# Predicting Income Groups Using World Development Indicators

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Capstone Project

Springboard Data Science

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# WDI & Income Groups

- Indicators help us understand a country's development level
- Income groups tell us the class a country falls into economically
- Gives insight on nonmonetary measures of the quality of life
- Can help us in our quest for true globalization

**Example China:**

2nd largest economy in the world

Lower middle and upper middle income categories

Disparities in living standards throughout the country

Income group gives us a broad understanding of the development, living standards and quality of life

# Approach

- **Identify Indicator Categories**
    - Economic Policy & Debt
    - Education and Gender Issues
    - Access to Advanced Communication
    - Health
- **Look for correlation with GNI per capita**
    - Main contributing factor to income category
- **Predict Class**
    - Anova Testing
    - Machine Learning
    - Feature Engineering

# Client

- **Government**
    - Understand developmental comparisons to those in the same class and to the world

- **Non-Government Organization (NGO)**
    - Specialize in certain aspects that may help with the development of a country of interest
    - Send volunteers to countries in need of certain aide (education)

- **International Funds, Banks and Financial Institutions**
    - Financing countries
    - Direct funding for development projects

# Dataset

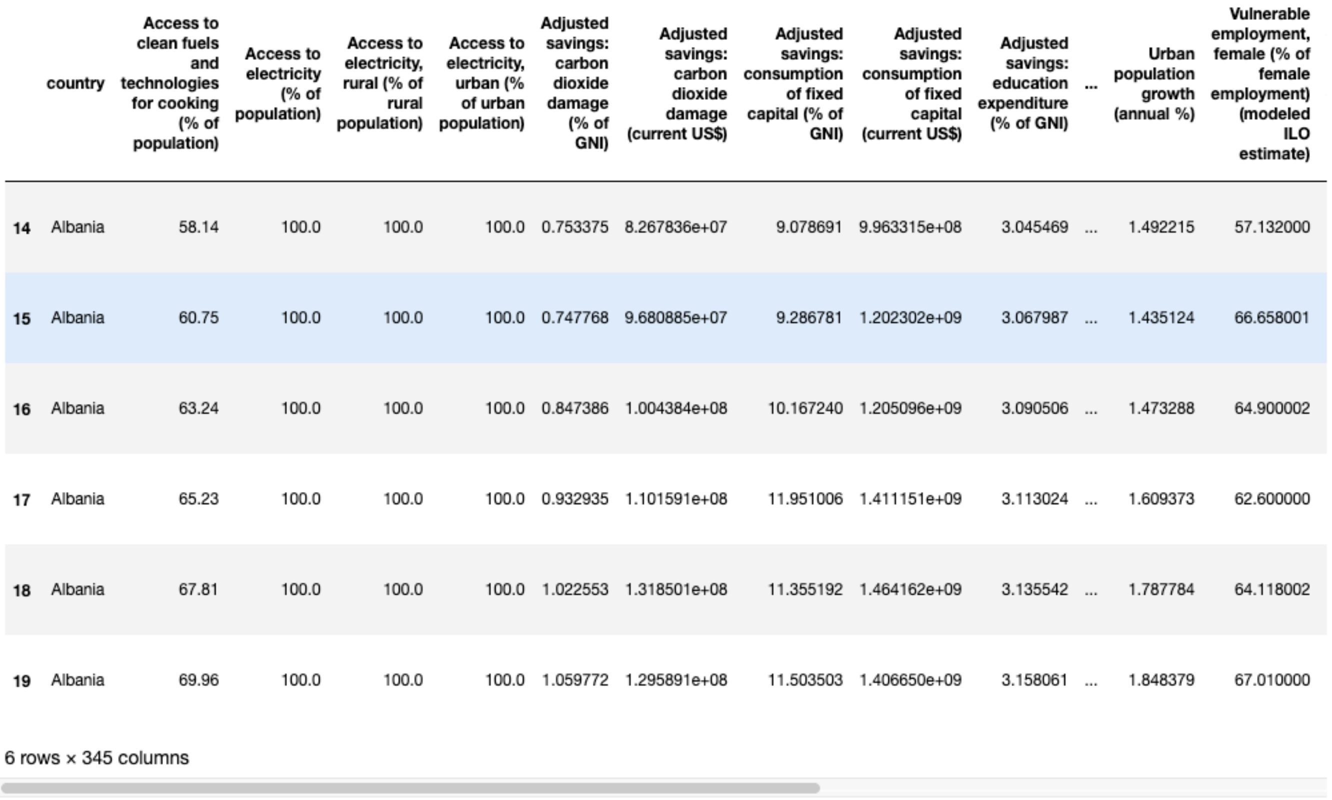
- **World Bank’s World Development Indicators Database**
  - 5 datasets featuring indicators, countries, regions, change over time, definitions, etc.
  - https://datacatalog.worldbank.org/dataset/world-development-indicators

- **World Bank Help Desk**
  - Historical information on income groups and GNI range for classes by year
  - https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries

