Livius gGmbH

Creating a
"Coffee Rejuvenation Impact"
Index for Ethiopia

Prepared by Enveritas

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Background

As coffee trees age, their productive potential declines. Rejuvenation is the practice of stumping or replanting the older trees on a coffee farm. A rejuvenated tree usually produces more coffee than an old tree within three years. A rejuvenated tree may reach peak production in its fourth or fifth harvest. Definitions vary, but a tree is generally considered "old" when it is 20-25 years old.

The rejuvenation of older coffee trees is a relatively simple and low-risk opportunity for farmers to increase their coffee production and incomes. Farmers, however, may struggle to rejuvenate because of the lost income in years one and two of the rejuvenation cycle. In the major coffee areas of South and Southwestern Ethiopia, there is widespread need of rejuvenation: more than half of farmers have trees that are 20 years old or older.

We proposed the creation of a "Coffee Rejuvenation Impact" index to help prioritize the districts (woredas) that would have the greatest impact from rejuvenation. The index looks specifically at tree age / rejuvenation related factors, as well as several economic variables related to the impact potential that successful rejuvenation would have on farmers' incomes.

Finally, it is important to emphasize that this index attempts to prioritize districts in the country, as opposed to specific farms or types of farms or types of supply chains, where rejuvenation programs are more likely to be successful.

Methodology

We created a "Coffee Rejuvenation Impact" index from seven variables that Enveritas tracks in its dataset and applied it to the nine regions verified with the Livius gGmbH during the 2018/19 Ethiopian coffee harvest.

The output is a set of dynamic maps showing each indicator, normalized indices (for rejuvenation and impact), and the Overall Index.

The first step was to identify the indicators that are relevant to quantifying the potential for Coffee Rejuvenation Impact. Our hypothesis was that there are seven indicators that are most relevant:

1. Age of trees
2. Stem count
3. Past rejuvenation experience
4. Price differential
5. Altitude
6. Importance of coffee income
7. Poverty likelihood (level of poverty).

Our hypothesis was vetted by our field operations teams and data scientists, and also shared with TechnoServe coffee agronomy experts in Ethiopia.

Second, we tested different weightings for the indicators. Through this process, we arrived at a proposed weighting for the first application – and leave it possible for users to re-run the model with different weighting formulas. The indicators and selected weightings are shown in the flow chart below.
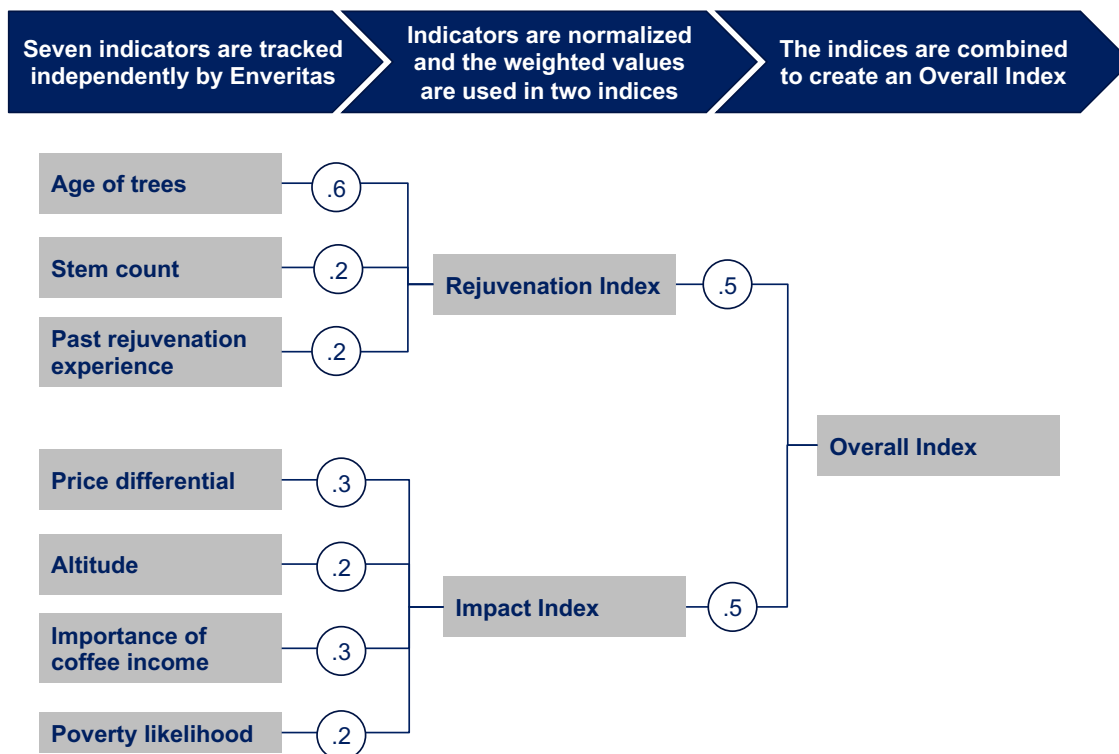
Results

In the following sections, we show the results for each of the seven components of the index as well as the overall (A) rejuvenation and (B) impact index values. Finally, we present the overall index values based on three different weighting scenarios.

Part A. Rejuvenation Index variables

1. Age of trees

This variable captures the age of the oldest trees present on the coffee farm. The overall distribution shows a median value of 20 years and mean of 24.1 years. A histogram of the distribution and choropleth map of the means by district appears as Exhibit (1).

2. Stem count

This variable captures the number of primary stems typically seen on the coffee farm. A high number of stems (above 3-4) often indicates a need for rejuvenation. The overall distribution shows a median value of 3 stems and mean of 3.2 stems. A histogram of the distribution and choropleth map of the means by district appears as Exhibit (2).

3. Past rejuvenation experience

This variable captures any past experience the farmer has rejuvenating (stumping or replanting) his or her coffee trees, based both on farmer responses and confirmation of rejuvenation practices observed by the enumerator. We observe that 77% of farms have no past experience rejuvenating and only 8% report performing some form of rejuvenation in the past year.
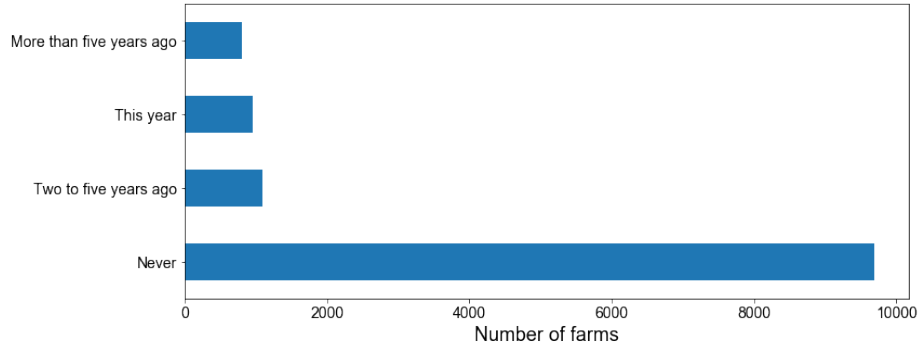

We convert this categorical variable into an 'index' by assigning points as follows:
   if s = 'this_year': 0
      if s = 'two_to_five_years_ago': 0.5
      if s = 'more_than_five_years_ago': 0.75
      if s = 'na': 1.0
A choropleth map of the mean index values by district appears as Exhibit (3) (note: high scores indicate less experience with rejuvenation).

