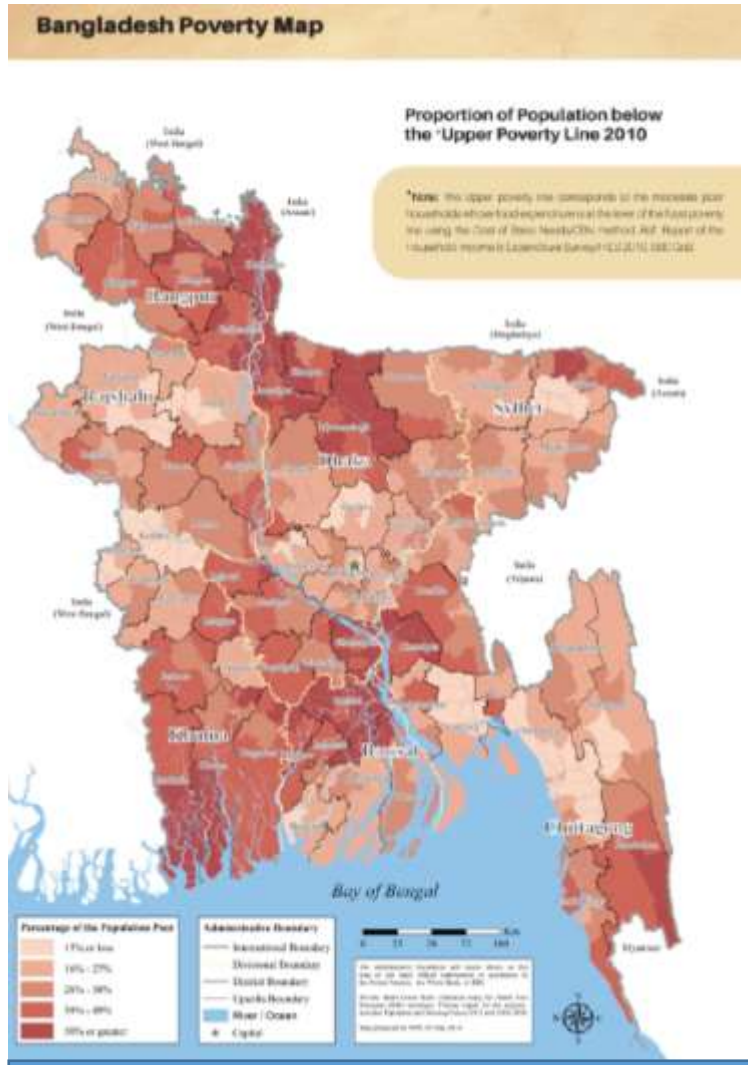
b) Household Income and Expenditure Survey

Poverty Map 2005



Poverty Map 2010





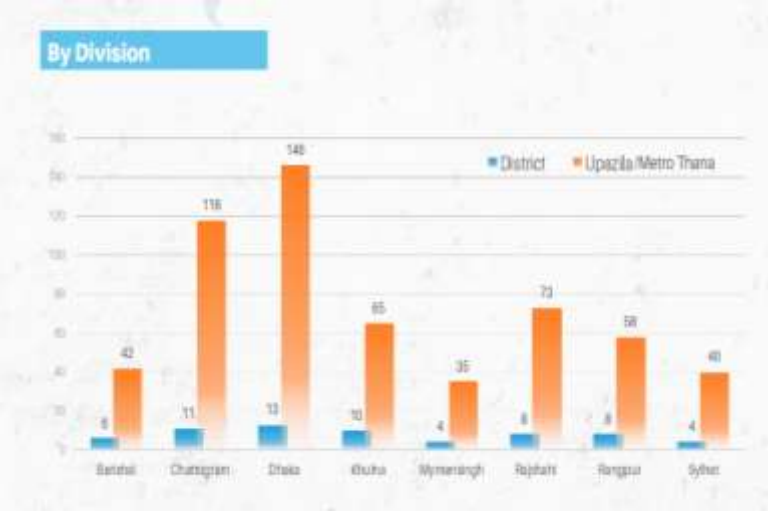
Source: BBS

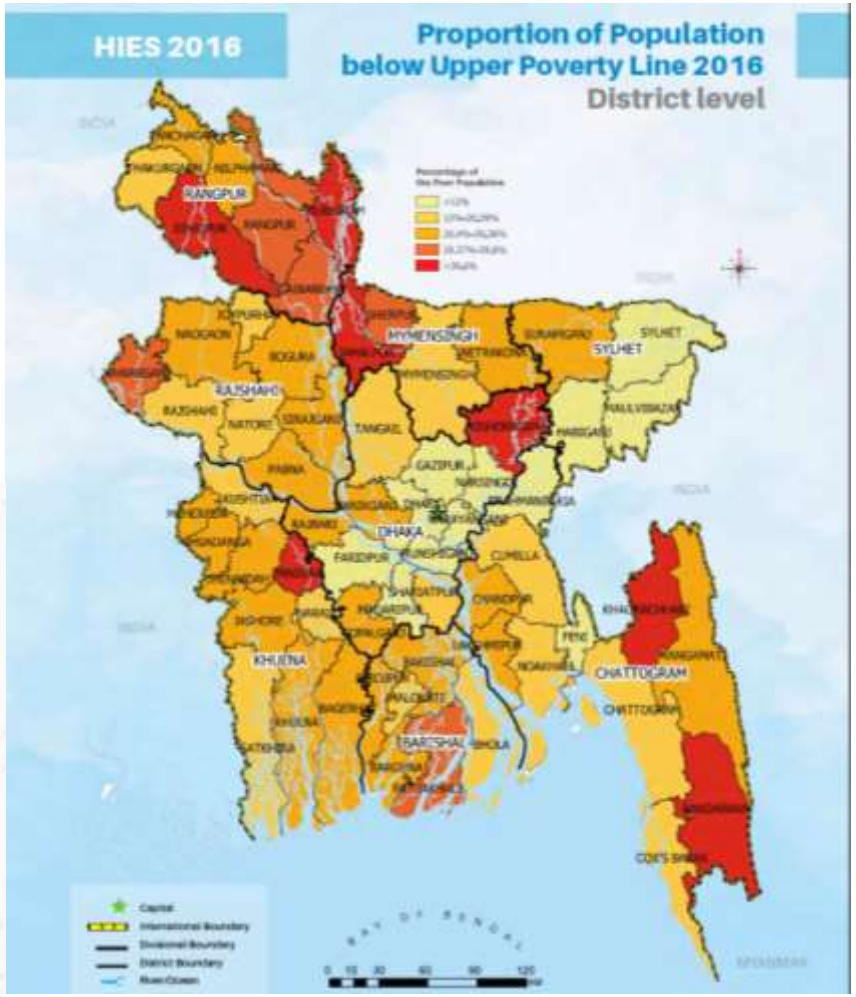
Poverty maps (2016)