# Data Wrangling

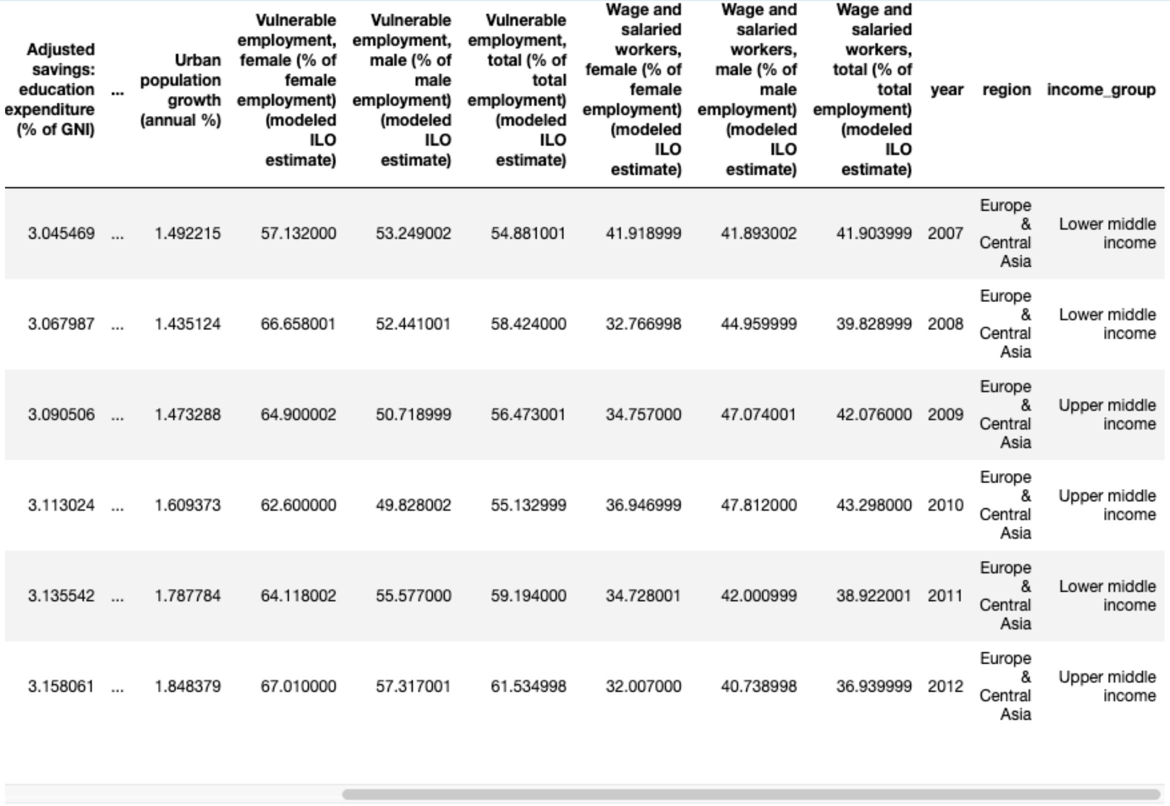
- Merge datasets
- Categorize indicators
- Drop insufficient information
- Drop unrelated columns
- Standardize column names
- Extract countries from noise
- Drop columns with too much missing data
- Drop indicators with too much missing data
- Find the income group of each country for each year
- Drop incorrect data
- Pivot the dataset for analysis and modeling

# Cleaned Dataset



| | country | Access to clean fuels and technologies for cooking (% of population) | Access to electricity (% of population) | Access to electricity, rural (% of rural population) | Access to electricity, urban (% of urban population) | Adjusted savings: carbon dioxide damage (% of GNI) | Adjusted savings: carbon dioxide damage (current US$) | Adjusted savings: consumption of fixed capital (% of GNI) | Adjusted savings: consumption of fixed capital (current US$) | Adjusted savings: education expenditure (% of GNI) | ... | Urban population growth (annual %) | Vulnerable employment, female (% of female employment) (modeled ILO estimate) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **14** | Albania | 58.14 | 100.0 | 100.0 | 100.0 | 0.753375 | 8.267836e+07 | 9.078691 | 9.963315e+08 | 3.045469 | ... | 1.492215 | 57.132000 |
| **15** | Albania | 60.75 | 100.0 | 100.0 | 100.0 | 0.747768 | 9.680885e+07 | 9.286781 | 1.202302e+09 | 3.067987 | ... | 1.435124 | 66.658001 |
| **16** | Albania | 63.24 | 100.0 | 100.0 | 100.0 | 0.847386 | 1.004384e+08 | 10.167240 | 1.205096e+09 | 3.090506 | ... | 1.473288 | 64.900002 |
| **17** | Albania | 65.23 | 100.0 | 100.0 | 100.0 | 0.932935 | 1.101591e+08 | 11.951006 | 1.411151e+09 | 3.113024 | ... | 1.609373 | 62.600000 |
| **18** | Albania | 67.81 | 100.0 | 100.0 | 100.0 | 1.022553 | 1.318501e+08 | 11.355192 | 1.464162e+09 | 3.135542 | ... | 1.787784 | 64.118002 |
| **19** | Albania | 69.96 | 100.0 | 100.0 | 100.0 | 1.059772 | 1.295891e+08 | 11.503503 | 1.406650e+09 | 3.158061 | ... | 1.848379 | 67.010000 |

