The Impact of Food Loss and Food Waste in Africa

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Ram Ben-David, Jordan Meyer, Justin Peabody, and Julie Oxenhandler

Overview

Background

For many Americans, particularly those living in urban areas, it can be hard to believe that a majority of the world's 570 million farms (more than 90%) are run by an individual or family. These small farms are estimated to produce about 80% of the world's food (FAO 2020). What's more, over one billion people are employed within the agriculture industry. In areas of Africa, 60% of the labor force claims farming as their profession (FAO 2020). As with any industry, loss and waste are of serious concern - impacting the quality of the crop, profitability, and stability of employment for staff. However, food scarcity and insecurity are global issues, currently impacting 820 million people worldwide (WHO 2019). Agriculture impacts everyone, from consumers' dinner options to a country's GDP.

Importance of Topic

In many African countries, agriculture makes up a substantial portion of the Gross Domestic Product (GDP). In recent years, climate change has made farming even less predictable. Irregular weather patterns lead to increased average temperatures, less precipitation, more severe droughts, and an increased potential for food loss and waste. Moreover, efforts to maintain desired levels of crop production also contribute to global warming. This vicious cycle has the capacity to be extremely detrimental, not just in Africa, but at a global scale if left unaddressed.

Research Questions

Primary Research Question

How has food loss in Africa changed over time?

Secondary Research Questions

How have these changes impacted the country's GDPs?

How does a nation's fragility impact food loss within that country?

Key Terms

Understanding the distinction between food loss and food waste is crucial to any discussion concerning agriculture. According to the Food and Agriculture Organization of the United Nations (FAO, 2020) food loss and food waste can be defined as follows :

Food Loss is the decrease in the quantity or quality of food resulting from decisions and actions by producers. Food loss occurs from post-harvest up to, but not including, the retail level.

Food Waste refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers. Food is wasted in many ways:

- Fresh produce that deviates from what is considered optimal, for example in terms of shape, size and color, is often removed from the supply chain during sorting operations.

- Large quantities of wholesome edible food are often unused or left over and discarded from household kitchens and eating establishments.

Another key term that merits a definition is the Gross Domestic Product (GDP), which The Economist (2020) defines as:

Gross Domestic Product (GDP), a measure of economic activity in a country. It is calculated by adding the total value of a country's annual output of goods and services. GDP = private consumption + investment + public spending + the change in inventories + (exports - imports).

Fragility: A state that is fragile has several attributes, and such fragility may manifest itself in various ways. Nevertheless, some of the most common attributes of state fragility may include:

- The loss of physical control of its territory or a monopoly on the legitimate use of force;
- The erosion of legitimate authority to make collective decisions;
- An inability to provide reasonable public services;
- The inability to interact with other states as a full member of the international community.

Methodology

Deciding to focus on food loss and food waste over time as a starting point provided several different avenues that needed to be explored to narrow our focus. Food loss and food waste can occur for so many reasons - weather, poor crop management, and inability to sell the crop before it goes rotten. Additionally, food loss and food waste can impact a country's GDP, labor force, and ability to ensure citizens of the country have adequate access to food.

In order to focus our exploration, we decided early on that narrowing our data set from global to African countries would allow us to provide a more cohesive analysis. Within the data available from the FAO on food loss and waste, African countries have the most consistent and comprehensive data available. Given that many African countries rely on agriculture as a dominant source of economic growth and labor, this wasn't too much of a surprise. The FAO data could be further checked for accuracy by utilizing the data provided by AFLIS. With these two data sources merged, we could begin to pull in additional data points for comparison.

The World Bank was the most reliable, accessible data source to explore the GDPs of African countries over time. This leads us to ask - how much of an impact does food waste and food loss have on countries whose GDPs are agricultural? To answer this question, we first needed to determine how much money was lost each year due to food waste and food loss. Further, we needed to convert these losses to be a percentage of the GDP for each country, to allow us to take into account the varying GDPs for each country.