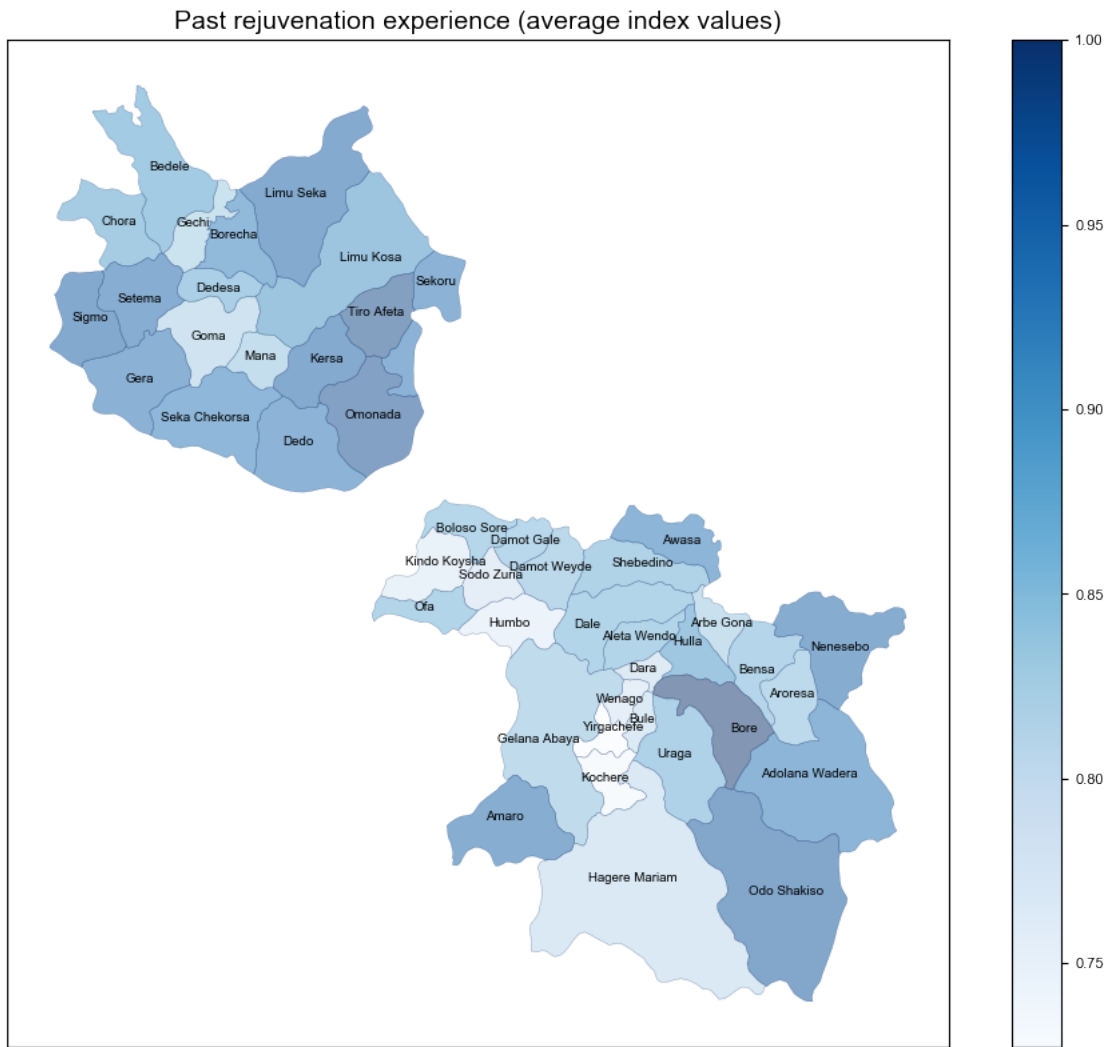**Exhibit (1) Age of coffee trees (histogram and choropleth map)**