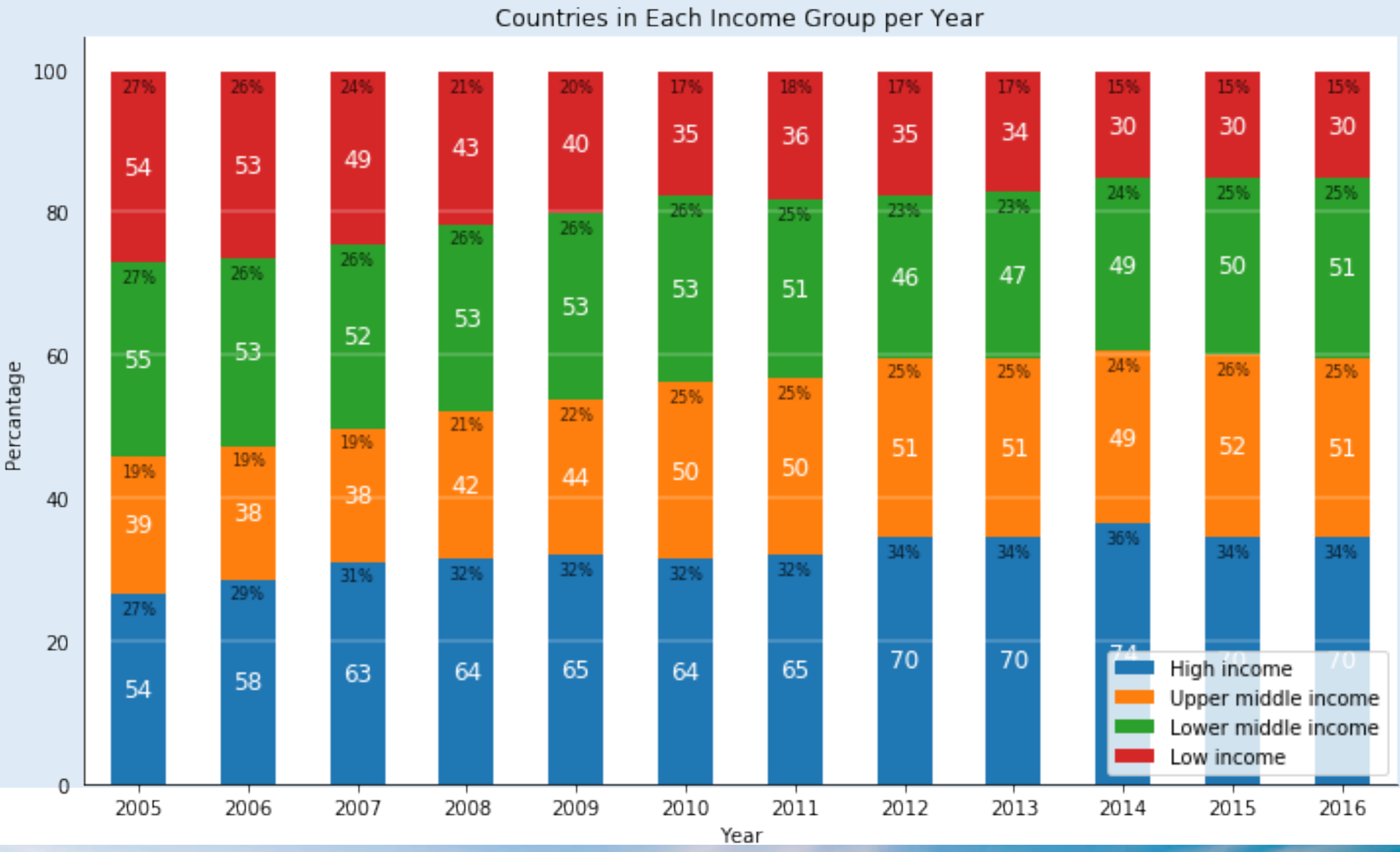
6 rows × 345 columns



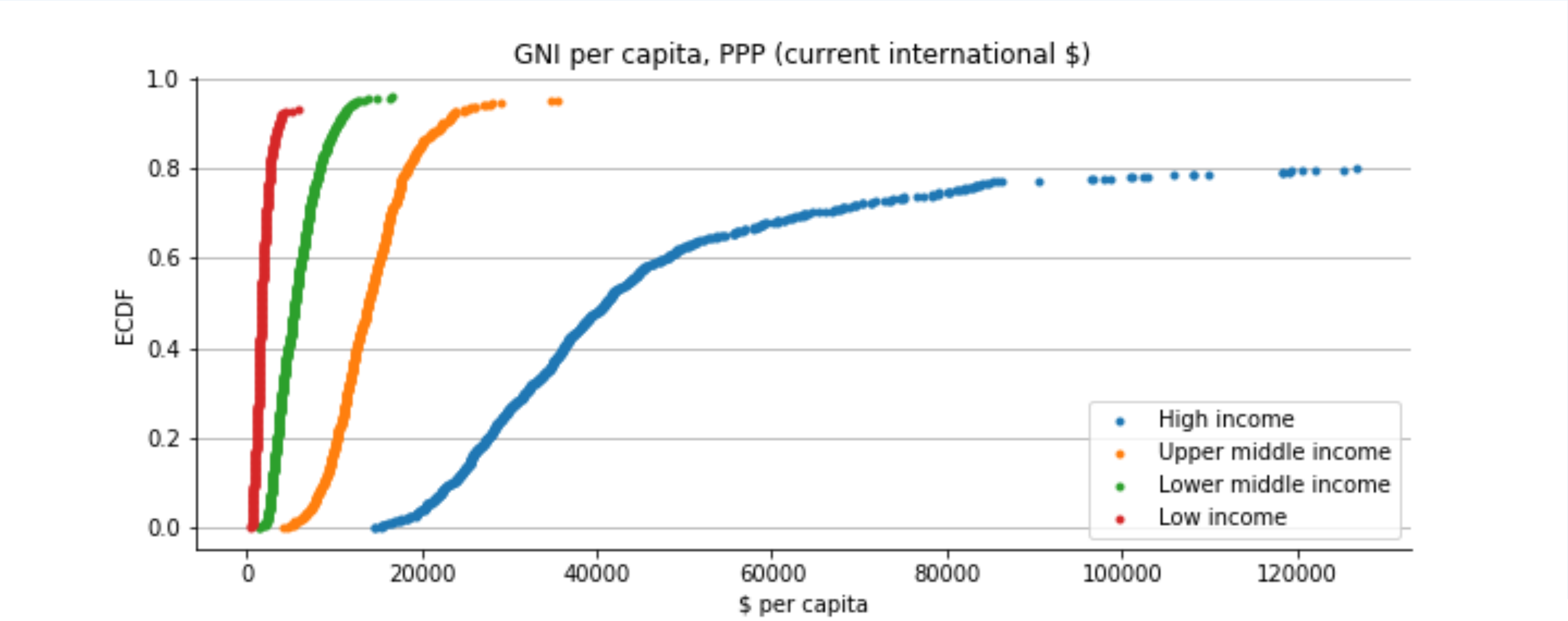
| Adjusted savings: education expenditure (% of GNI) | ... | Urban population growth (annual %) | Vulnerable employment, female (% of female employment) (modeled ILO estimate) | Vulnerable employment, male (% of male employment) (modeled ILO estimate) | Vulnerable employment, total (% of total employment) (modeled ILO estimate) | Wage and salaried workers, female (% of female employment) (modeled ILO estimate) | Wage and salaried workers, male (% of male employment) (modeled ILO estimate) | Wage and salaried workers, total (% of total employment) (modeled ILO estimate) | year | region | income_group |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.045469 | ... | 1.492215 | 57.132000 | 53.249002 | 54.881001 | 41.918999 | 41.893002 | 41.903999 | 2007 | Europe & Central Asia | Lower middle income |
| 3.067987 | ... | 1.435124 | 66.658001 | 52.441001 | 58.424000 | 32.766998 | 44.959999 | 39.828999 | 2008 | Europe & Central Asia | Lower middle income |
| 3.090506 | ... | 1.473288 | 64.900002 | 50.718999 | 56.473001 | 34.757000 | 47.074001 | 42.076000 | 2009 | Europe & Central Asia | Upper middle income |
| 3.113024 | ... | 1.609373 | 62.600000 | 49.828002 | 55.132999 | 36.946999 | 47.812000 | 43.298000 | 2010 | Europe & Central Asia | Upper middle income |
| 3.135542 | ... | 1.787784 | 64.118002 | 55.577000 | 59.194000 | 34.728001 | 42.000999 | 38.922001 | 2011 | Europe & Central Asia | Lower middle income |
| 3.158061 | ... | 1.848379 | 67.010000 | 57.317001 | 61.534998 | 32.007000 | 40.738998 | 36.939999 | 2012 | Europe & Central Asia | Upper middle income |