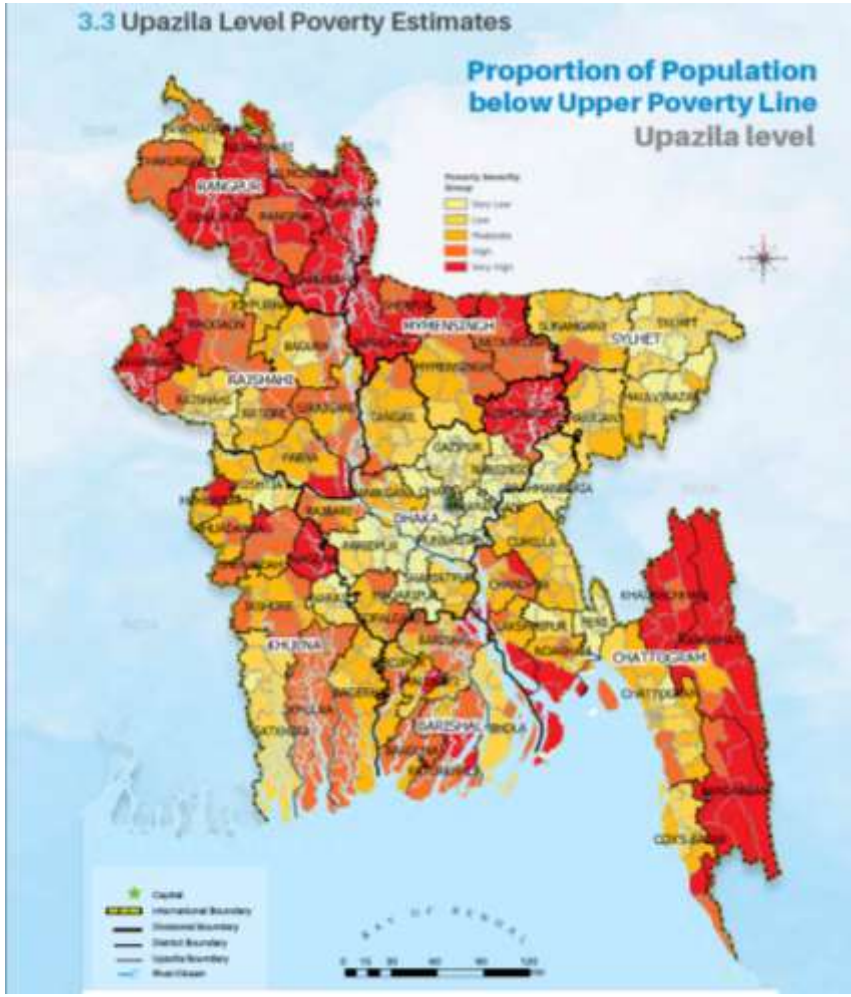
Division (8)

Districts (64)

Upazilas (577)







Source: BBS

Available Methods using Satellite Images

- **World Bank**
- Poverty from Space: Using High-Resolution Satellite Imagery for Estimating Economic Well-Being – **Sri Lanka**

- **ADB**
- Mapping the spatial distribution of Poverty using Satellite Imagery in **Thailand**

- **Research Works**
  - Using publicly available satellite imagery and deep learning to understand economic well-being in Africa;
  - Stanford scientists combine satellite data, and machine learning to map poverty;
  - Satellite images can map poverty: New machine learning method uses daytime photos to more accurately --------- predict poverty

What's New in this Method

No traditional data (such as Census, Survey, etc.)

