Predicting Water Pump Operability in Tanzania

Claude Fried

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Problem Statement

How can we use information about these pumps to predict if they are working or not?

Goal:

- Our goal is to build a model that can accurately predict the condition of a water pump in Tanzania.

Value:

- Make data-driven decisions on how **to allocate resources** in order to maintain / fix pumps that are most in need.
  - **Save money** – spend only on pumps which are most in need of repairs.
  - **Save time** – avoid erroneously targeting pumps which are functional.
- **Improve maintenance operations** for these water pumps and significantly improve many people's quality of life.

Methodology – OSEMN

Obtain – Scrub – Explore – Model – iNterpret

1. Obtain: Gather data.
2. Scrub: Clean data.
3. Explore: Get to know the data. Engineer features.
4. Model: Train, test, validate, and compare models.
5. Interpret: Glean insights from the model's predictions.

Methodology – OSEMN

Obtain

- The data has been collected from Taarifa (*http://taarifa.org/*) and the Tanzanian Ministry of Water.
- 59,000 training data points.
- 41 original features.

Methodology – OSEMN

Scrub

Examples:

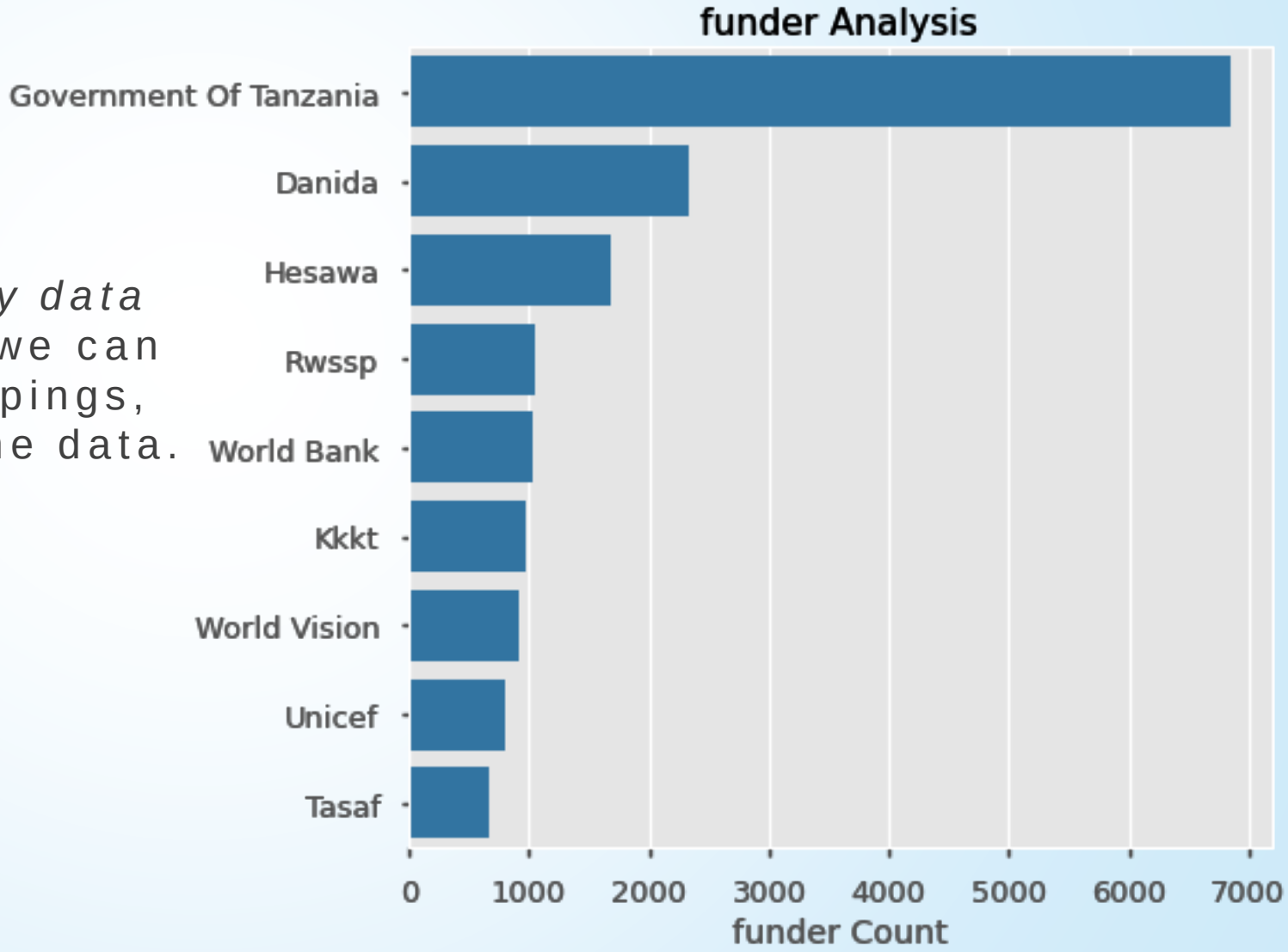
- Format each feature into the correct data-type.
  - e.g.: Is this feature numerical or categorical?