# EDA – Income groups change over time

- Countries change income groups from year to year
- Higher income groups are growing while lower income groups are shrinking from year to year.
- The shift happening between income groups is showing that the world is becoming more developed.

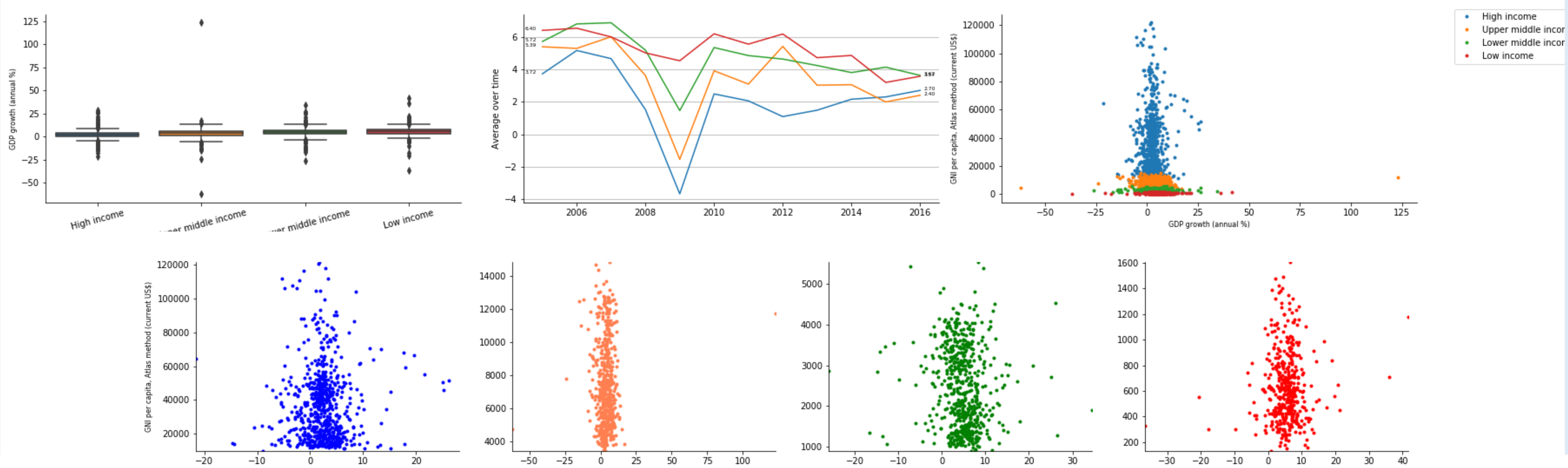


# EDA – GNI per cap direct correlation to income groups



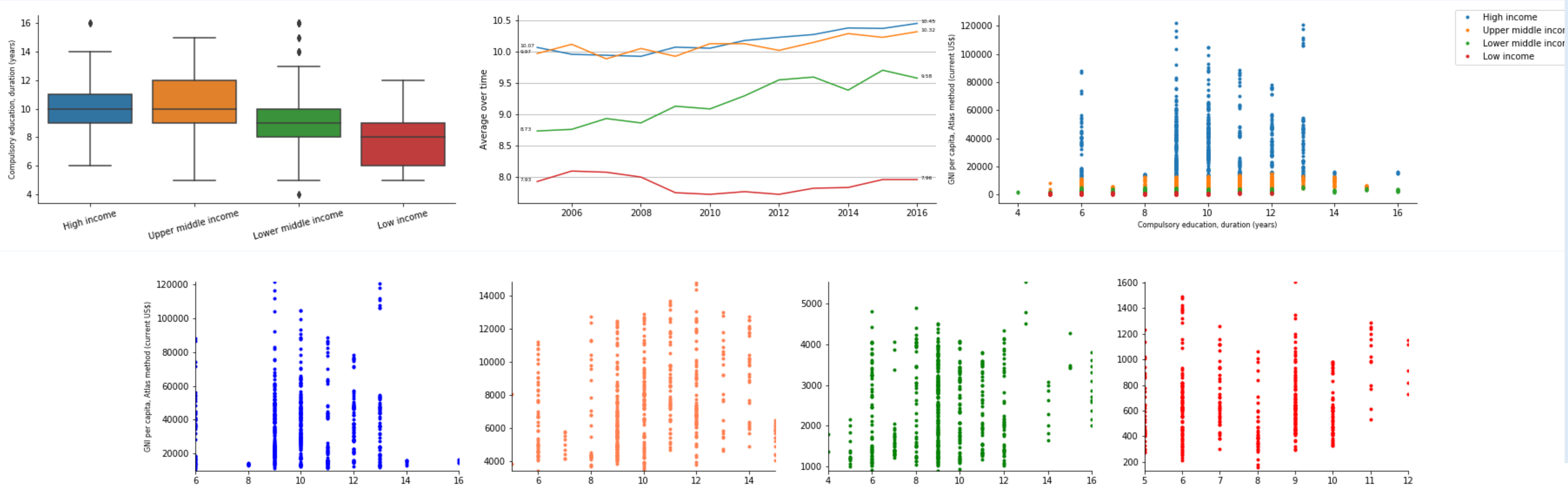
# EDA – Economic Policy & Debt

- Annual GDP growth is larger among lower income countries than higher income countries.