Uses of Satellite Images (Open data source)

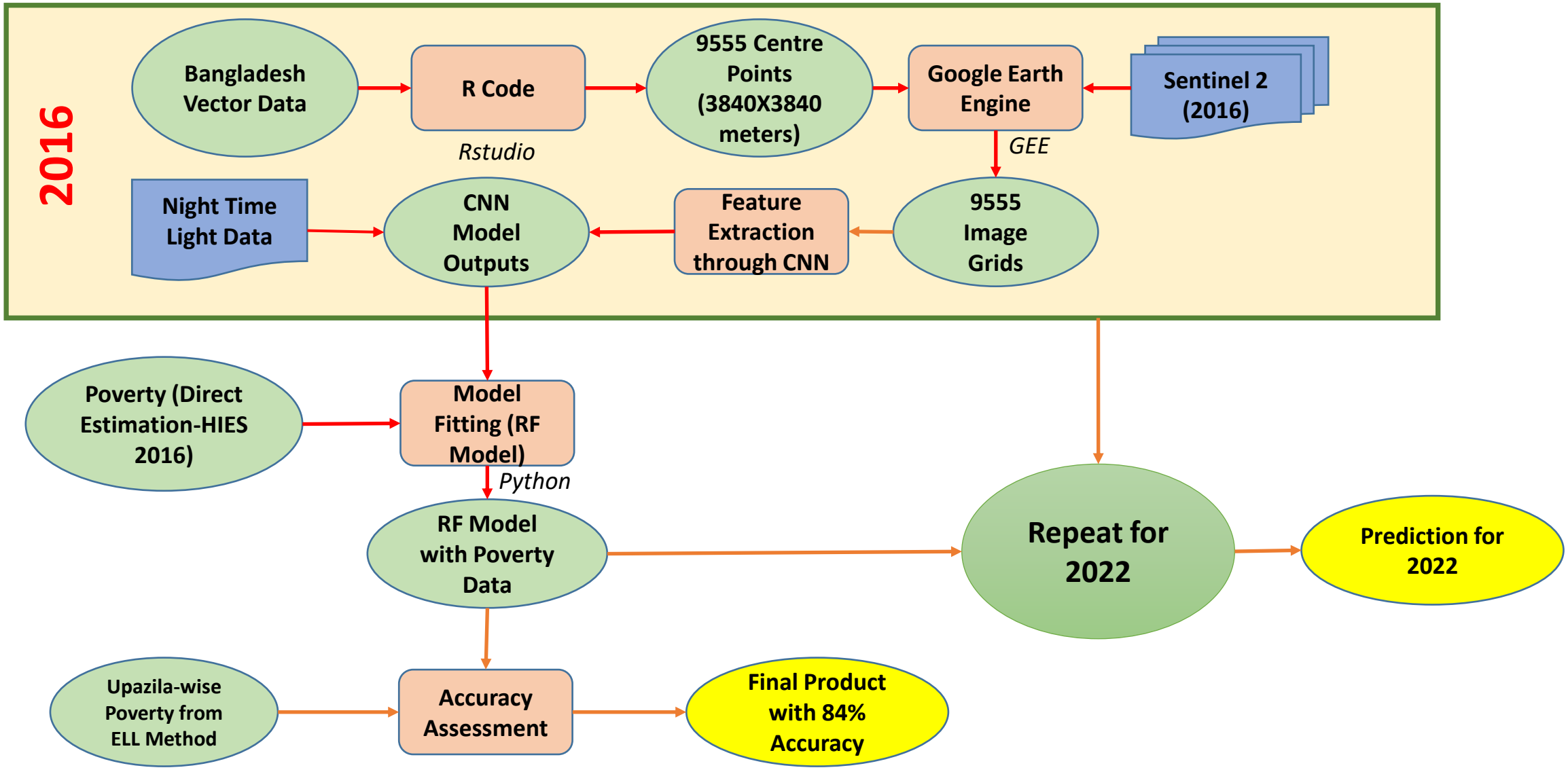
Uses of Night Time Light Data (Development Indicators)

Quick Calculation with High Accuracy

High-frequency result availability

Need very high computational cost (e.g. High configured Server, High bandwidth Internet connection)

Methodology



Input Variables

Satellite Image

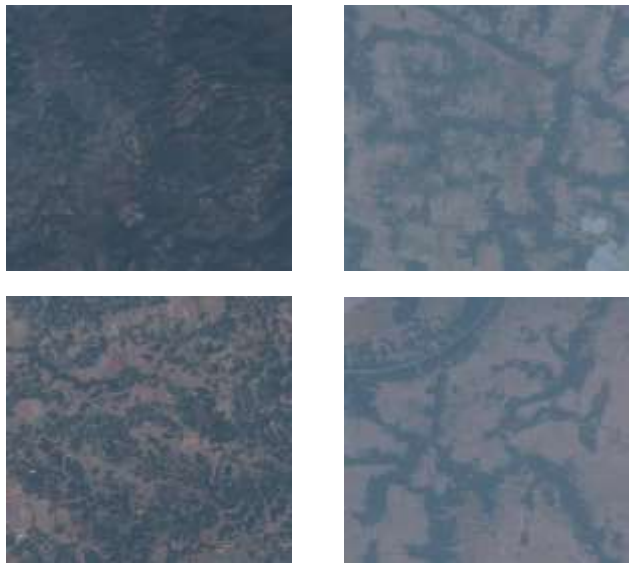
Sentinel (2016)

10-meter Spatial Resolution

Grid

Bangladesh Covers **9555** Grid

Each Grid Size is **3840 X 3840** meters



Night Time Light Data

Field 1: VIIRS SDR or Product that made the composite "SVDNB"
Field 2: satellite name "npp"
Field 3: date range "20160101-20161231 “
Field 4: ROI "75N060E"
Field 5: config short name "vcmcfg“
Field 6: version "v10" is version 1.0
Field 7: creation date 201807311200: avg_rade9