Age of trees (years)
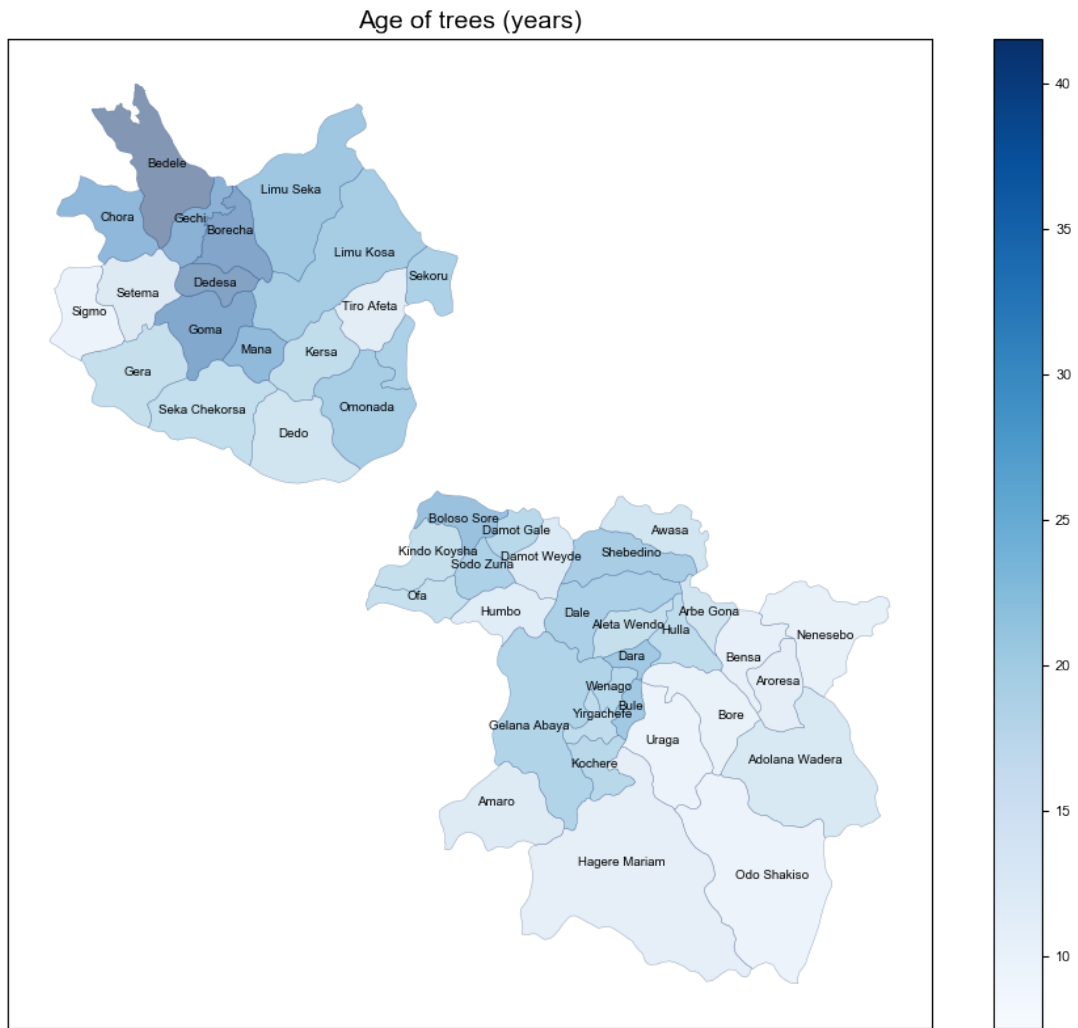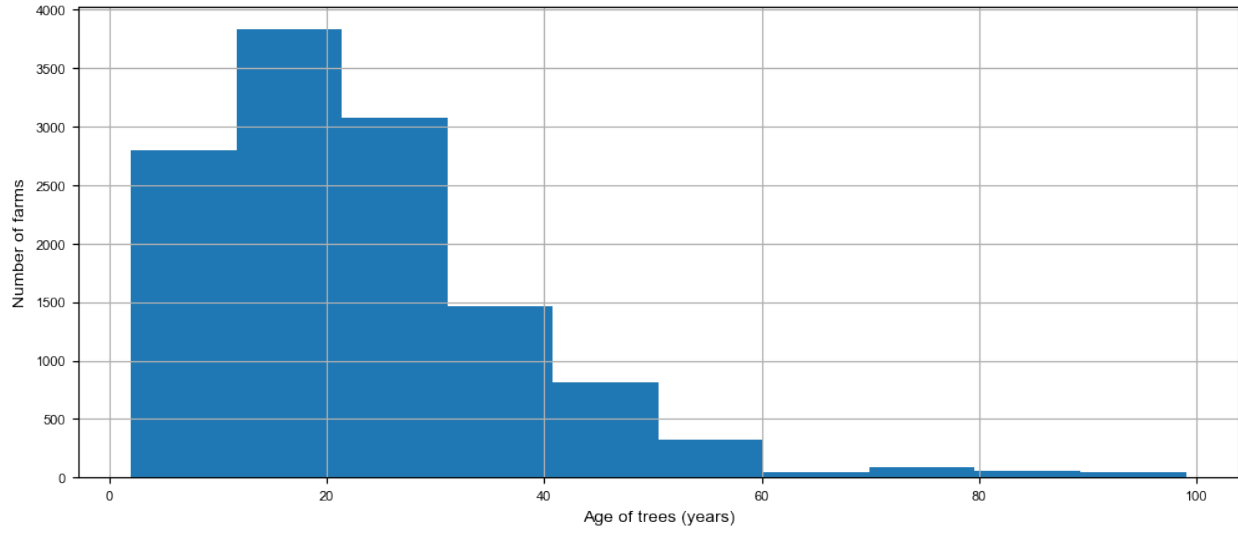
Exhibit (2) Number of primary stems on tree (histogram and choropleth map)
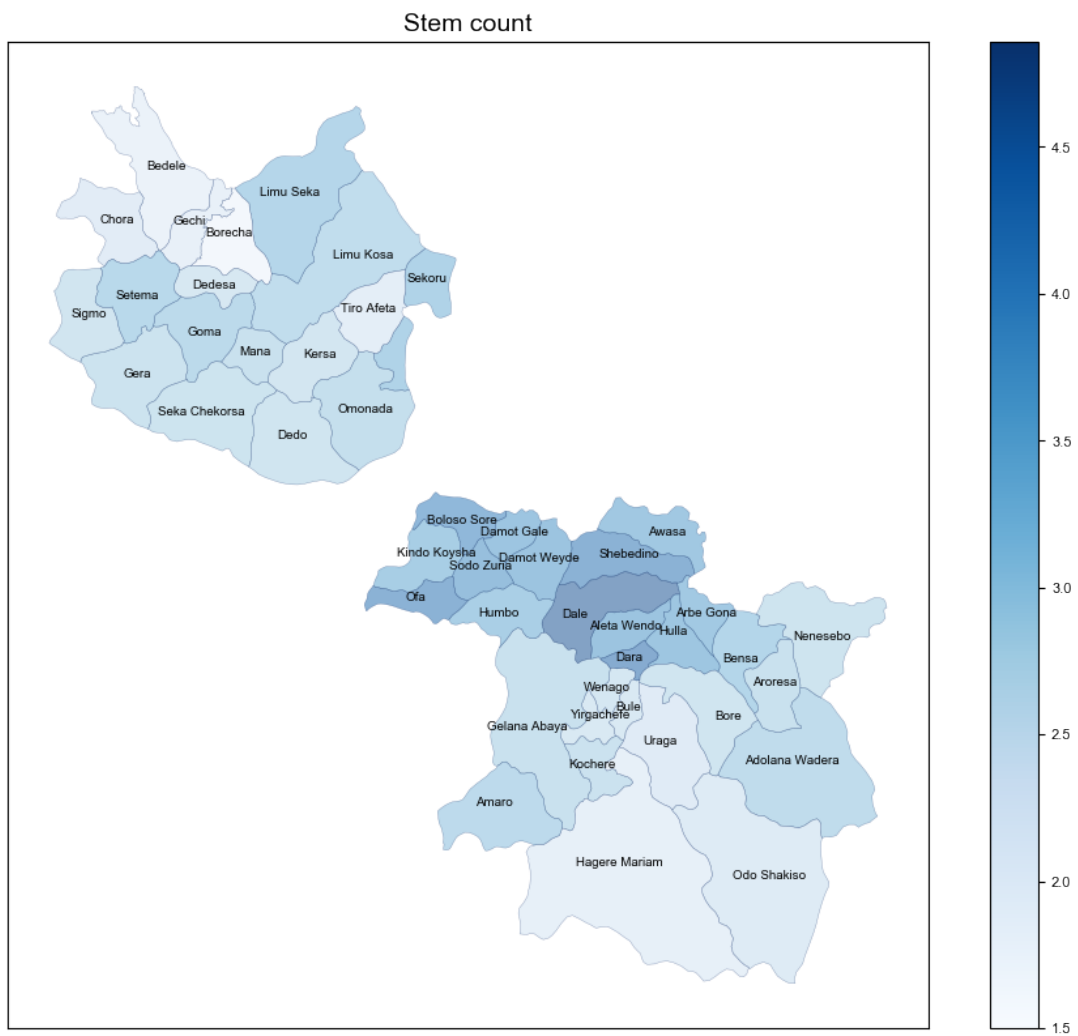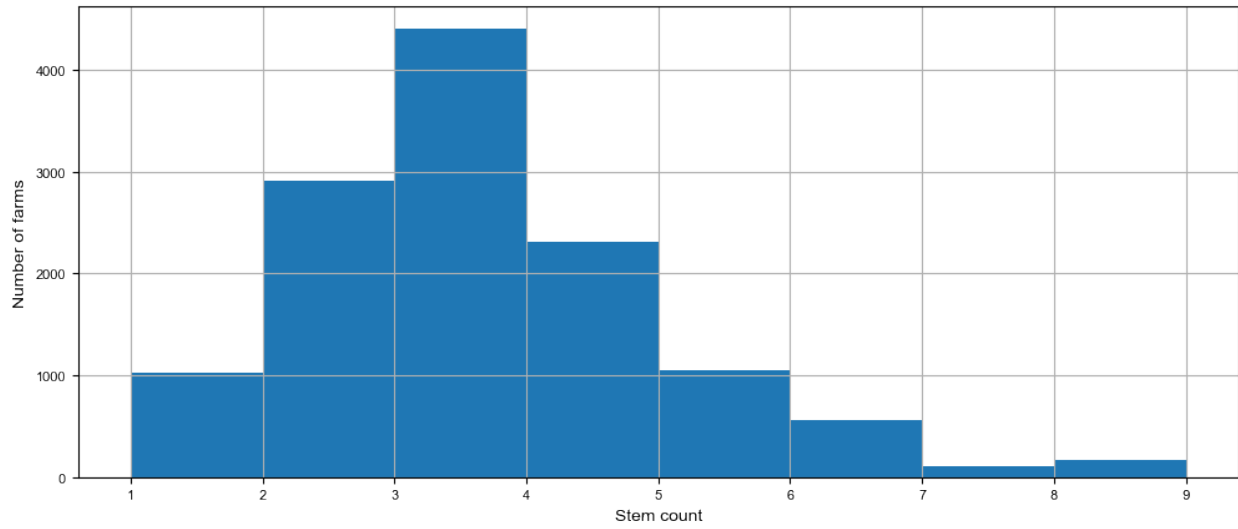
Exhibit (3) Past rejuvenation experience (index values) choropleth map
Note: higher values indicate less experience with rejuvenation


Past rejuvenation experience (average index values)

Combined Rejuvenation Index

We now combine the three variables into a single Rejuvenation Index, weighting the Age of Trees variable at 0.6 and the other two variables at 0.2 apiece. This produces a choropleth map shown below.