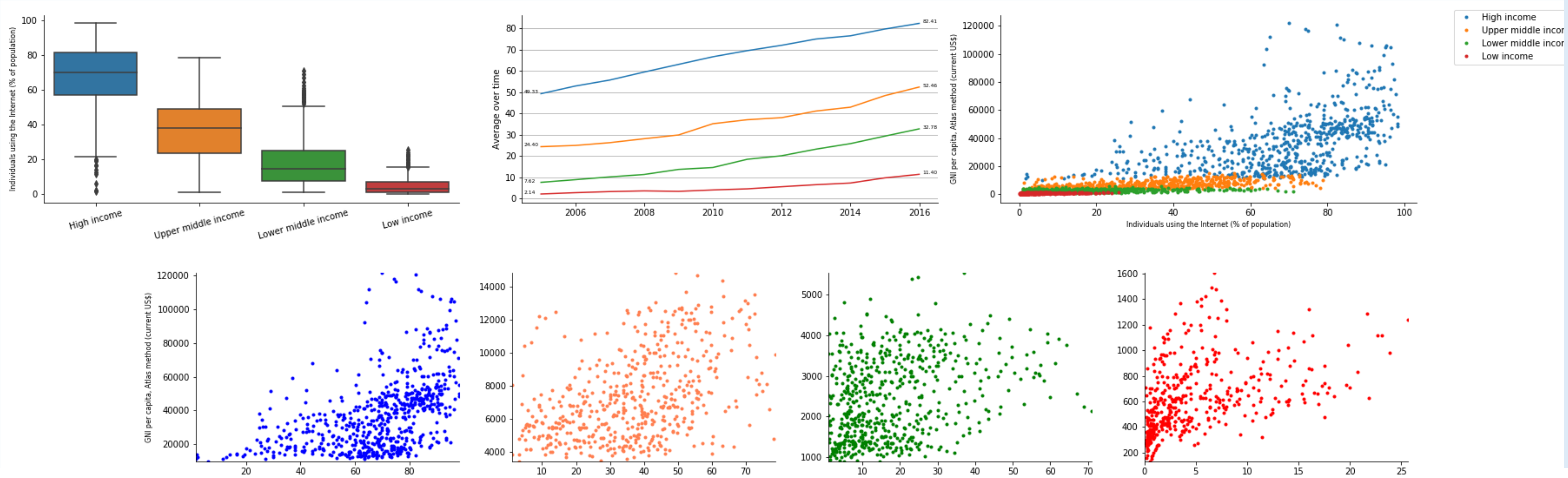
# EDA – Education & Gender Issues

- Average years for schooling between 8 and 10
- Proportion of seats held by women in government between 21.8% and 17.5% for all income groups



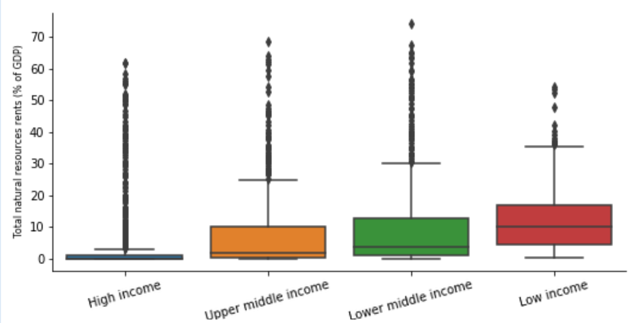
# EDA – Access to Advanced Communication

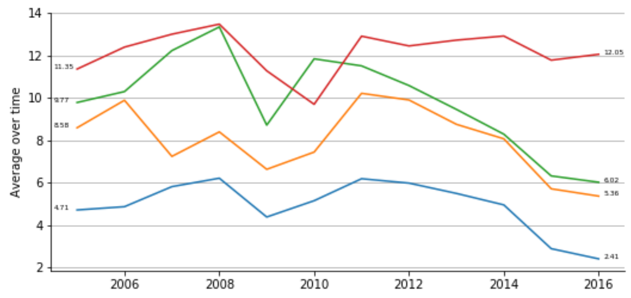
- Income groups have seen a rise in internet usage over time
- Mobile cellular subscriptions increase with the income level

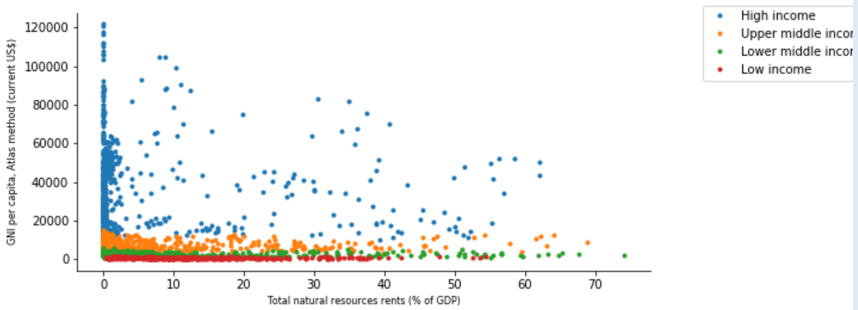


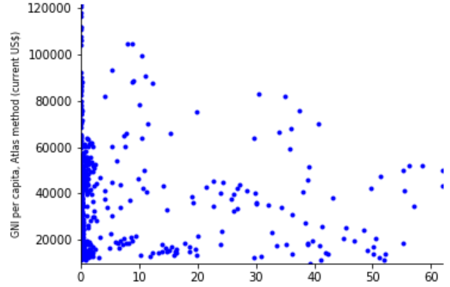
# EDA – Environment, Resources & Population

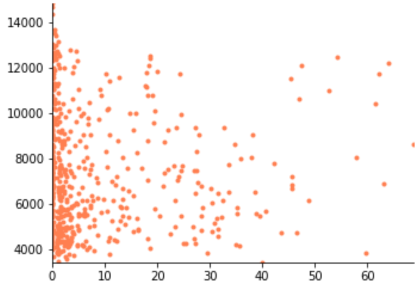
- Access to clean fuels and technologies for cooking relates to access to electricity
- Total natural resources rents see a few countries, regardless of income group, produce most of the natural resources
- There is a significant difference in means of urban population to total population from income group to income group