- Determine what to do with…
  1. Missing values for each feature.
  2. Numerous categories within a feature.
  3. Duplicate / similar features.

Methodology – OSEMN

Explore

Using *exploratory data analysis* (**EDA**), we can find trends, groupings, and outliers in the data.



Methodology – OSEMN

Model

The modeling process included several steps.

1. Selecting which model-types to train.
2. Searching for optimal settings for these models.
3. Creating a new model made up of these trained and optimized models.
4. *Select a final model from which we will gain insights.*

Methodology – OSEMN

Final Model – Random Forest

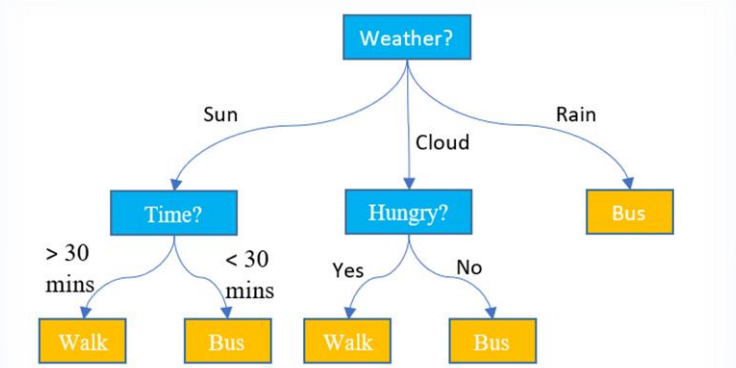
The model that best-balanced performance and speed was the **Random Forest Classifier.**

Random Forests use a collection of *Decision Trees* to make predictions.

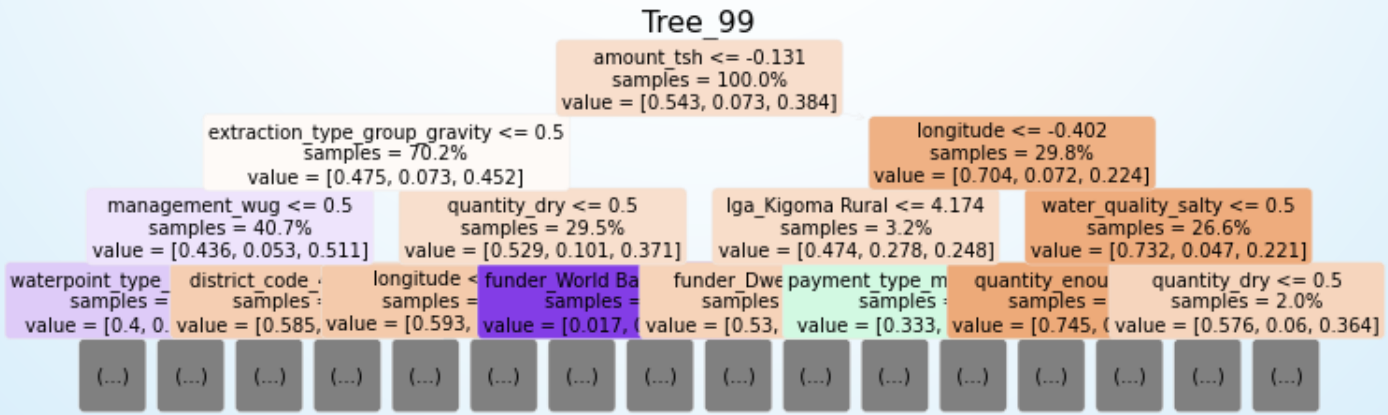
Methodology – OSEMN

Decision Trees

A *Decision Tree* takes all the data and splits it numerous times into smaller and smaller groups until each group contains only a single data point.



https://www.displayr.com/what-is-a-decision-tree/



Here are the first three splits of a Decision Trees.