Exhibit (4) Rejuvenation Index values
Note: higher values indicate greater need for rejuvenation

Rejuvenation Index
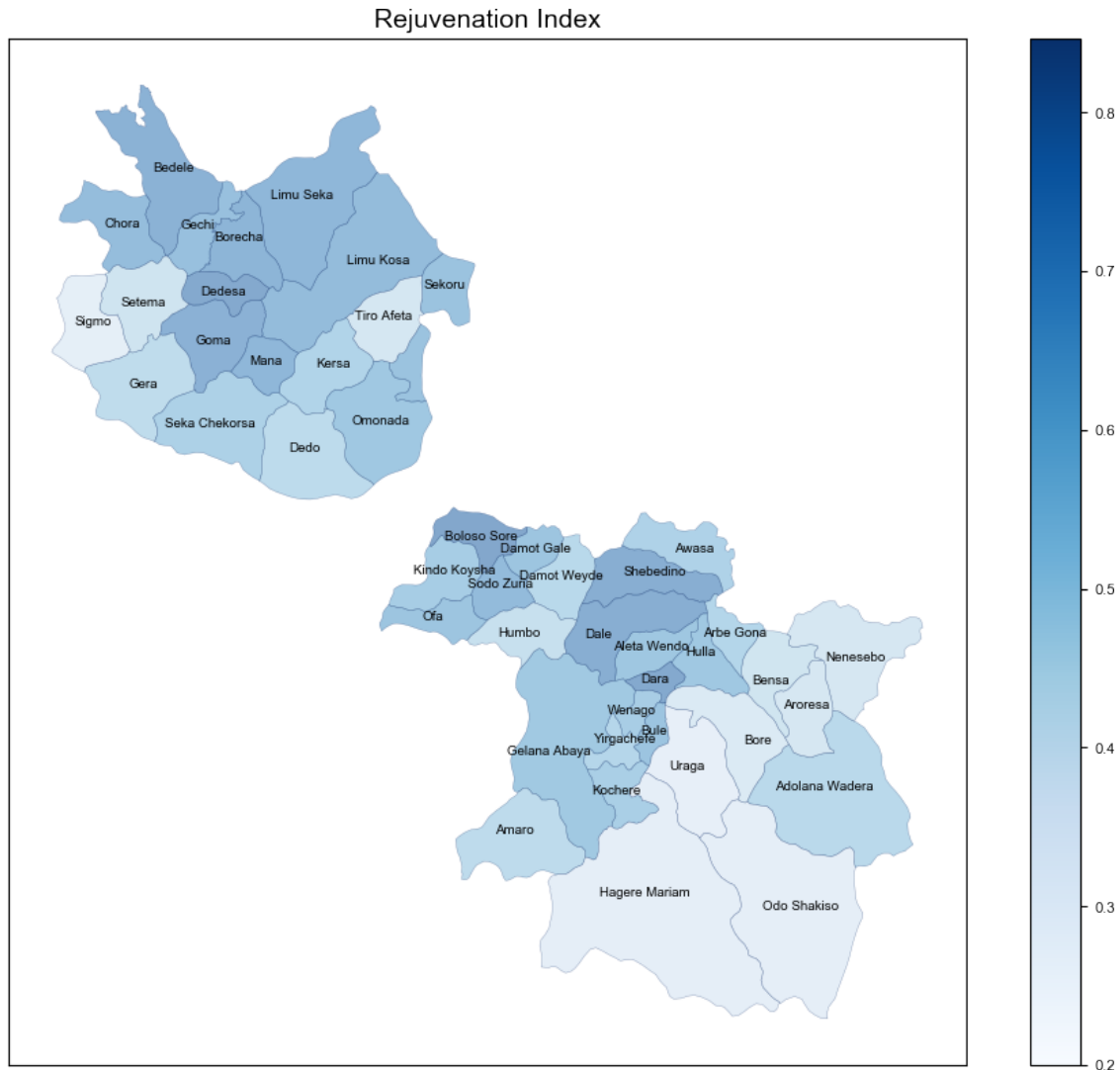
The woredas with the lowest index values (lowest need for rejuvenation) include: Uraga, Hagere Mariam, Setema-Sigmo, and Odo Shakiso. These likely indicate areas of newer coffee production. The woredas with the highest index values (greatest need for rejuvenation) include: Dara, Dale, Shebedino, Boloso Sore, and Dedesa.

4. Price differential

This variable captures the estimated export price differential on top of the underlying coffee market price (C price). Variables were assigned based on market analysis by export grade for washed coffee types (Sidamo A/B/C, Yirgachefe, and Limu). The choropleth plot below shows the estimated export price for each district.

The preference for using an export price, rather than a farm-gate price, is to indicate the *potential* for impact given that some regions are characterized by greater market demand and thus price premiums regardless of how efficient the supply chain is between farmer and export. In this way, the index tells us which regions would benefit most from rejuvenation efforts, rather than which farmers would have the greatest economic impact from rejuvenation (in which, the model would favor farms receiving higher prices, are larger, higher yielding, etc.)

Exhibit (5) Export prices associated with each region
Note: these represent market differentials on top of an average NY C price of ~$2.20/kg green

Export price (US$ per kg green)
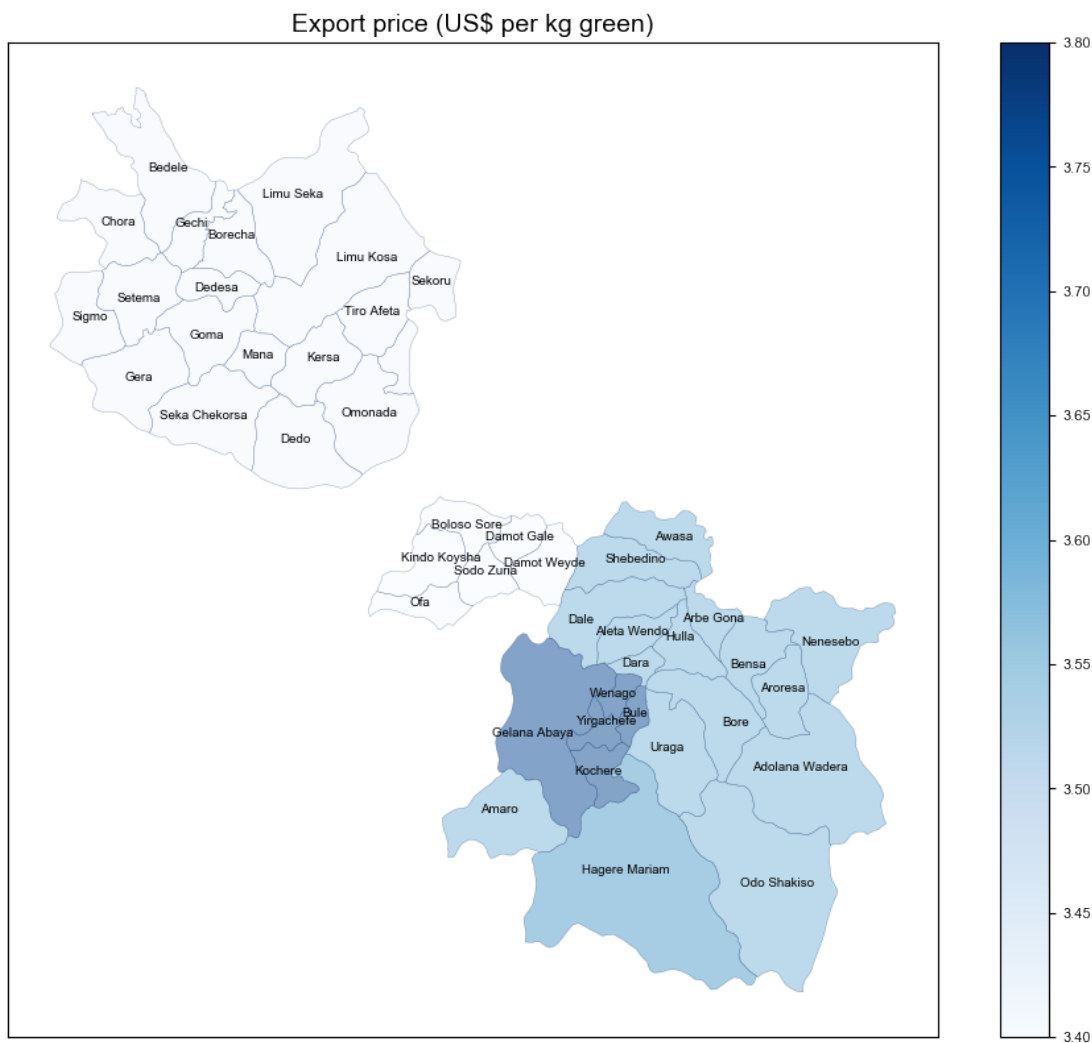
5. Altitude

