Transfer Learning and Ridge Regression Applied on Satellite Images for Poverty Estimation and Mapping-Zambia

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Overview

Goal and Objectives

- GOAL
  - The Goal of the research is to estimate the Wealth Index in Zambia with the help machine learning and remote sensing.
- Objectives
  - To use remote sensing data to estimate the Wealth Index (Living Standards) in Zambia
  - To estimate the Wealth Index (Living Standards) at at lower administrative levels in Zambia

Object and Subject

- OBJECT
  - Country Zambia
- Subject
  - We considered the Wealth Index in Zambia;

Motivation

Goal number 1 of the sdgs is “end poverty in all its forms everywhere”.

It is estimated that more than 700 million people, or 11 percent of the world population, still live in extreme poverty.

The lack of reliable data in developing countries is a major obstacle to sustainable development, food security, and disaster relief.

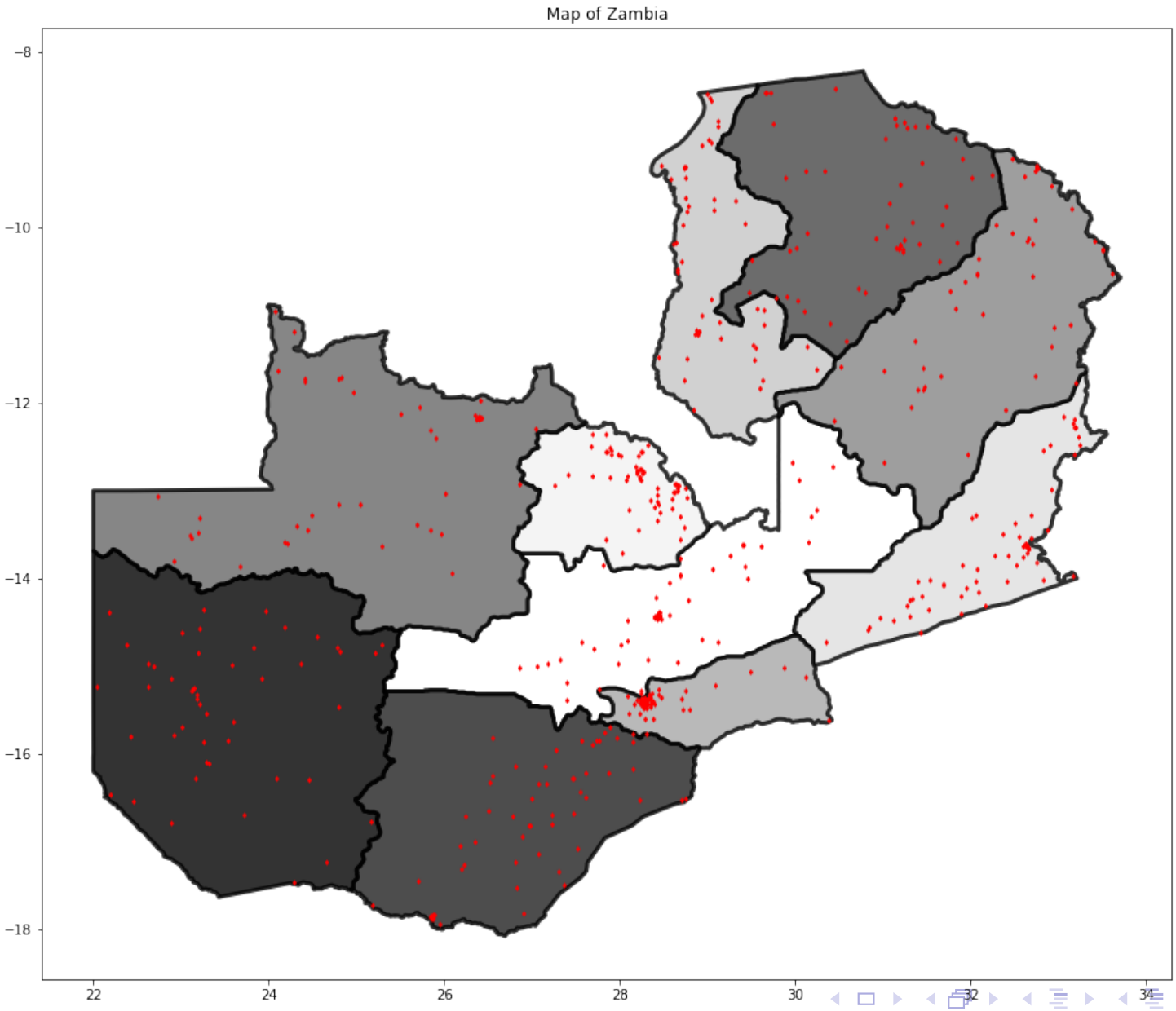
Assumption: World's Nightlights

Figure: World Night Lights

Data Sources

- DHS (https://dhsprogram.com)
- Google
- National Oceanic and Atmospheric Administration (NOAA)

Location of Clusters Covered by the ZDHS



Methodology

- We shall construct a linear chain transfer learning graph with : V = (P1, P2, P3) and E = (P1, P2), (P2, P3).
- The first transfer learning problem P1 is object recognition on ImageNet
- The second problem P2 is predicting nighttime light intensity from daytime satellite imagery, simultaneously learning features that are useful for poverty prediction;
- The third problem P3 is predicting poverty from daytime satellite imagery.