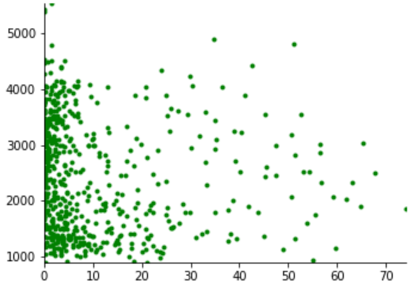


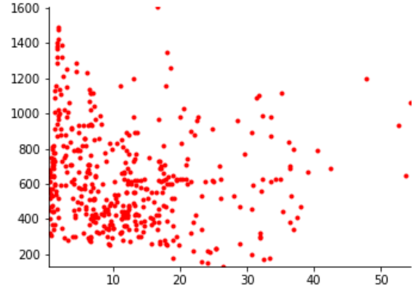






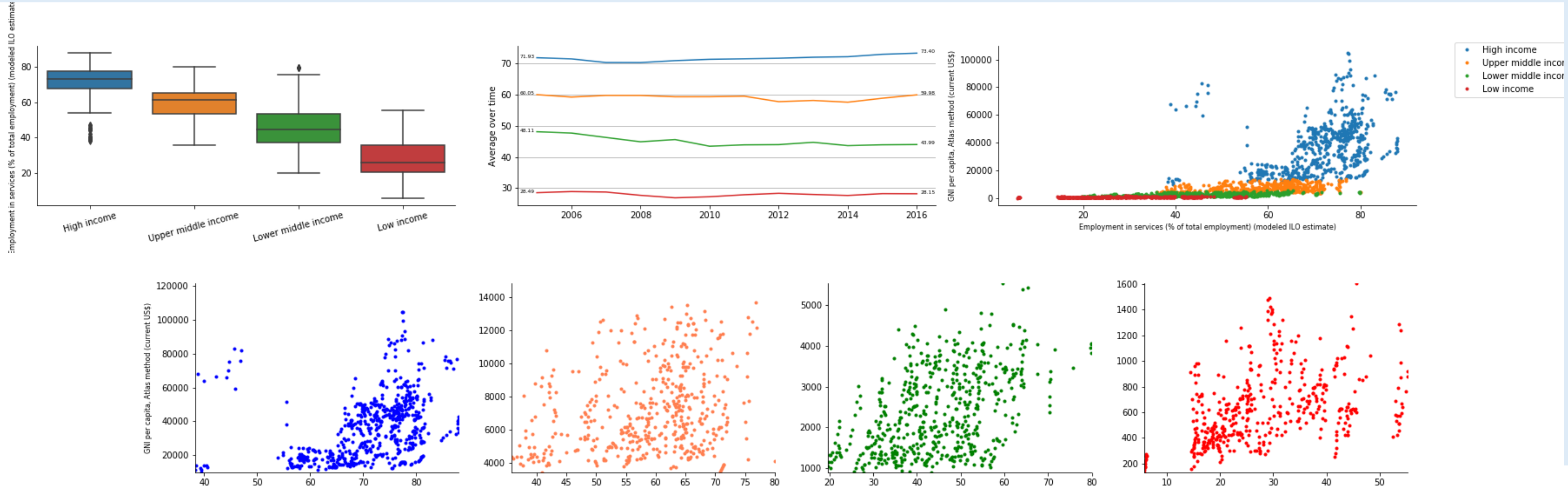






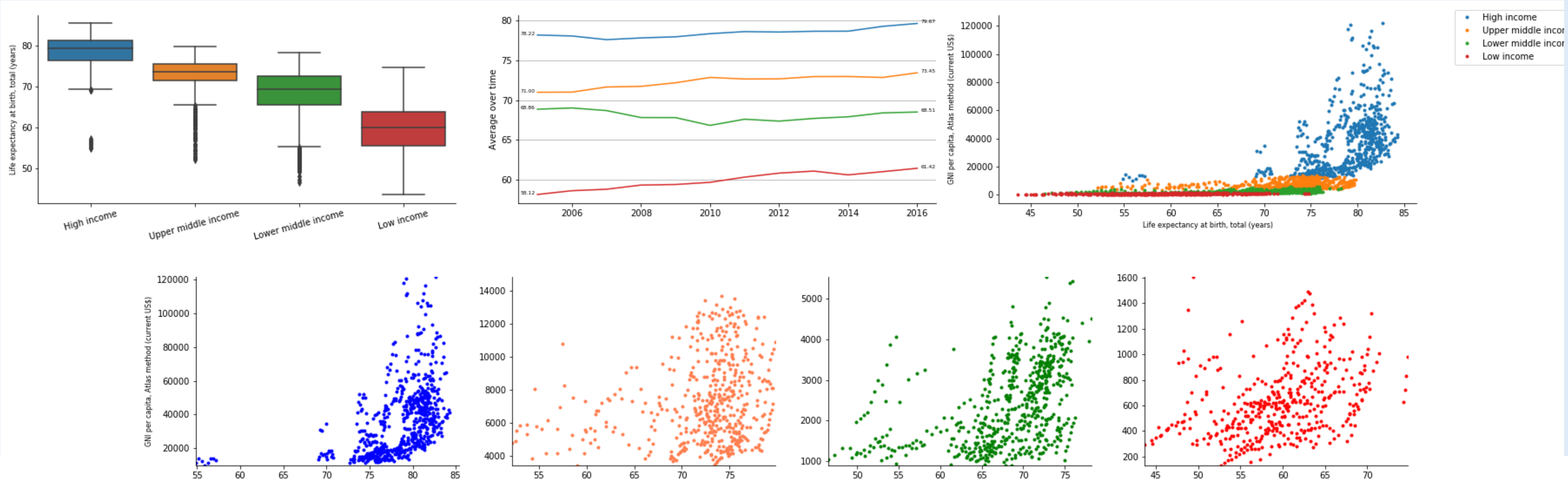
# EDA – Social Protection & Labor

- Labor force participation the same for high income countries and low income
- Low income work to survive, while high income work for comfort
- Employment in services is extremely high among high income countries