This variable captures the altitude of the coffee farm in meters above sea level. Altitude is associated with higher quality, harder coffee beans. The choropleth plot below shows the average altitude for each district.

Exhibit (6) Average altitude by district
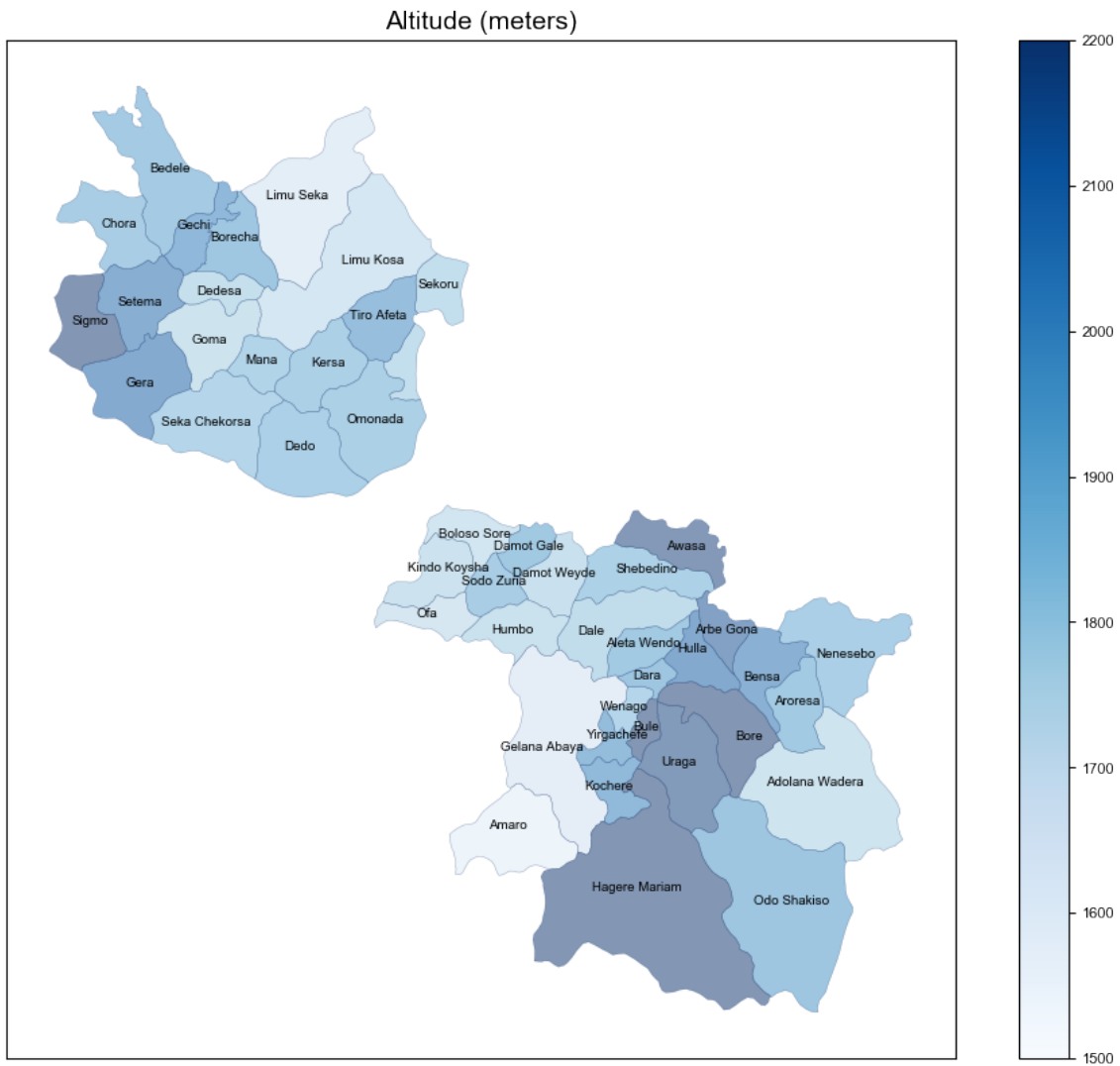
6. Importance of coffee income

This variable captures whether coffee is the household's primary source of income or not. It is a Boolean variable. The choropleth plot below shows the percent of households in each district that say coffee is the primary source of income.