Implementation of Methodology

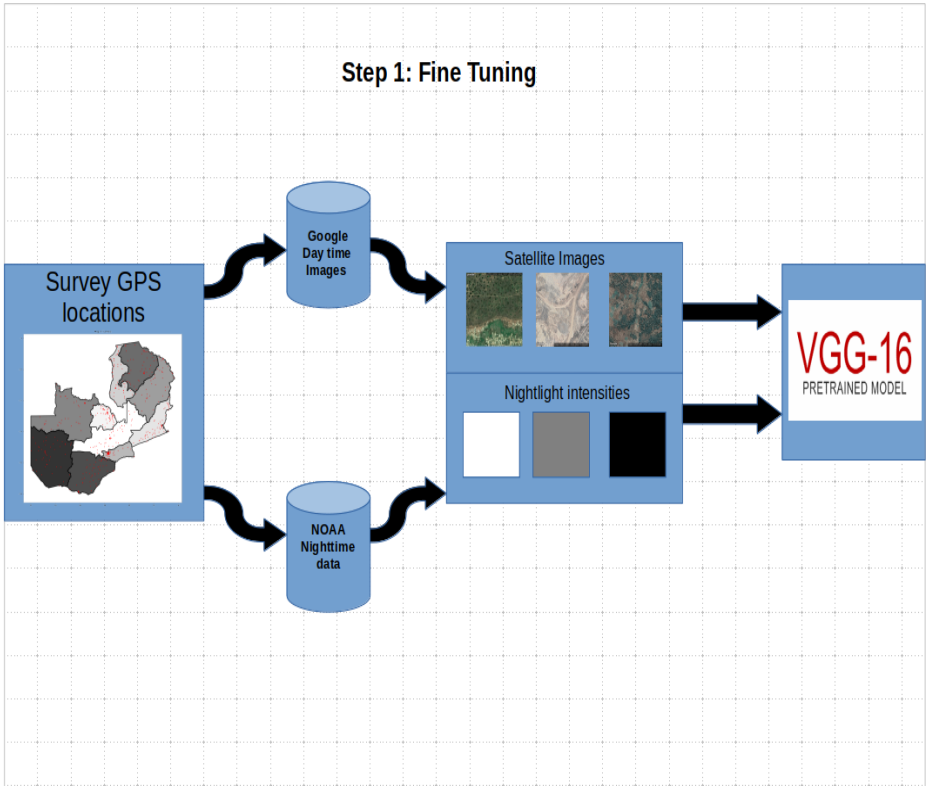


Figure: Fine Tunning

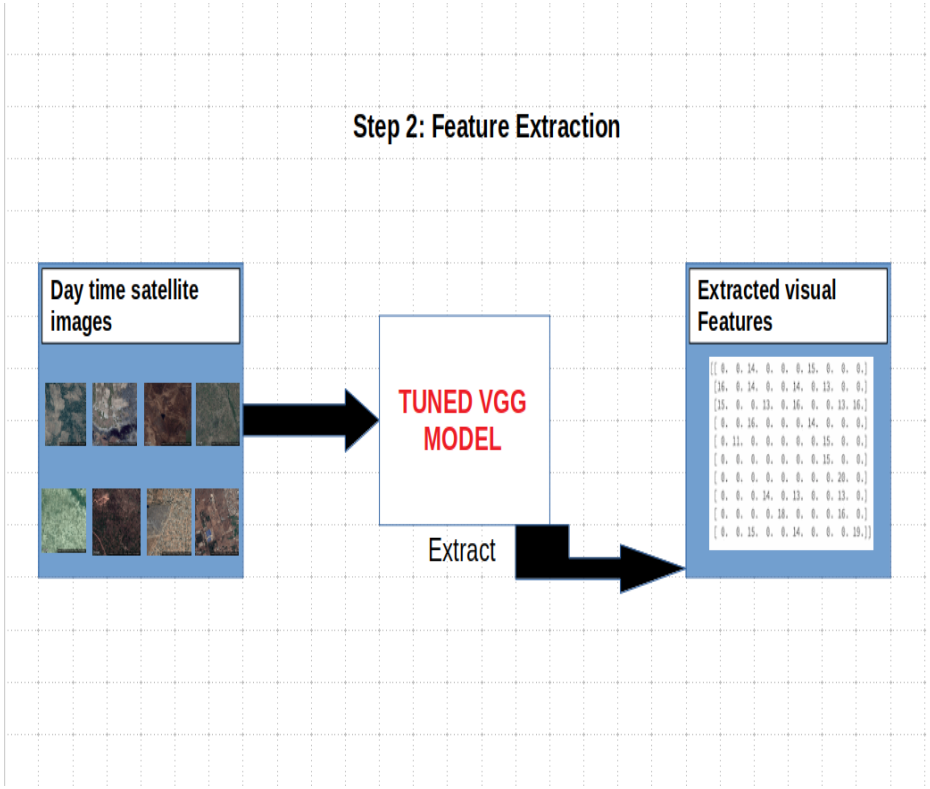


Figure: Feature Extraction

Implementation of Methodology cont'