Additionally, we looked at prices for major crops. After comparing multiple data sources, it was clear that the data was inconsistent. To address this we took the mean crop price across African countries, when available. To further focus our research, we determined that it would be best to focus on an even smaller subset of African countries and the crops with the largest production data. To help influence our choice in countries, we also consulted The Fund for

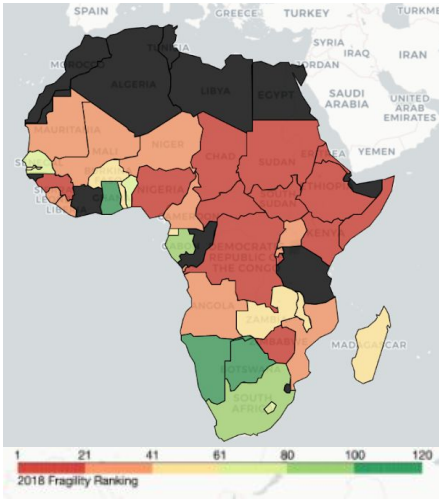
Peace's Fragile State Report. In the sections of the report that follow, we'll explore, in depth, the impact that food loss and food waste has on our sample of African countries. Given the diversity of our sample, we'll conclude with recommendations and next steps both for further research suggestions that could be extrapolated to countries across Africa, as well, as non-African countries that also have largely agricultural economies.

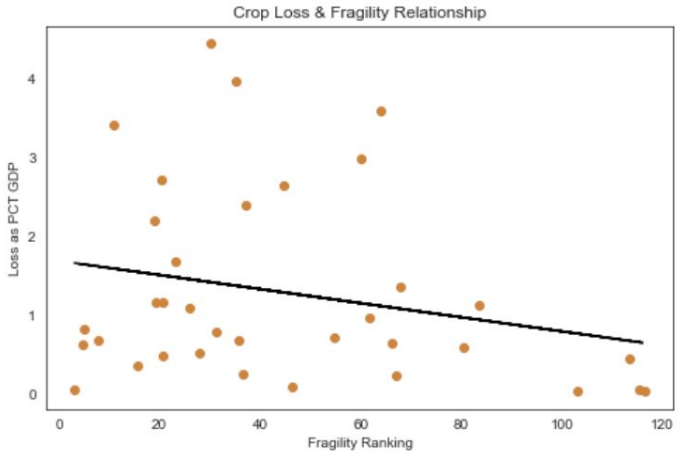
We intended to investigate potential causes of crop loss and hypothesized climate and infrastructure to be leading contributors. For climate, we wanted temperature and precipitation time series data, but ran into issues accessing accurate data for impacted African countries. We were able to overcome this issue by utilizing an international disaster database which tracked droughts and other weather related climate events (International Disaster Database - EM-DAT) - the drought data by country by year enabled us to perform an exploratory analysis.

What Did We Learn From the Data?

As with any externally collected data source, we had to approach the data knowing that it might not be comprehensive. To begin, we determined which African countries we would choose to focus our analysis on. Figure 1 shows the fragility rankings of countries in African that have comprehensive crop loss data. The color gradation visually indicates the stability level (yellow to red scale), as well as, countries that have been omitted from this portion of our analysis (muted gray). The fragility ranking, determined by The Fund for Peace, uses Cohesion, Political, Economic, and Social Indicators to determine a country's fragility score. Scores are compared to across 180 countries to produce each country's fragility rank. Of note, Figure 1 shows a rank scale of 1 - 120, indicating that no African countries have a rank higher than 121. Additionally, it is worth noting that the higher the rank, the more stable the country. This is not a particularly intuitive interpretation, leading us to ensure that the color gradation - red to yellow - associates lower rankings with the color red to indicate less stability within a given country.

Figure 1a: Fragility Ranking of African Countries with Crop Loss Data[1] (left)
Figure 1b: National Crop Loss vs Fragility (right)





1 - Please see Appendix A for a comprehensive list of African countries

A country's stability may indicate their ability to ensure less food loss and also impact whether or not their GDP will be higher or lower in a given year. With these questions in mind, we began to further explore crop prices, percent of GDP that is classified as agricultural, and the impact of weather and natural disasters on these counties. Our assumption at this point in our research is that less stable countries will have more food loss and worse / downward trending GDPs.