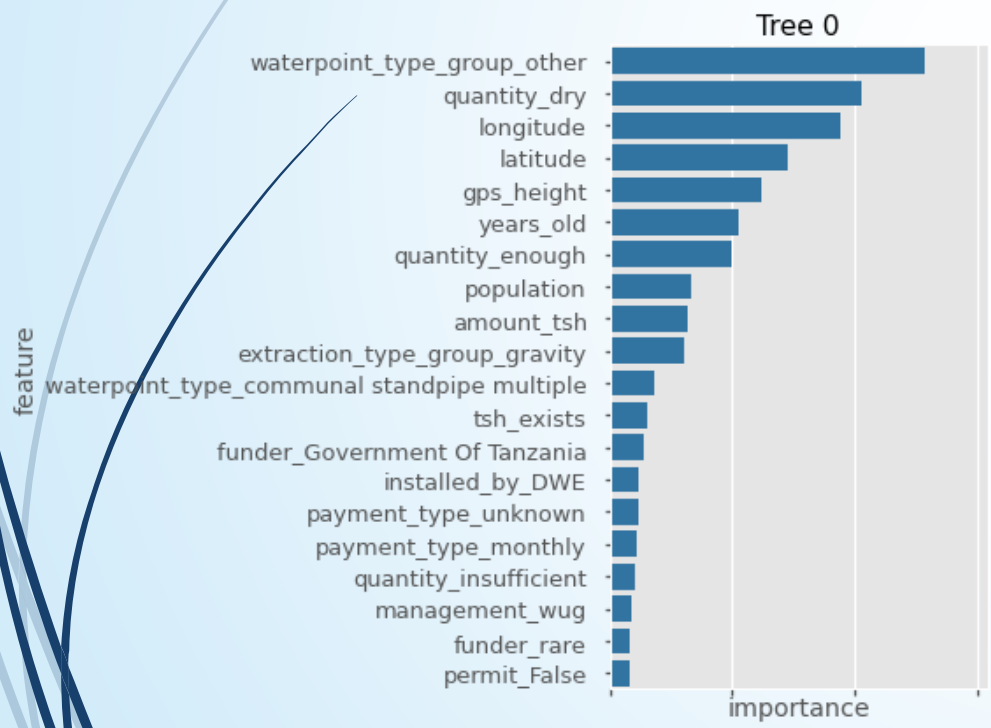
The Forest that was used to make final predictions and insights uses 100 unique trees which split the data (over 44,000 points) until each split contains a single entry.

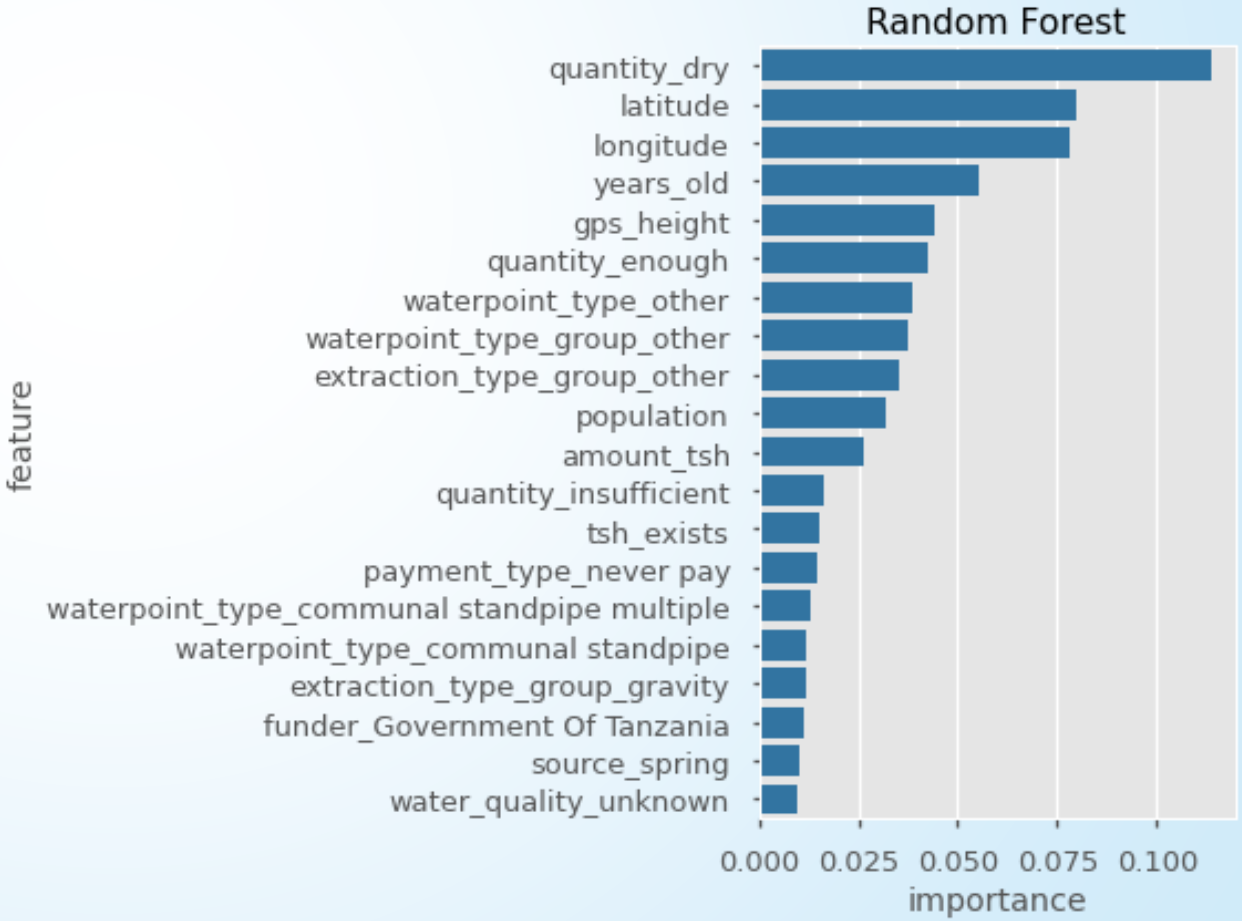
That's a huge tree!