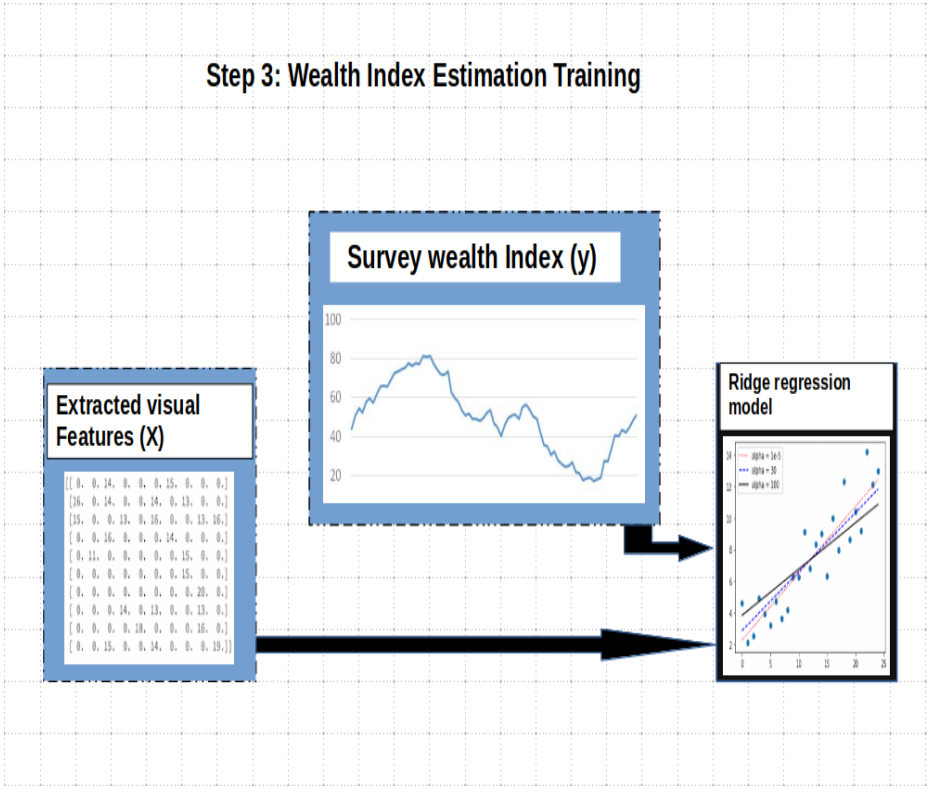


Figure: WI Training

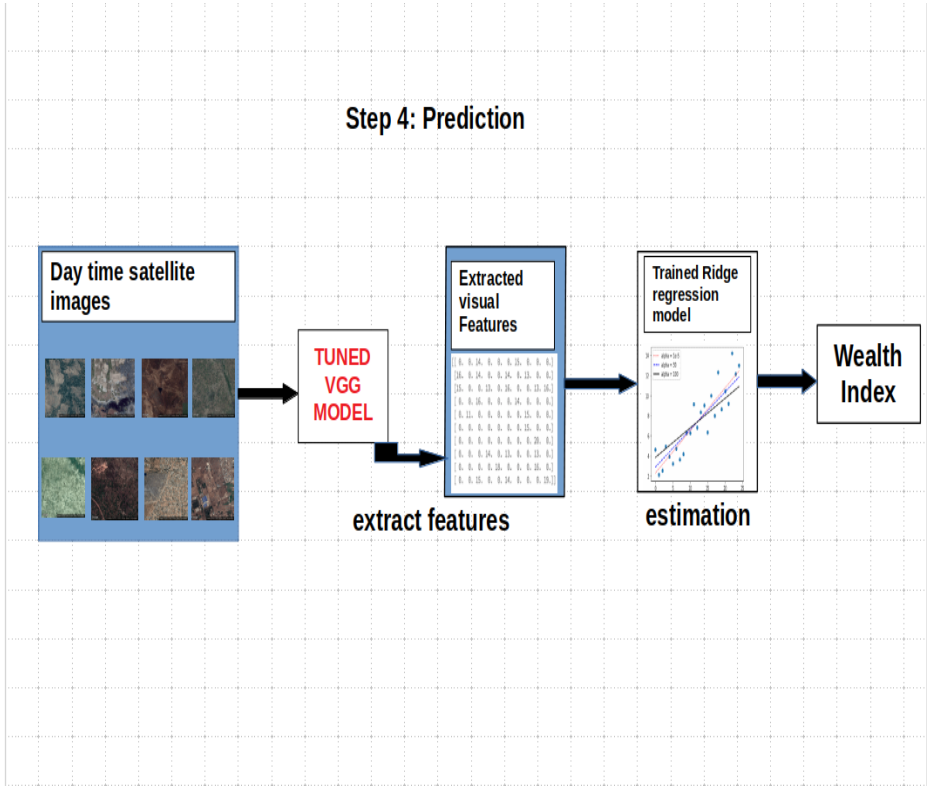


Figure: Prediction

Methods Explained

- First Step
  - First, we start by employing a convolutional neural network (CNN) model that has been pretrained on ImageNet and fine tune to predict night time intensities from day time google images. In learning to classify each image correctly, the model learns to identify features that are important for prediction of teh wealth index.
- Second Step
  - Next, we use the "tuned" model as a feature extractor that has learned a nonlinear mapping from each input image to extract visual features from the images.
- Third Step
  - In the final step, we use mean cluster-level values from the survey data along with the corresponding image features extracted from daytime imagery by the CNN to train ridge regression models that can estimate cluster-level Wealth Index. Regularization in the ridge model guards against overfitting.

Step 2 - Visualization of features(Further Illustrated)'