Exhibit (7) Importance of coffee income
Note: this represents the share of households reporting coffee as the primary source of income
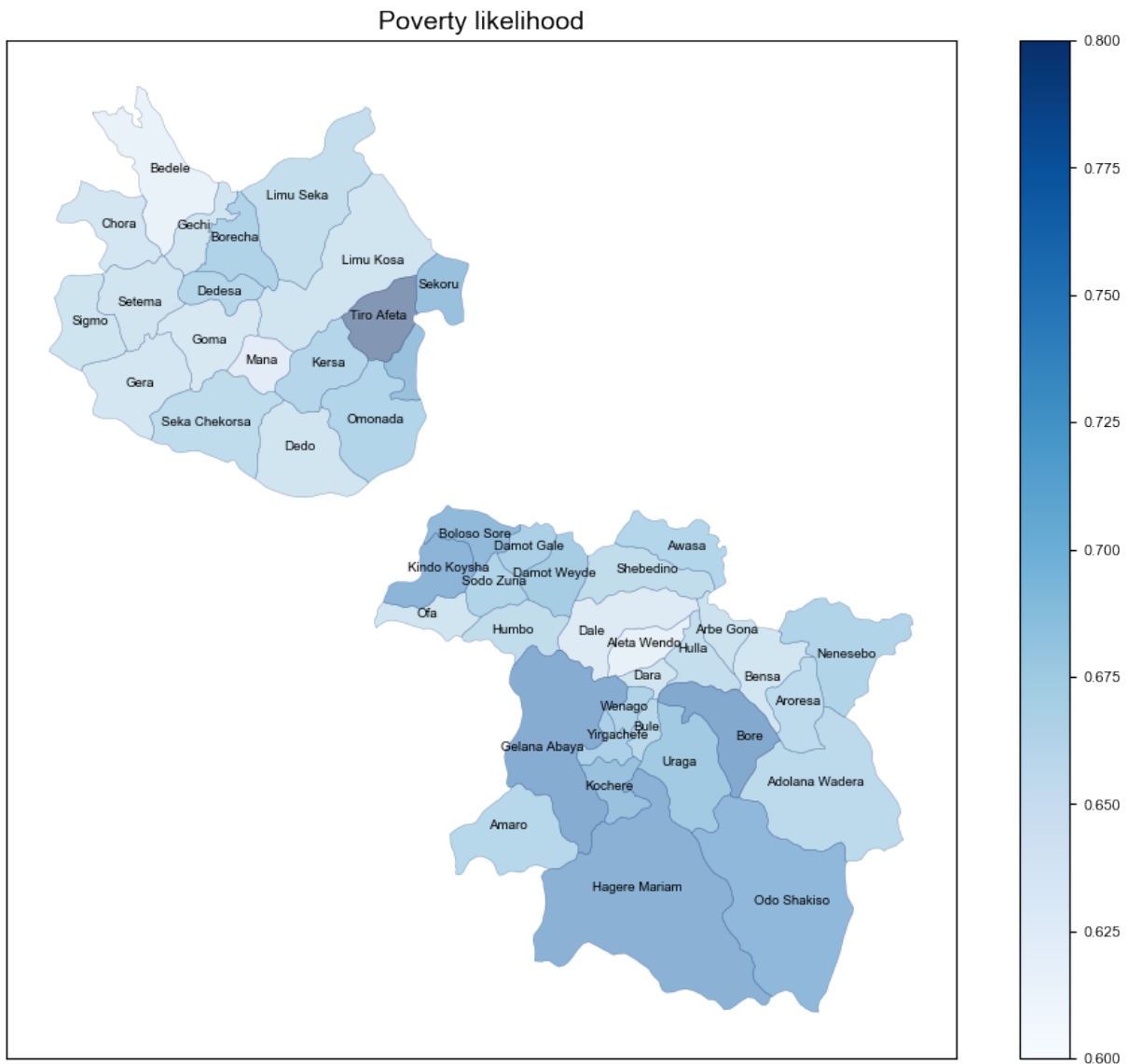

Importance of coffee income
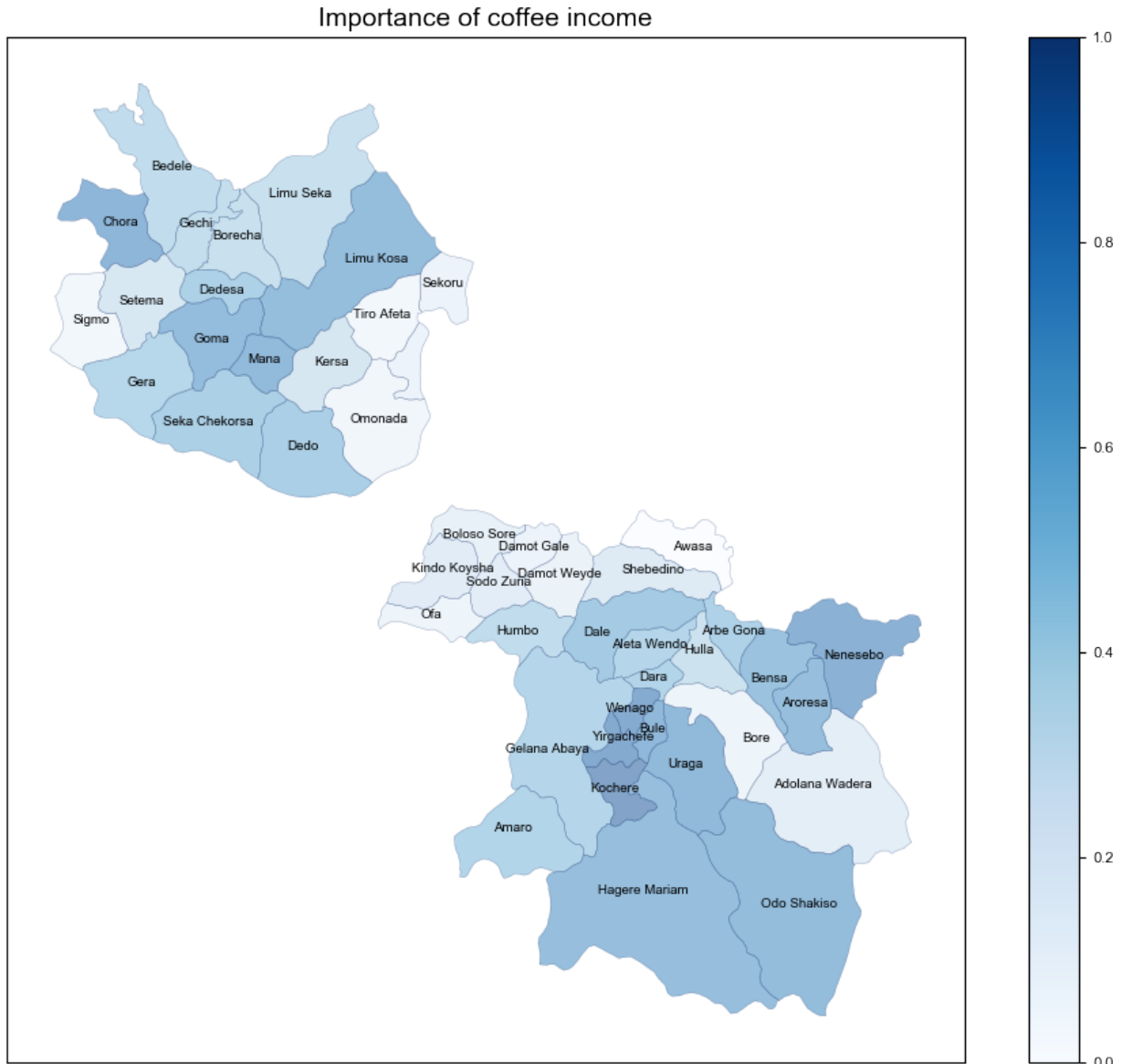
7. Poverty likelihood

The PPI score is an indicator of poverty likelihood. Higher PPI scores correlate with increase income and lower probability of being in poverty. The choropleth plot below shows normalized PPI score averages by district, inverted so that a higher score represents a *higher* poverty likelihood.

Exhibit (8) Poverty likelihood
*Note: this represents the percentage of households estimated to be in poverty based on PPI*

Combined Impact Index

We now combine the four variables into a single Impact Index, weighting the Price Differential and Importance of Coffee Incomes variables at 0.3 and the other two variables at 0.2 apiece. This produces a choropleth map shown below.