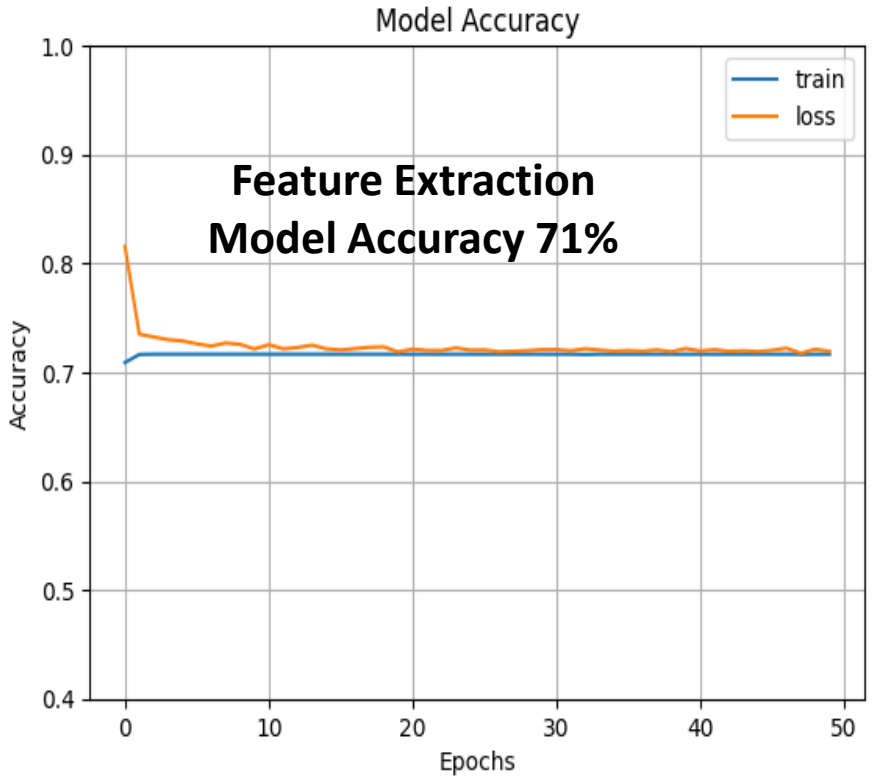
Layer (type)	Output Shape	Param #
resnet152 (Functional)	(None, 2048)	58370944
dropout_13 (Dropout)	(None, 2048)	0
dense_19 (Dense)	(None, 2048)	4196352
flatten_6 (Flatten)	(None, 2048)	0
dropout_14 (Dropout)	(None, 2048)	0
dense_20 (Dense)	(None, 512)	1049088
dense_21 (Dense)	(None, 3)	1539

Total params: 63,617,923
Trainable params: 5,246,979
Non-trainable params: 58,370,944

Model Fittings with 50 Epoch

Feature Extraction through CNN Model

```
244/244 [==============================] - 1310s 5s/step - loss: 0.7218 - accuracy: 0.7167
Epoch 41/50
244/244 [==============================] - 1320s 5s/step - loss: 0.7196 - accuracy: 0.7167
Epoch 42/50
244/244 [==============================] - 1326s 5s/step - loss: 0.7208 - accuracy: 0.7167
Epoch 43/50
244/244 [==============================] - 1331s 5s/step - loss: 0.7192 - accuracy: 0.7167
Epoch 44/50
244/244 [==============================] - 1321s 5s/step - loss: 0.7198 - accuracy: 0.7167
Epoch 45/50
244/244 [==============================] - 1314s 5s/step - loss: 0.7190 - accuracy: 0.7167
Epoch 46/50
244/244 [==============================] - 1310s 5s/step - loss: 0.7202 - accuracy: 0.7167
Epoch 47/50
244/244 [==============================] - 1323s 5s/step - loss: 0.7222 - accuracy: 0.7167
Epoch 48/50
244/244 [==============================] - 1326s 5s/step - loss: 0.7175 - accuracy: 0.7165
Epoch 49/50
244/244 [==============================] - 1325s 5s/step - loss: 0.7212 - accuracy: 0.7167
Epoch 50/50
244/244 [==============================] - 1335s 5s/step - loss: 0.7192 - accuracy: 0.7167
```