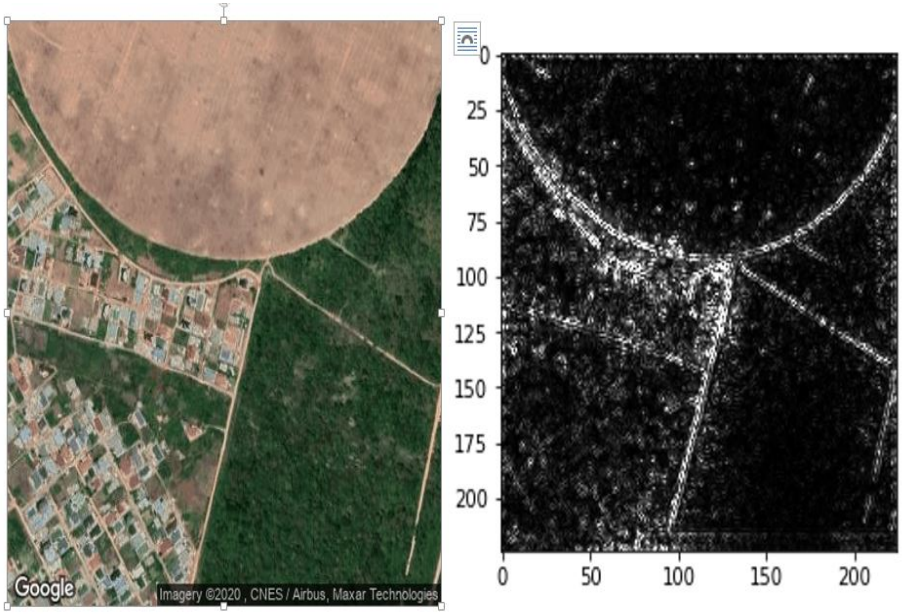


Figure: WI Training

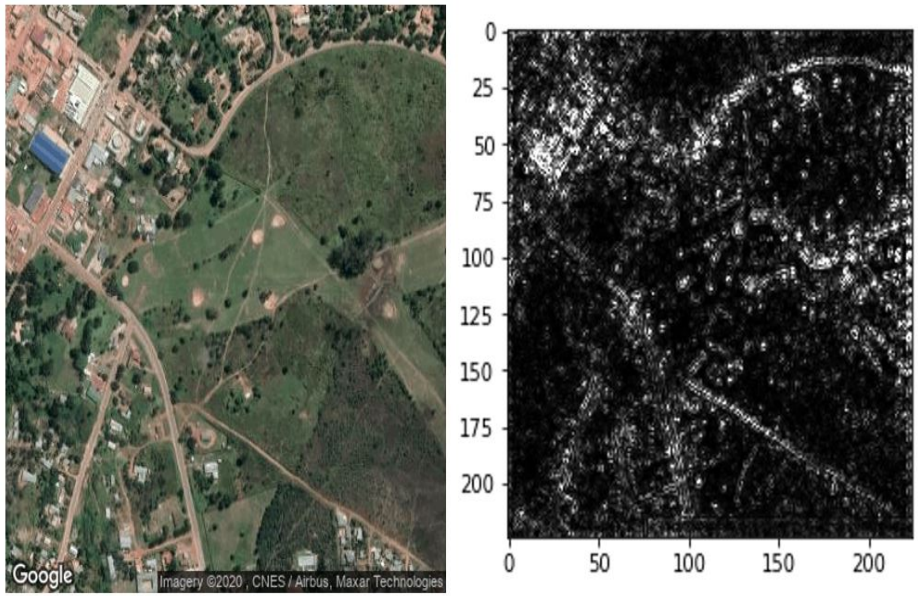


Figure: Prediction

Evaluation Metrics

- 5-Fold Cross Validated R-squared
  - It is a statistical measure that represents the proportion of the variance for a target variable (Poverty rate) that is explained by the independent variables (Extracted features). R-squared values range from 0 to 1 and are commonly stated as percentages.
- Randomization Test
  - To make sure that the results obtained are not as a result of a statistical chance, we perform a randomization test where we replace the true labels with junk and see how the model performs.