Exhibit (9) Impact Index values
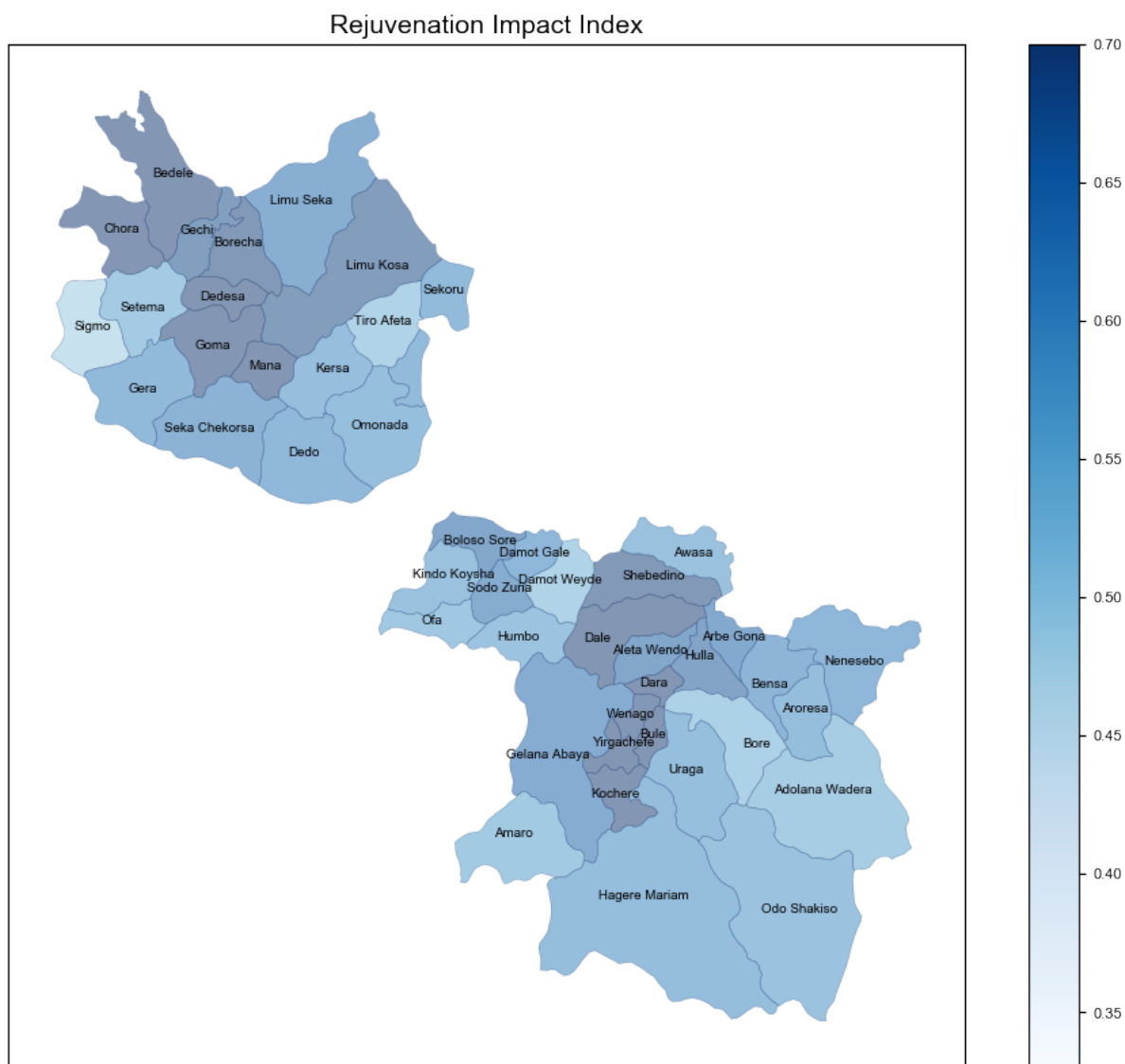*Note: higher values indicate greater impact potential for the district*
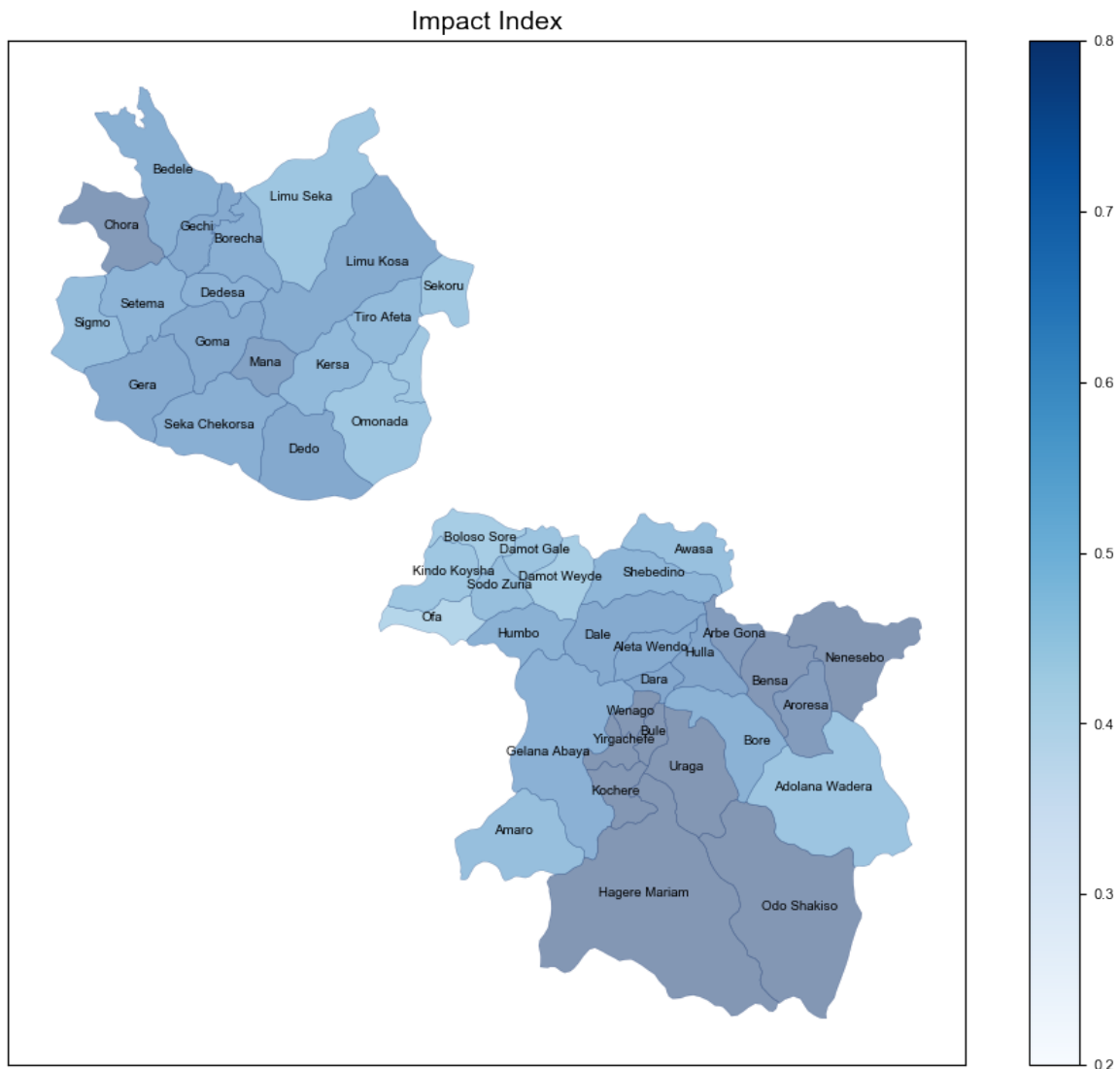
The woredas with the lowest index values (lowest impact potential) include: Ofa, Boloso Sore, Damot Weyde, Omonada, and Sekoru. These likely indicate areas with less quality / altitude potential and where coffee is more of a marginal crop. The woredas with the highest index values (greatest impact potential) include: Uraga, Bule, Kochere, Yirgachefe, and Wenago.

Overall Rejuvenation Impact Index

Finally, we can combine the Rejuvenation and the Impact indices into a single metric. This map is shown below.