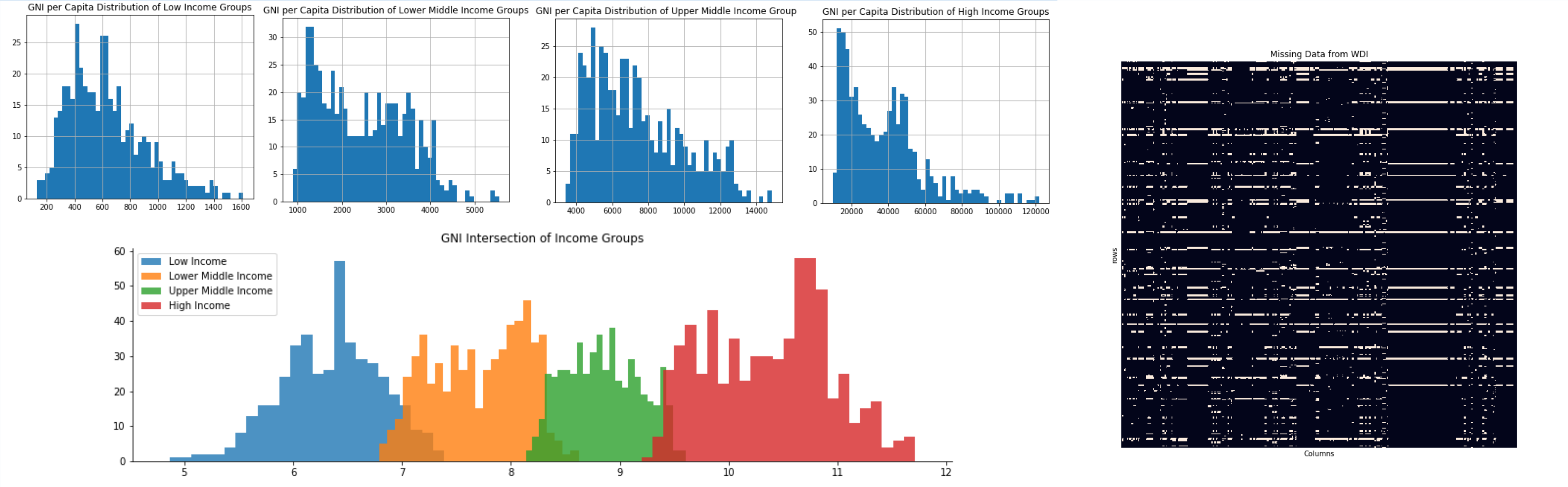
# EDA – Health

- Access to basic drinking water is major in determining income groups
- Average life expectancy is much higher for high income countries
- Minimum life expectancy on the rise for all income groups