Methodology – OSEMN

Decision Trees

Decision Trees and *Random Forests* can show the most important features that they used to make their predictions.





Methodology – OSEMN

Interpret

- One of the great advantages of a Random Forest Classifier is its **interpretability.**
- Because of its method of classification (using splits of the data), the most vital features can be easily obtained.
  - A Random Forest using ***all 137 features*** of the data scores **81% accuracy**.
  - A Random Forest using ***only the 11 most-important features*** still performs very well **(79%)**

Recommendations

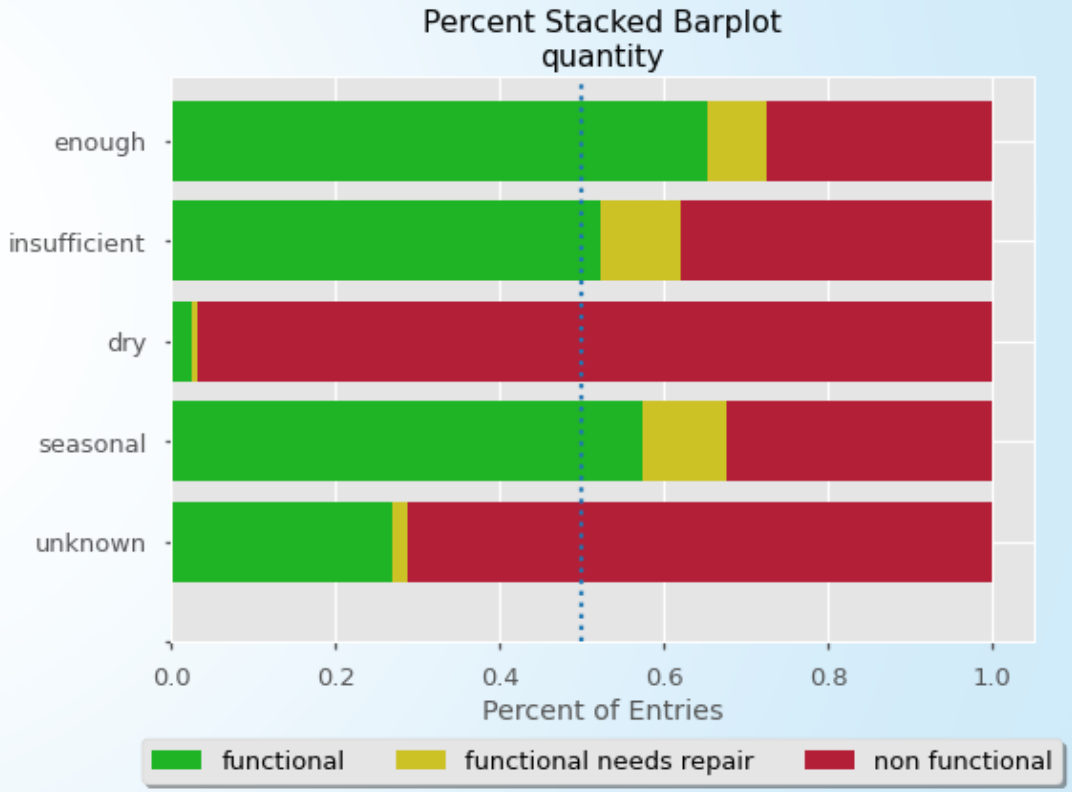
The 5 most-important features to determine whether a well is functional are:

1. Quantity - dry: Is the well dry or not?
2. Latitude: Geographical latitude of the well.
3. Longitude: Geographical longitude of the well.
4. Years old: How many years ago was the well installed?
5. GPS height: Altitude of the well.