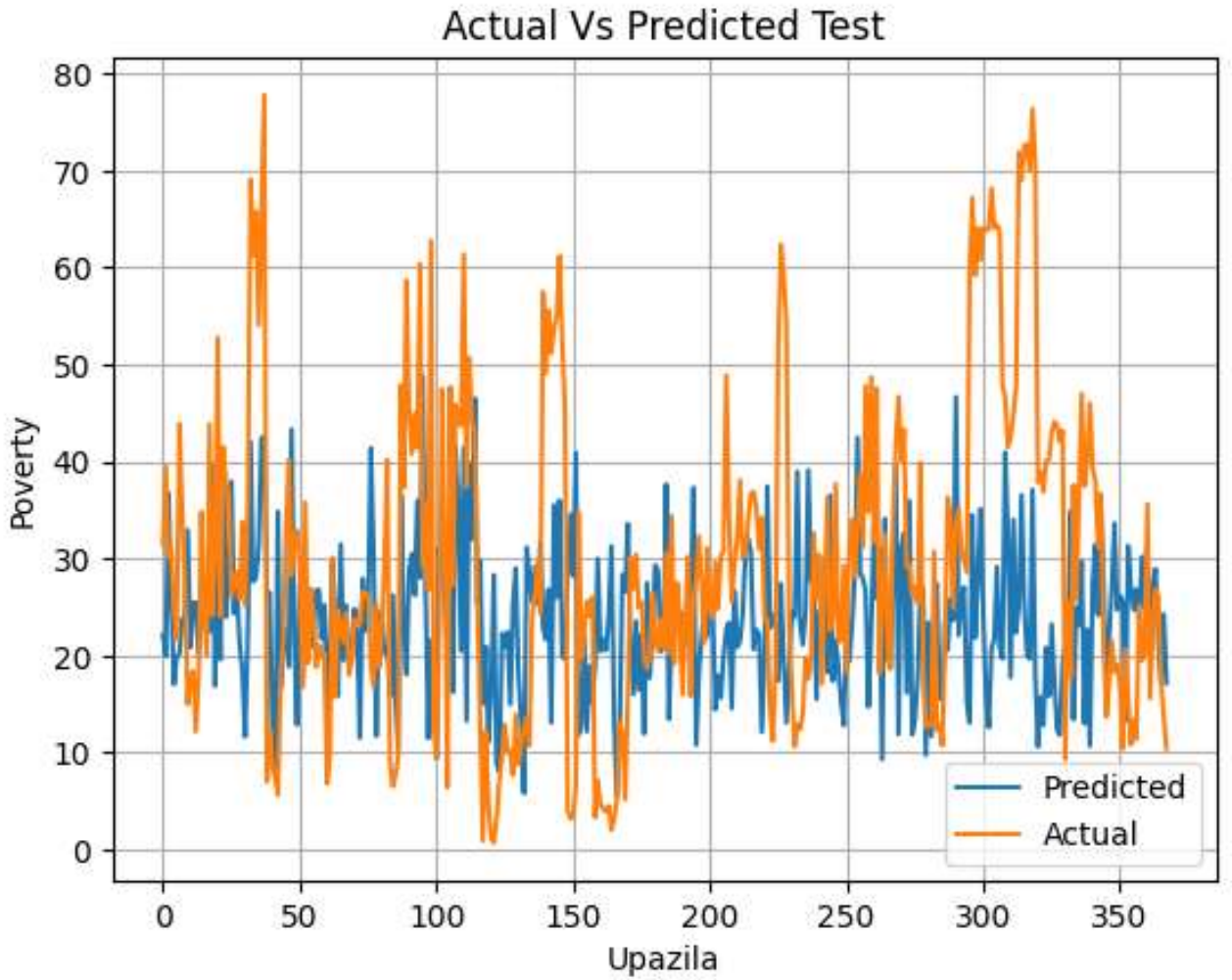


Model Accuracy 84%

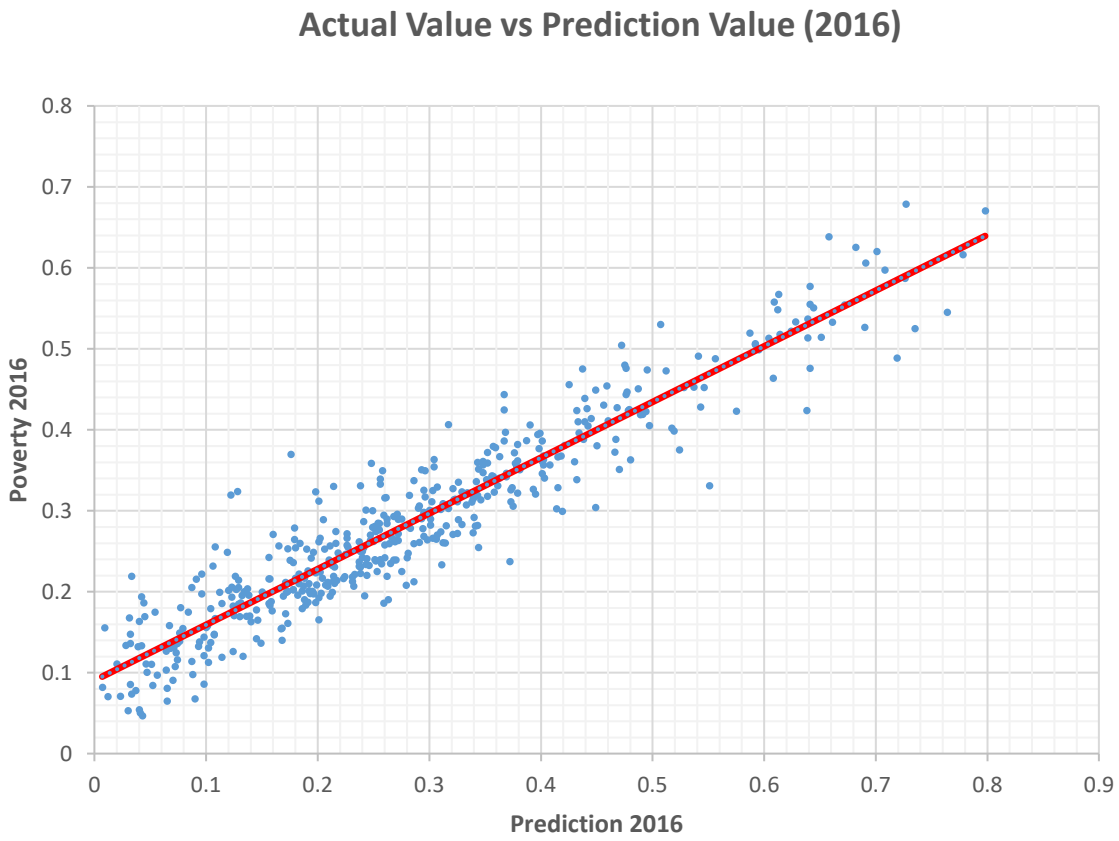
2016 (Trained Vs Validation)