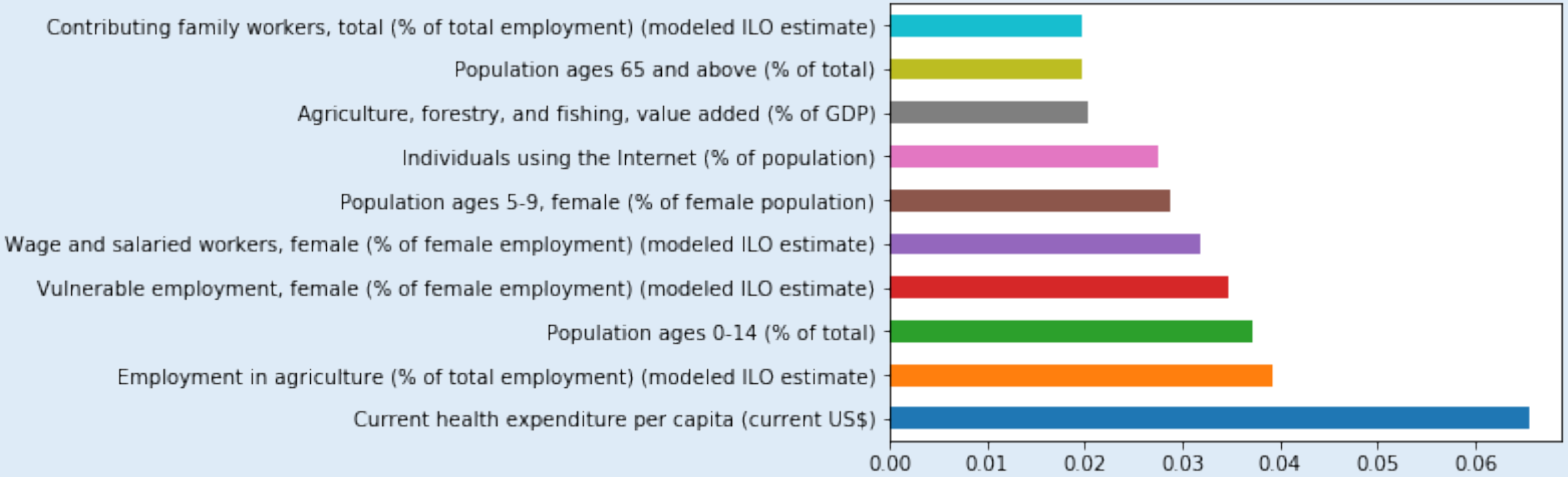
# Model Preparation - Data

- NaN values
- GNI, GDP & World Development



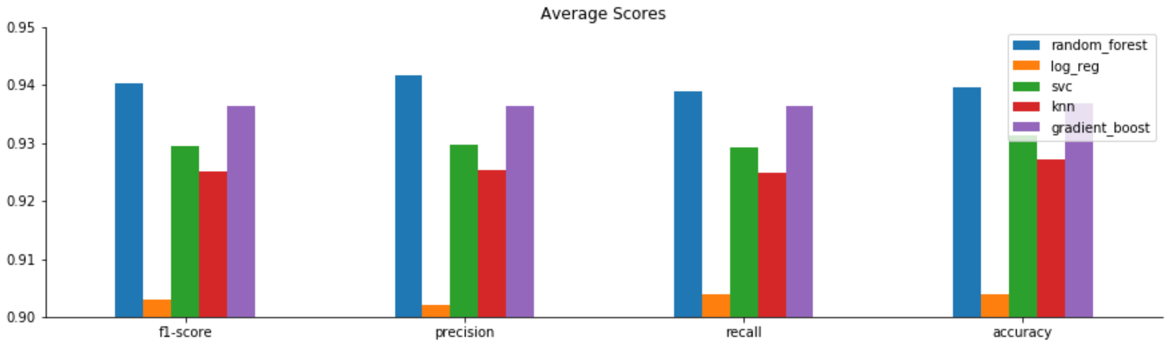
# Model Preparation - Features

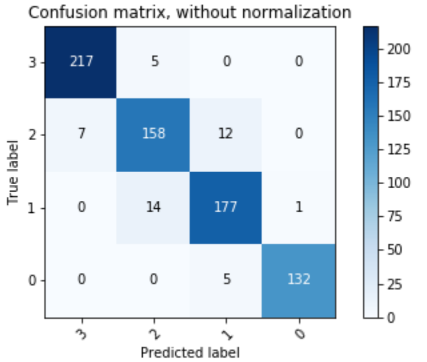
- Normalize data – subtract by mean and divide by standard deviation
- Feature Selection – univariate anova, tree-based, mix & match



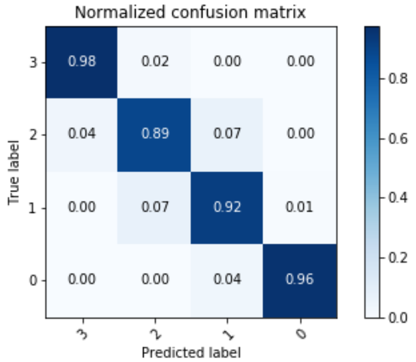
# Model Testing & Tuning

- Pipeline to test each feature & hyperparameter combination on a 5 fold cv set
- Get best output, test on unseen data, repeat
- 5 models tested & tuned





| True label \ Predicted label | 3 | 2 | 1 | 0 |
|---|---|---|---|---|
| 3 | 217 | 5 | 0 | 0 |
| 2 | 7 | 158 | 12 | 0 |
| 1 | 0 | 14 | 177 | 1 |
| 0 | 0 | 0 | 5 | 132 |

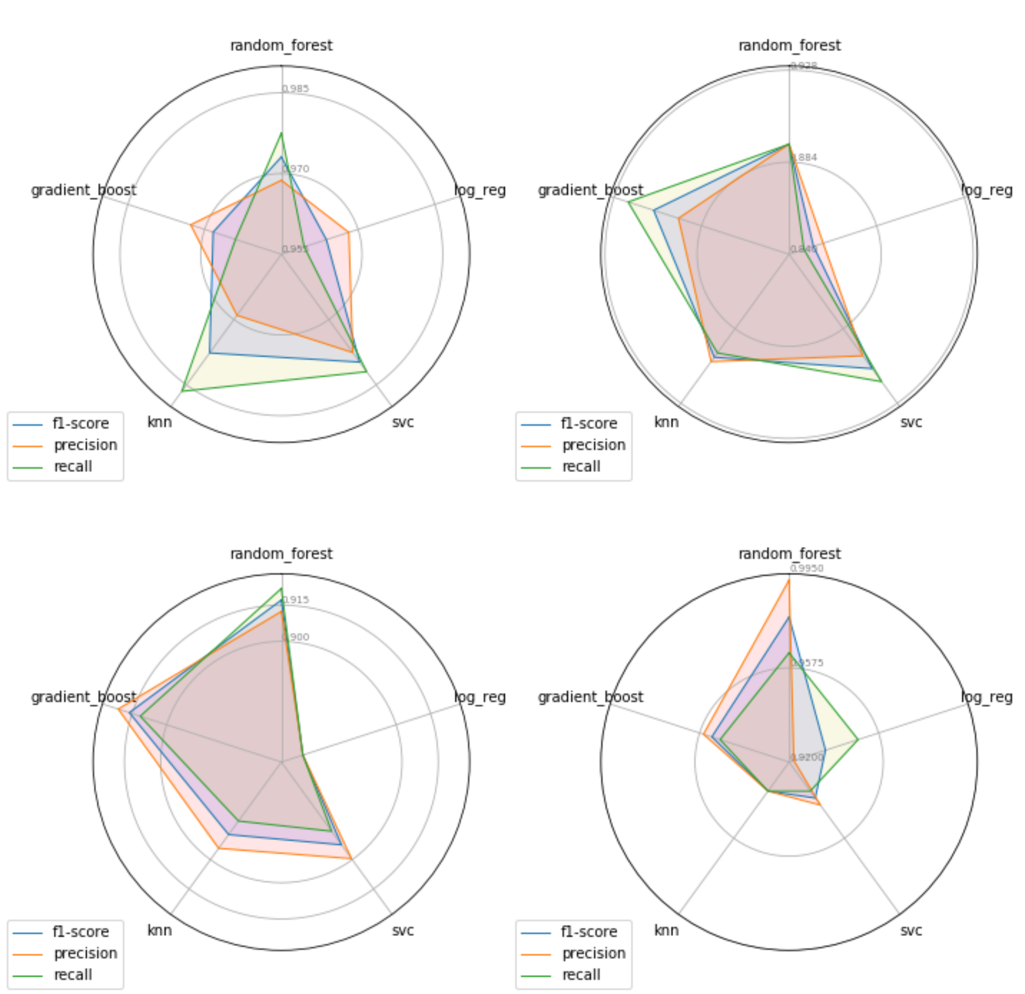


| True label \ Predicted label | 3 | 2 | 1 | 0 |
|---|---|---|---|---|
| 3 | 0.98 | 0.02 | 0.00 | 0.00 |
| 2 | 0.04 | 0.89 | 0.07 | 0.00 |
| 1 | 0.00 | 0.07 | 0.92 | 0.01 |
| 0 | 0.00 | 0.00 | 0.04 | 0.96 |

# Model Performance

- **Best Model – Random Forest**
  - Only 17 features needed
  - Highest accuracy 93.9%
  - Best at precision for low income groups 99%

- All models had over 95% accuracy & precision on high income groups
- All models had some issue with middle income groups



# Limitation & Future Work

- A lot of missing data in WDI database
- Many indicators could not be used because of missing information
- May have affected more accurate predictions

- Try using one vs. one or one vs all approach (took very long on tuning models)

# Questions?