How can I tell if a well is functional?

Recommendations

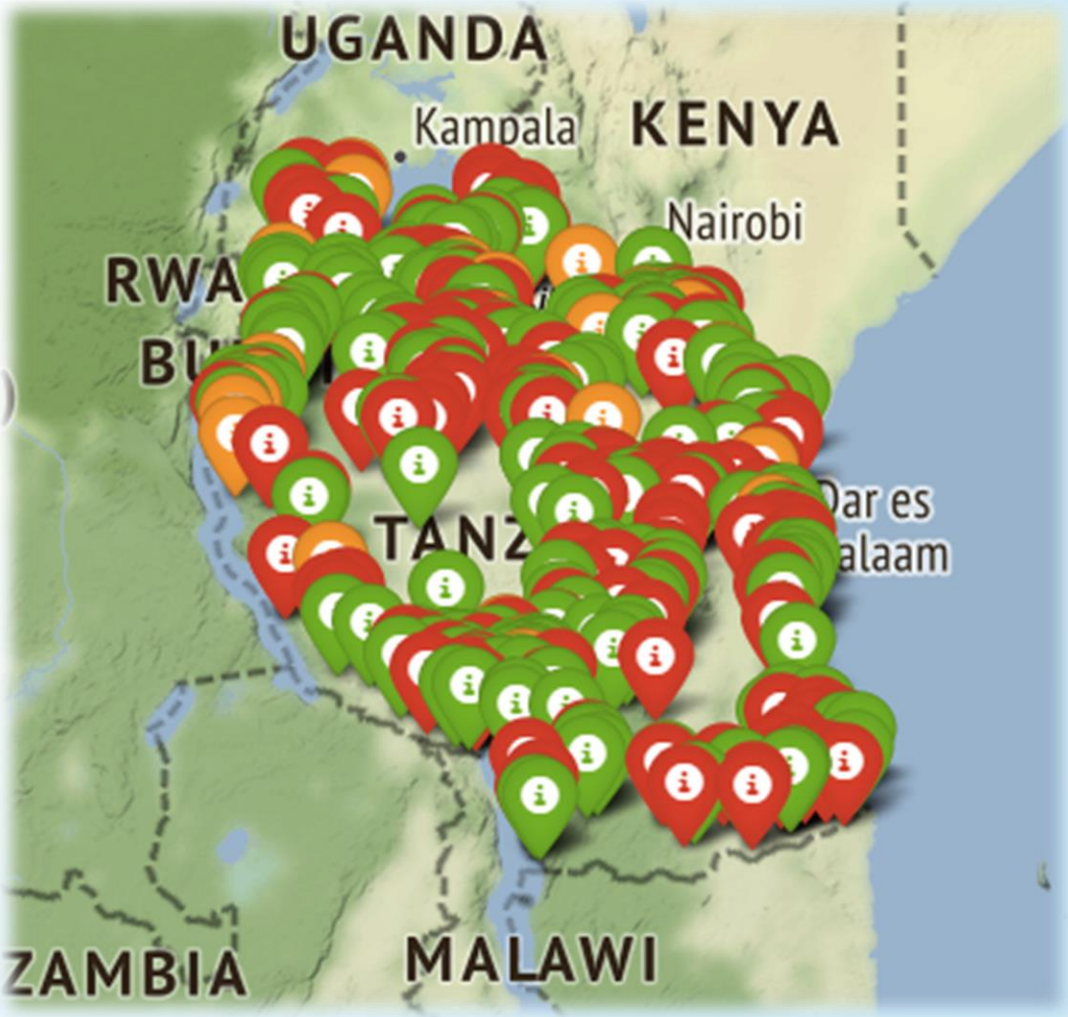
1. **Quantity**: Look for wells that with dry or unlabeled water quantities.
   - Wells that are labeled as **dry** are almost all *nonfunctional*.
   - Conversely, less than 25% of wells that have **enough** water are *nonfunctional*.
   - Note: The missing values for this feature are not missing at random (i.e.: when the label is **unknown**, it is much more likely to be *nonfunctional*).



How can I tell if a well is functional?