Model Evaluation Results

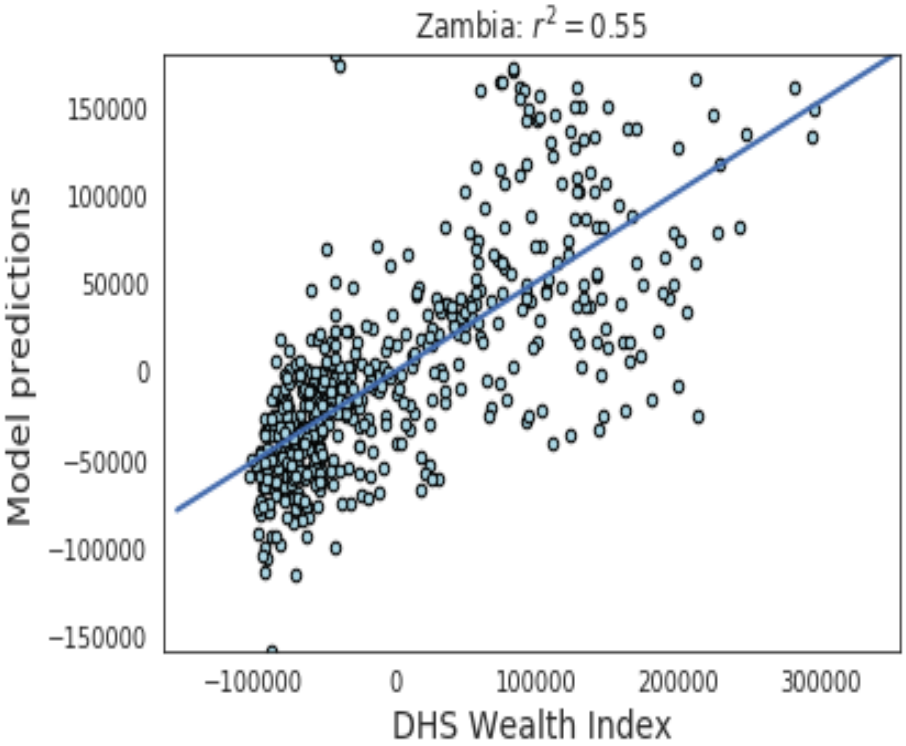


Figure: R-squared

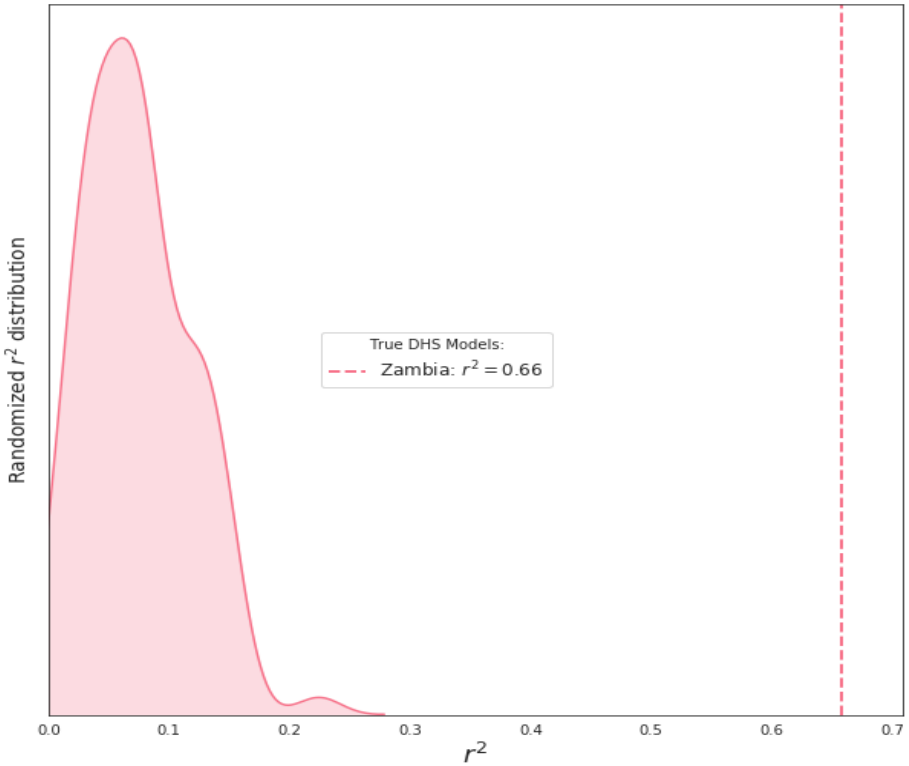


Figure: Randomized Test

Model Evaluation Results