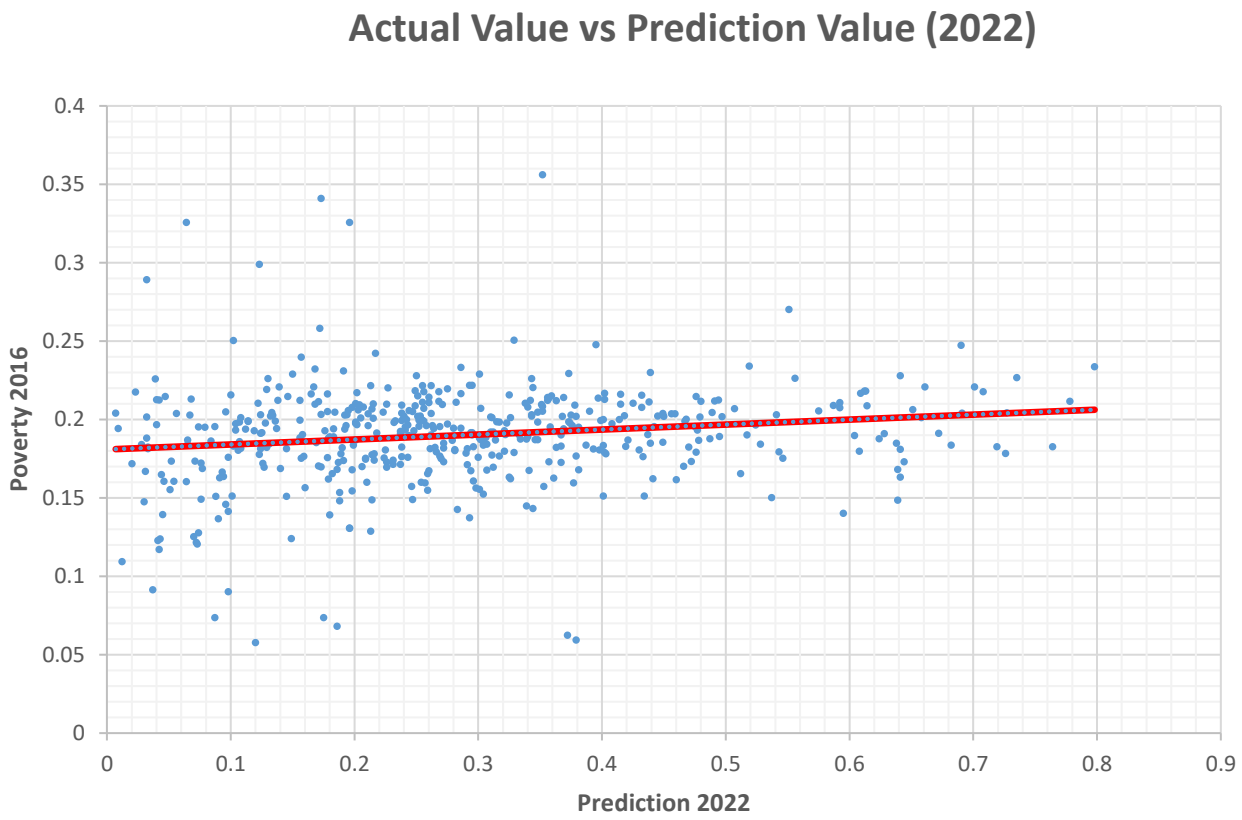
```
print("RMSE: ", np.sqrt(mean_squared_error(ya, ya_hat)))
print("R2: ", str(int(r2_score(ya, ya_hat)*100))+'%')
```

```
RMSE:  0.06531708067448559
R2:  84%
```



Distribution of Poverty (Predicted)