Recommendations

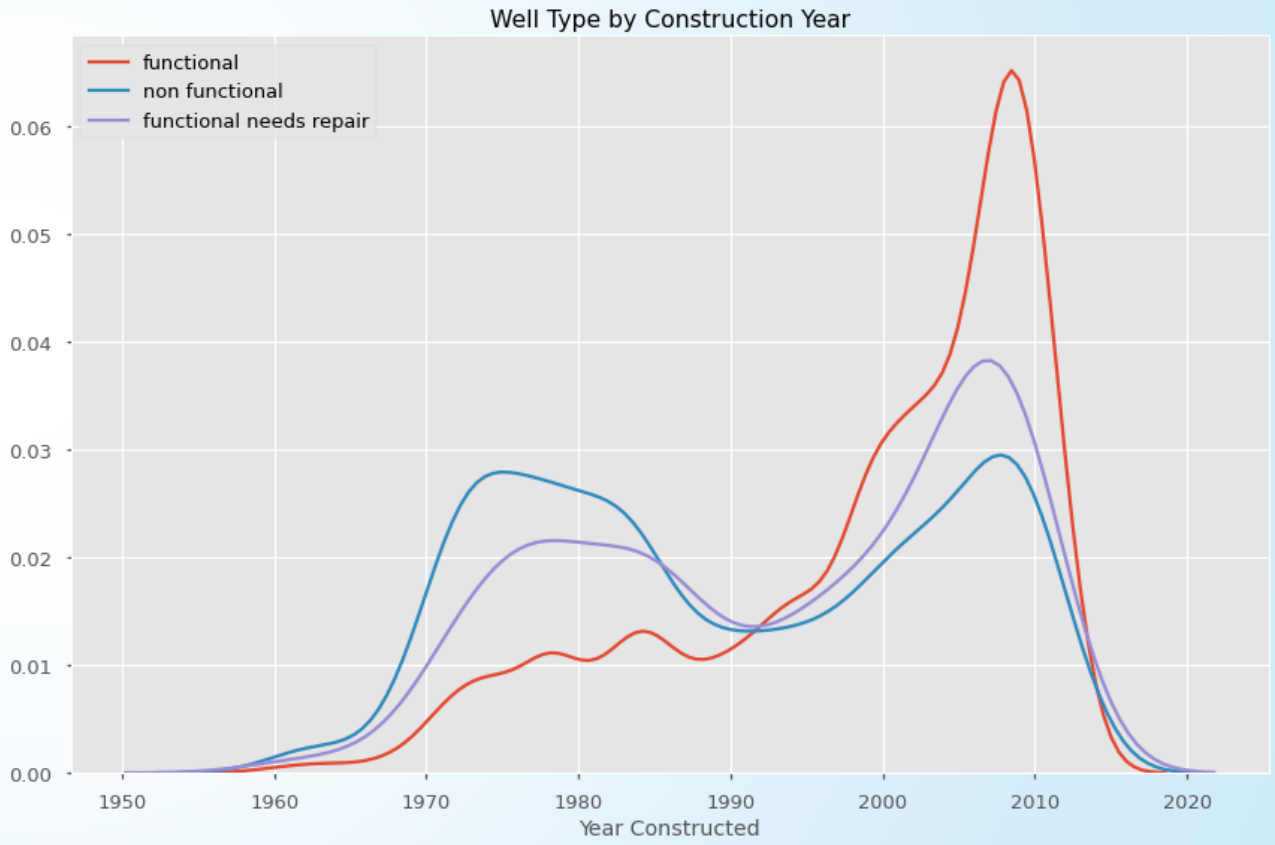
2. **Latitude / Longitude**: While there are functional and *nonfunctional* wells spread over the country, there do seem to be "pockets" of non-functional wells. This could be due to the water source or other geographical features of an area.
    - If there is a pocket of *nonfunctional* wells in an area, other wells in the same area might be *nonfunctional* as well.



How can I tell if a well is functional?