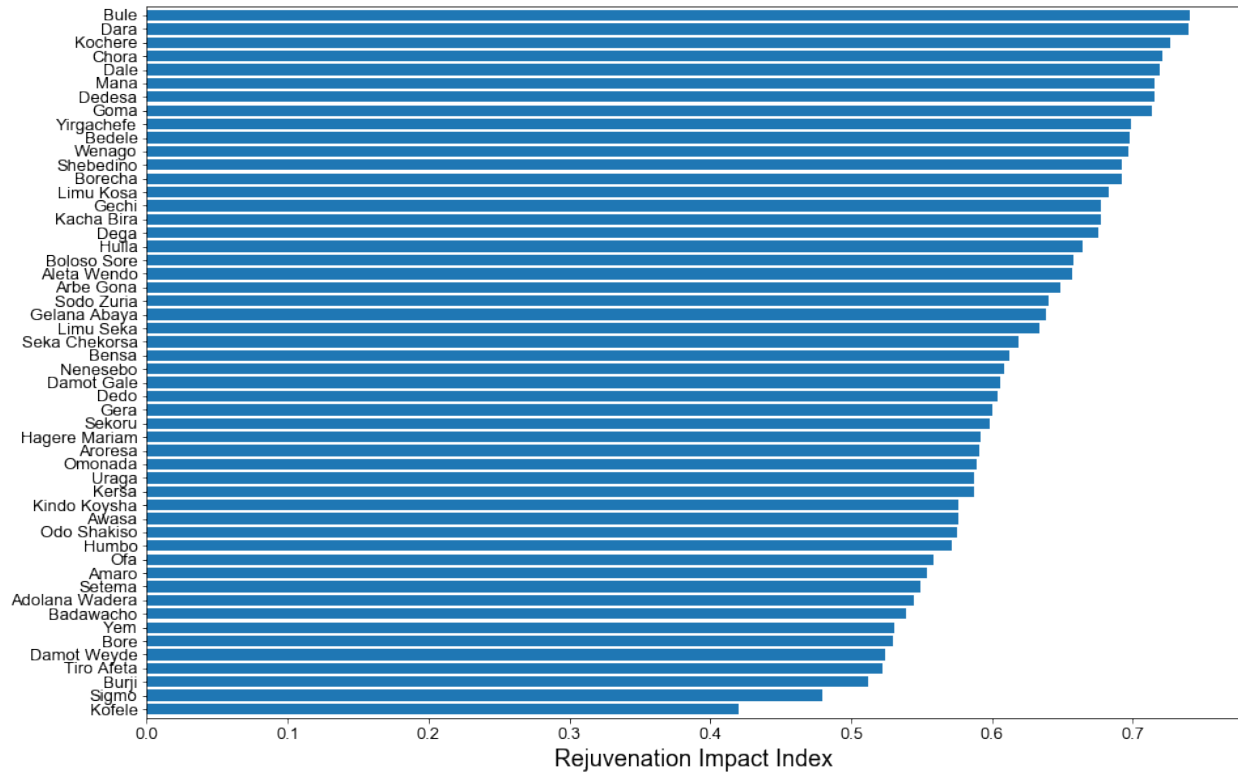**Exhibit (10) Combined Rejuvenation Impact Index values**
Note: higher values indicate greater rejuvenation impact potential for the district
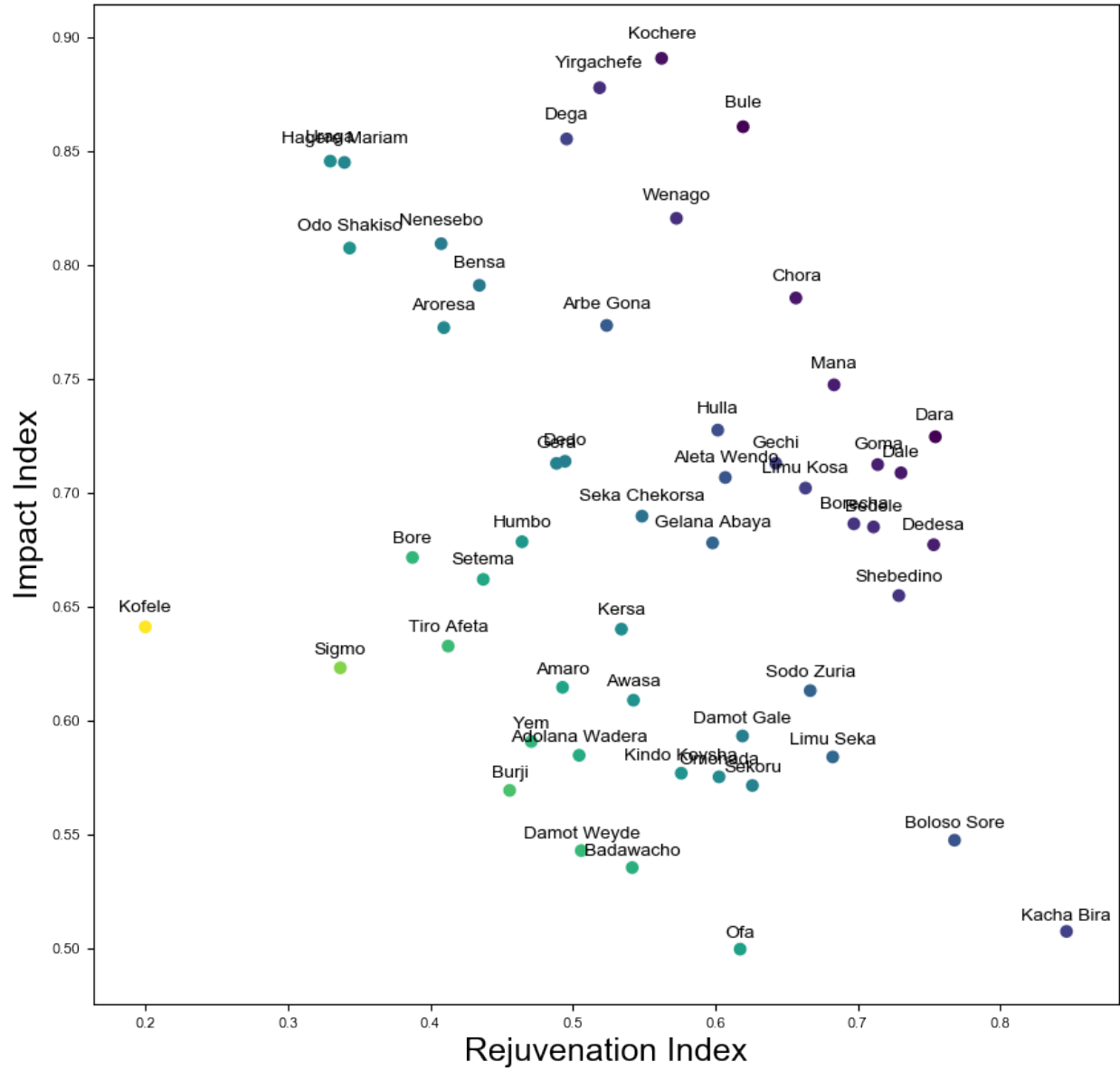
The same results are shown in barchart form below.

Exhibit (11) Combined Rejuvenation Impact Index values
Note: higher values indicate greater rejuvenation impact potential for the district

Finally, in scatter plot form showing each index value.

Exhibit (11) Combined Rejuvenation Impact Index values

Conclusion

Our analysis shows that coffee tree rejuvenation can be impactful in many districts of Ethiopia. There are important regional differences, driven by exogenous factors such as altitude and the importance of coffee farming as a source of income for the population, as well as agronomic practices and knowledge, namely old trees and high stem counts. Given that 77% of farmers in Ethiopia have not performed any rejuvenation, there is broad scope for initiatives that help farmers adopt rejuvenation practices. Additional work could be done refining the variables and weightings, and using it as a predictive or diagnostic tool in coffee communities.