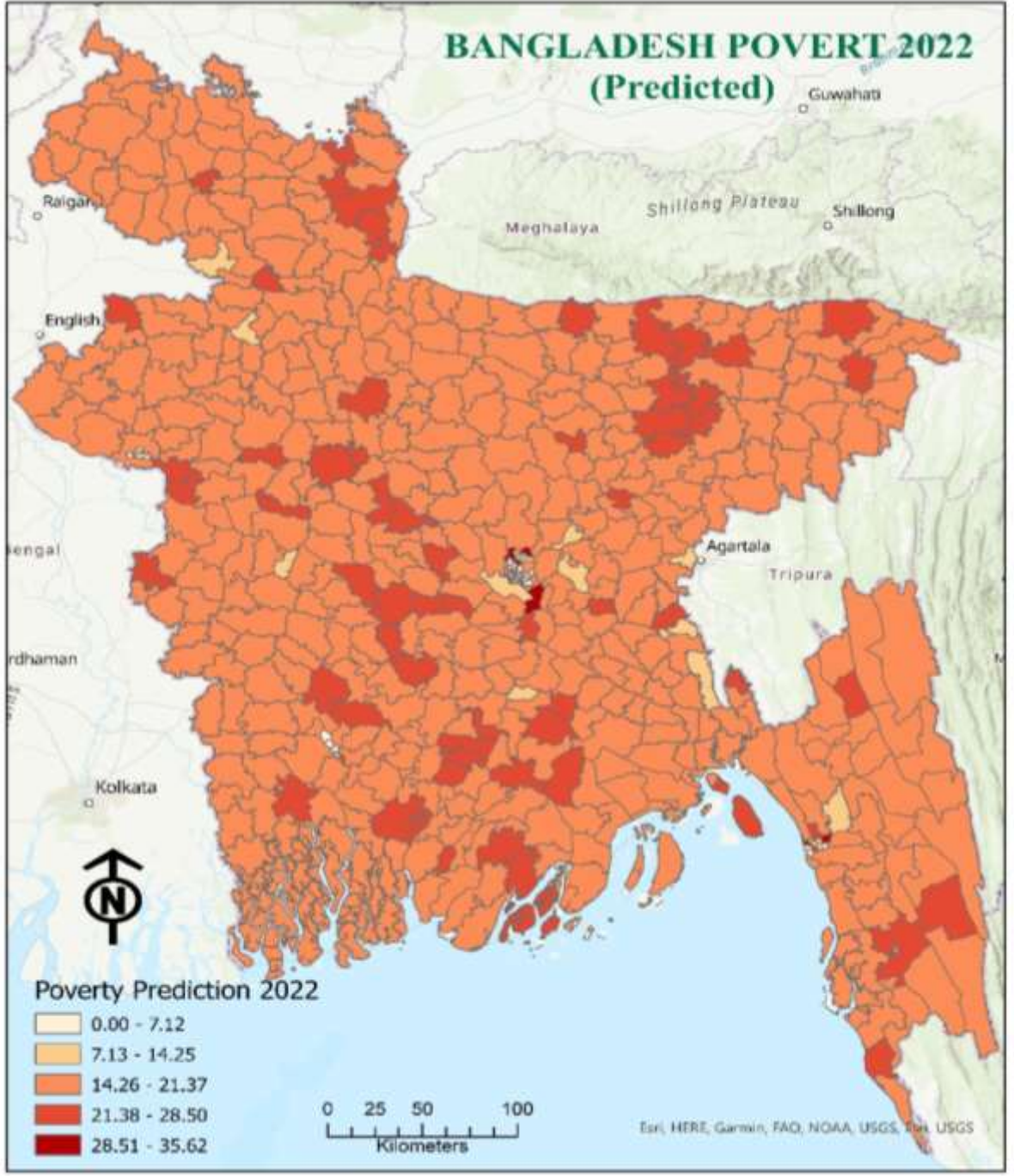


	Poverty 2016	Predicted 2016	Predicted 2022
Min	0.70	4.69	5.78
Max	79.80	67.86	35.62
Un-weighted Average	28.42	28.59	19.00

Std
3.174864

Distribution of Estimated Poverty 2022

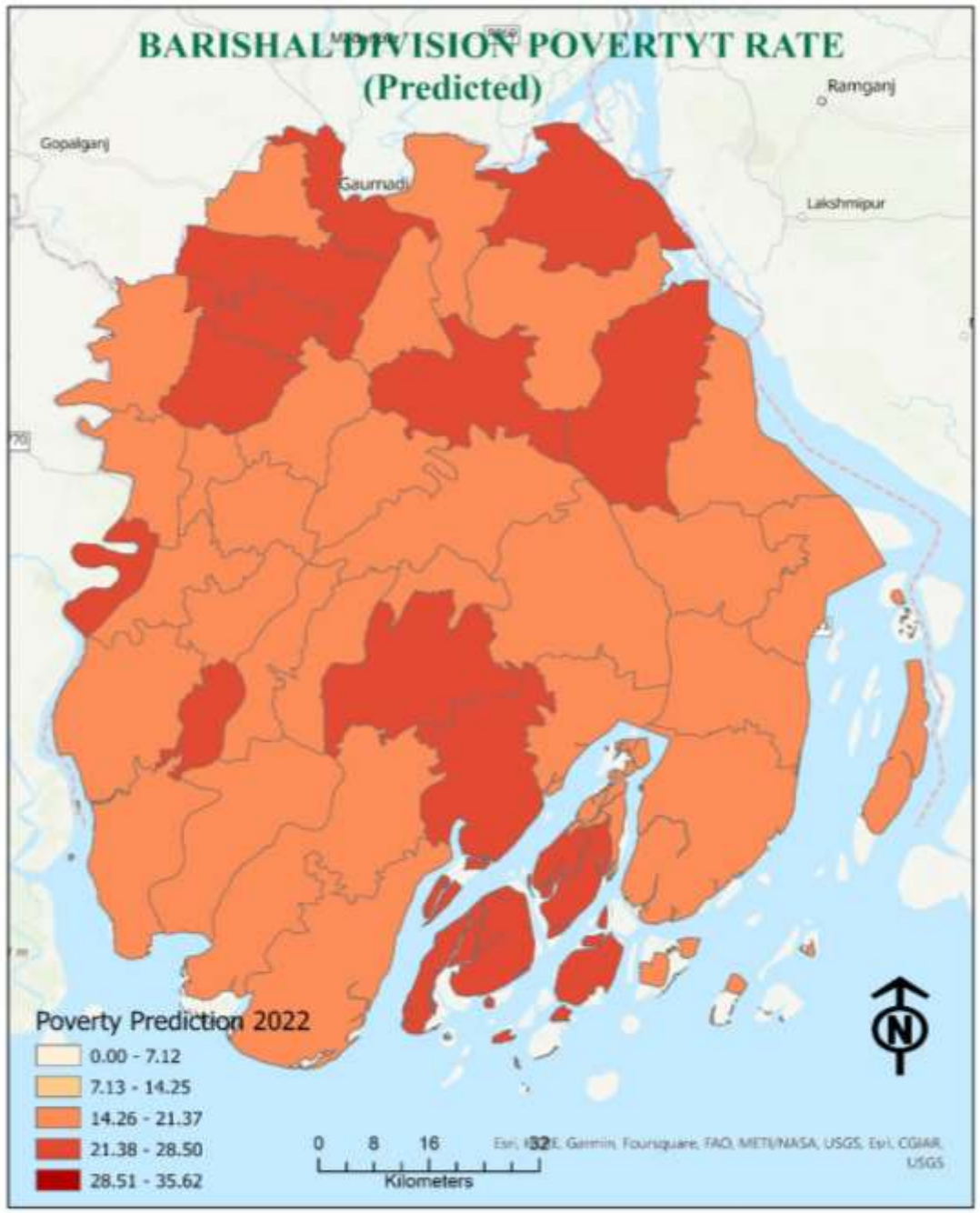
Division	Min	Max	Mean
Mymensingh	15.38	24.59	19.06
Barishal	15.13	25.06	20.08
Chattogram	7.37	34.10	19.20
Dhaka	6.82	35.62	18.88
Khulna	5.94	23.32	18.33
Rajshahi	5.78	23.10	18.55
Rangpur	14.01	24.73	18.89
Sylhet	15.96	22.64	19.73
		National	**19.00**