Recommendations

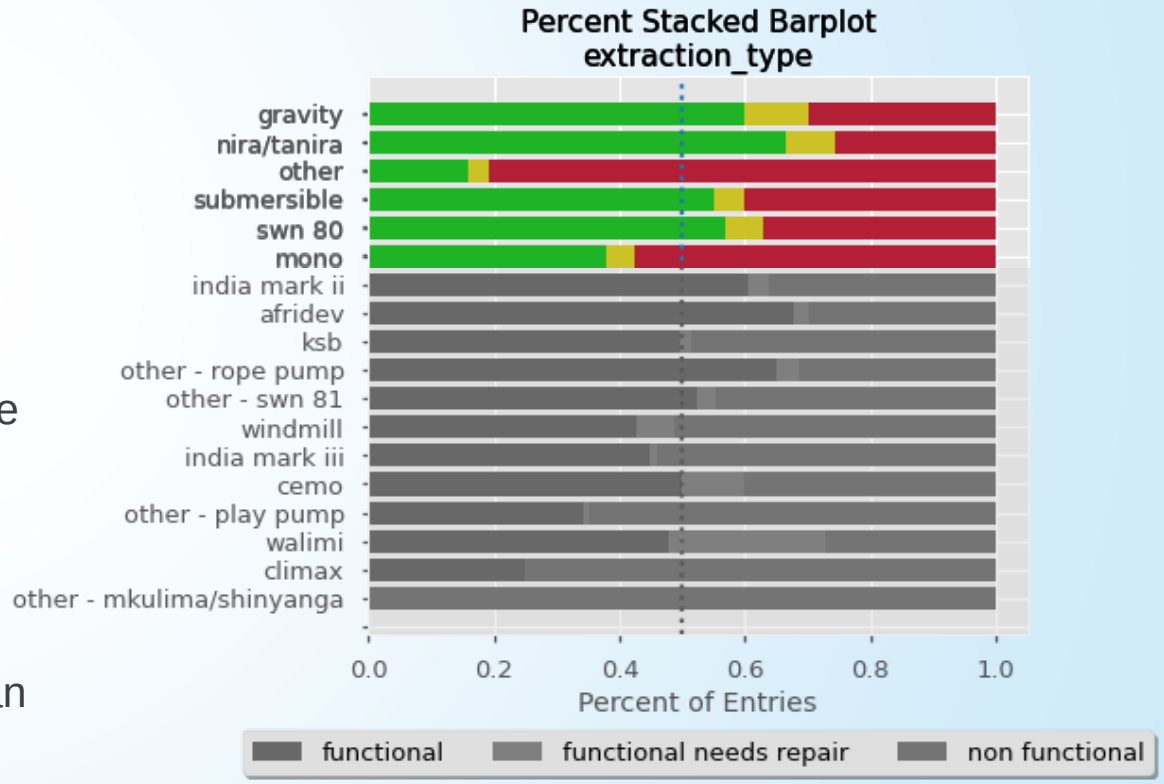
3. **Years Old**: Look for older wells (especially built before 1990).
   - As the construction year increases, the wells become much more likely to be functional.
   - Wells built before **1990** are more likely to be *nonfunctional* or *needing repair*, while after 1990 are more likely to be *functional*.



How can I tell if a well is functional?

Recommendations

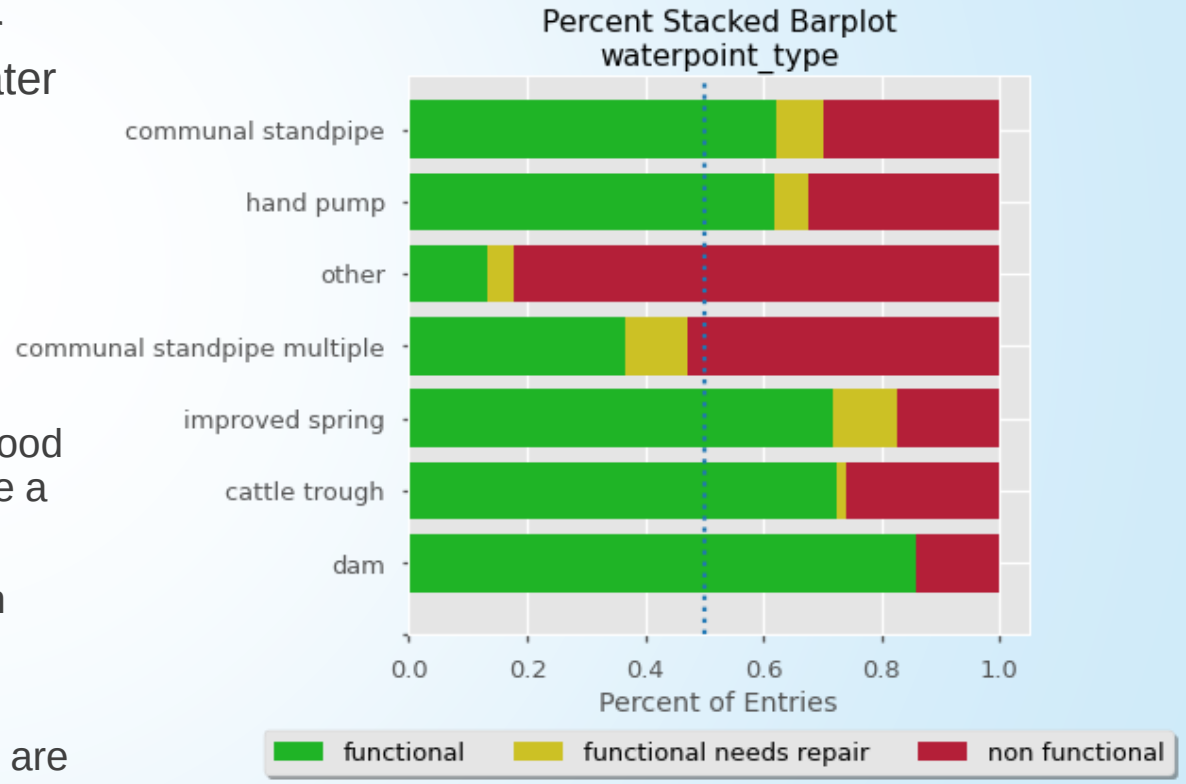
4. **Extraction Type**: Determine the extraction type.
   - **Gravity** pumps (the most common) are 60% likely to be *functional* and 25% to be *nonfunctional*.
   - The most common type or well to have more *nonfunctional* wells than *functional* is **mono**. These have over a 60% chance to be at least *in need of repair*.
   - Note: Wells that are labeled **other** have a much higher likelihood of being *nonfunctional* than otherwise.