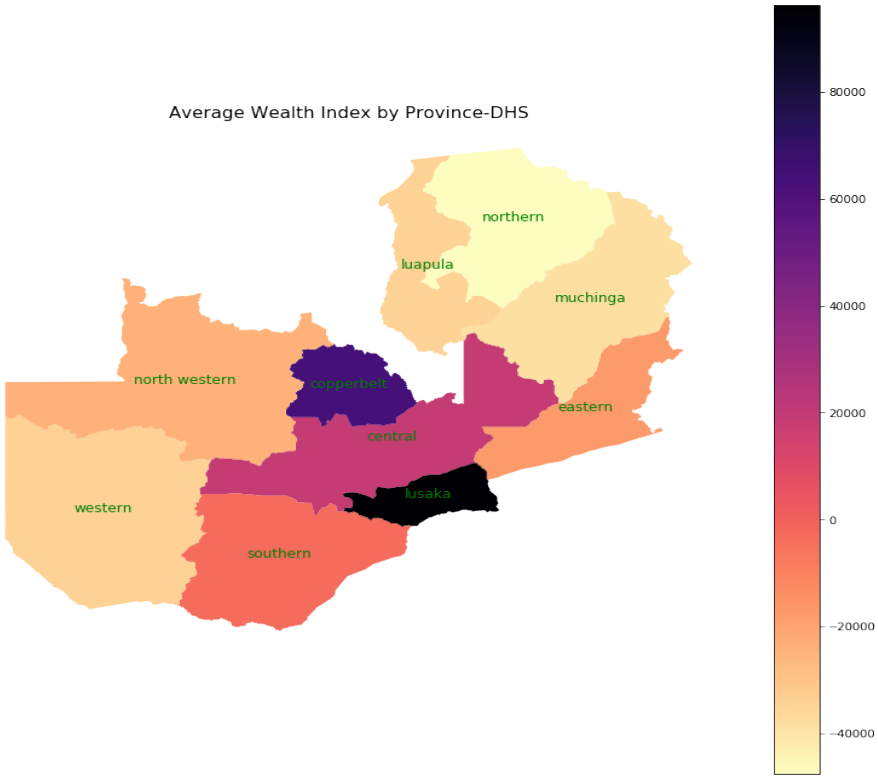


Figure: DHS Results

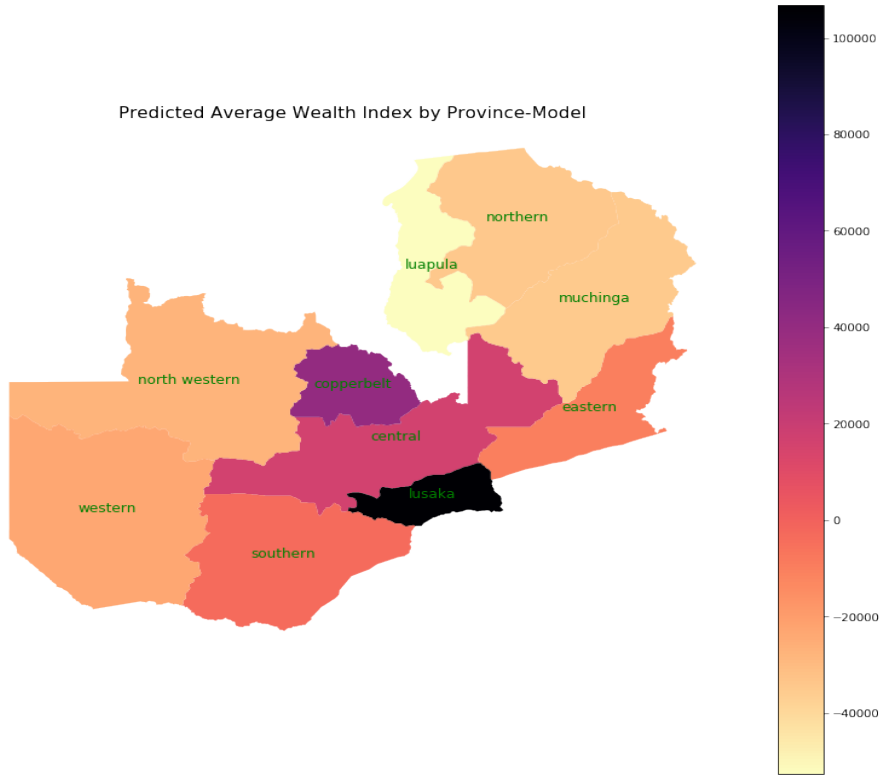


Figure: Predicted by Model

Next Steps

- Finalise the text
- Thesis defense

Thank You for your Attention