DATA FOR THE GOALS
DATA FOR NOW

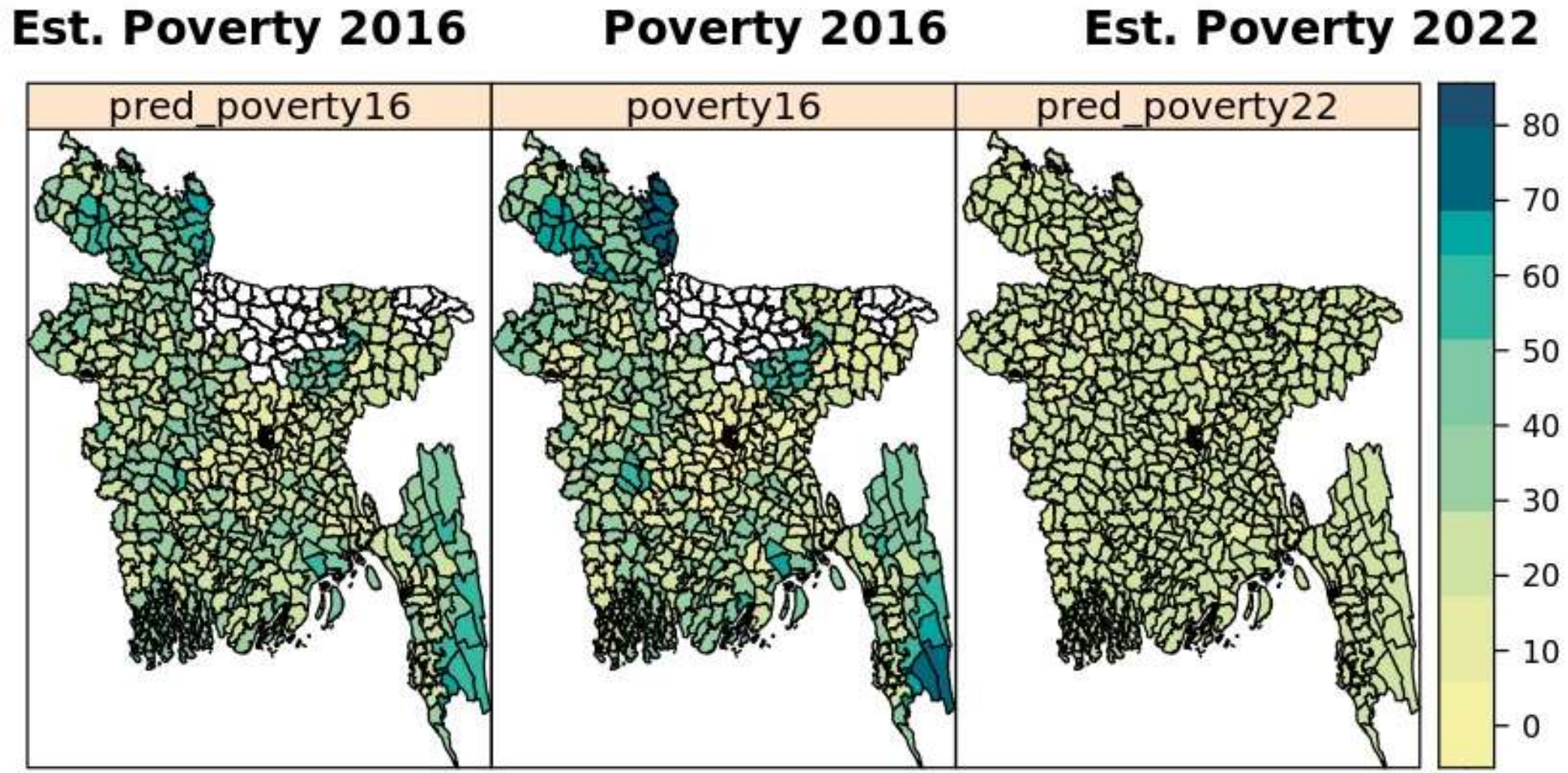
Distribution of Estimated Poverty 2022
Barishal Division

District Name	Min	Mean	Max
Barguna	17.74	20.07	24.78
Barishal	16.33	20.95	25.06
Bhola	16.21	20.02	22.91
Jhalakathi	18.48	19.56	20.00
Patuakhali	17.27	19.82	22.16
Pirojpur	15.13	19.47	21.52
		19.98	



DATA FOR THE GOALS
DATA FOR NOW

Poverty 2016 (ELL Method), Poverty 2016 (RF Model) and Predicted Poverty 2022



Way forward

- Adopt as official statistics for non-survey /interval periods
- Validate with HIES 2022 data
- Reduce the Spatial Grid Size (<2 km) to increase accuracy rate
- Incorporate possible ancillary data in the RF Model and feature extraction
- Publication

Focal points

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