How can I tell if a well is functional?

Recommendations

5. **Waterpoint Type**: Find wells that have less common waterpoint types (other than a communal standpipe) for greater likelihood that it will need repairs.
   - The most common **communal standpipe** is over 60% likely to be *functional* and 25% to be *nonfunctional*.
   - Having a **communal standpipe multiple** though increases the likelihood of the pump being *nonfunctional* quite a lot.
   - If the waterpoint type is less common (marked **other**), it is almost certainly (over 80%) *nonfunctional*.
   - It seems that **improved spring** wells are the most likely to need repairs (these waterpoint types may require more frequent maintenance than others).



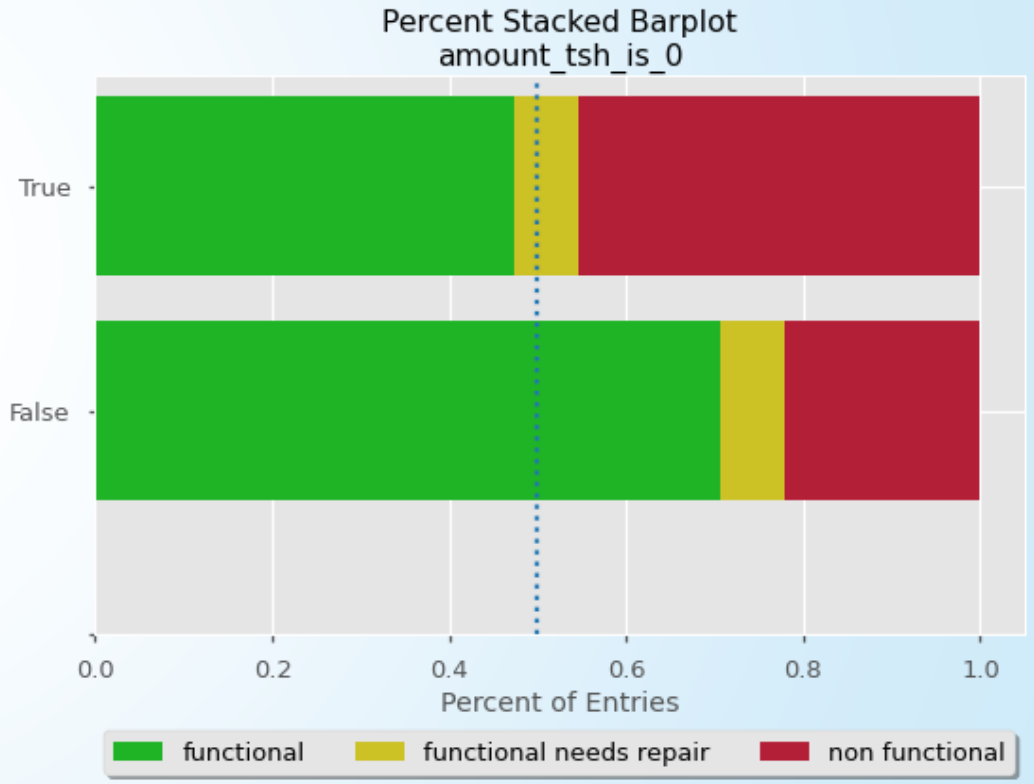
How can I tell if a well is functional?

Recommendations

6. **Amount Total Static Head**: Most wells have 0 total static head (available static water), but some have as much as 200,000 units.

   Wells that have 0 **tsh** are much more likely to be *nonfunctional* compared to wells with more than 0 **tsh**.

   - As a general principal, the greater the **tsh**, the more likely it is to be *functional*.



Next Steps

- Dive deeper into the **location** of each well.
  - Are there regions where certain well-types work best?
  - Are certain water-sources likely to run dry soon?
  - Are there geographical features (mountains, deserts, plains) that impact the wells' condition?
  - Are wells within a close vicinity to one another more likely to be nonfunctional?

Thank You!

- Flatiron School
- Taarifa (*http://taarifa.org/*) and the Tanzanian Ministry of Water.