Figure 2a: Global Percentage Contribution of Agriculture to Total GDP

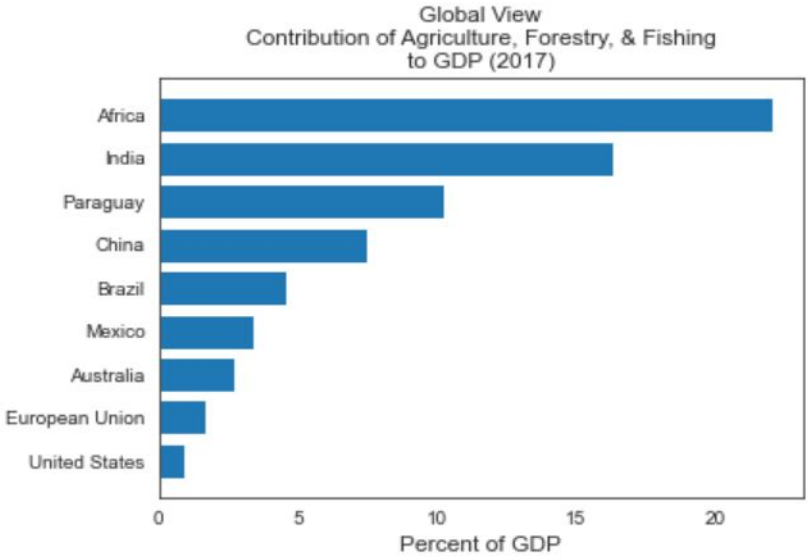
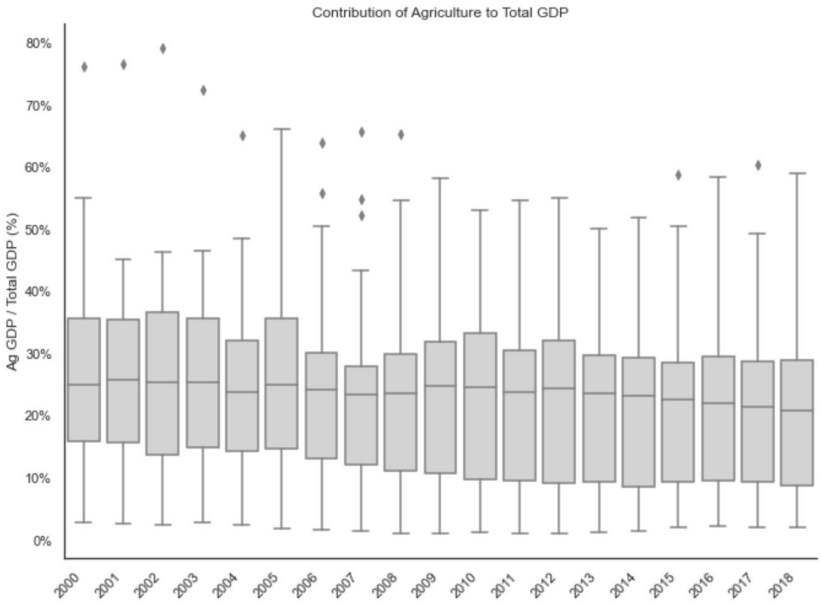


Figure 2b: Annual Contribution of Agriculture to Total National GDP



Of particular note, is the disproportionate skew of how largely agriculture influences the GDP of countries in Africa versus other countries around the world. Figure 2a, illustrates the percentage of GDP that consists of economic activities that are classified as agriculture in 2017. This relationship has been decreasing slightly from year to year (Figure 2b). African countries

are, unequivocally, relying more heavily on agriculture to create jobs and generate income than other countries globally.

Knowing that the GDP comprised more heavily of agriculture in African countries, merits further exploration into how this impacts commodity pricing. Take for example, the price of maize in Africa, relative to the global price, as shown in Figure 3a. Maize prices in Africa are consistently above the global average. This implies that a larger loss of crops, maize for example, will have a more significant financial impact on African countries. Furthermore, it also suggests that there may be an exaggerated influence from weather and natural disasters in Africa relative to the rest of the world.

To explore the financial losses per crop type, we required the prices of the crops. The Aphlis data contained prices for some countries, but not all. As mentioned above, the global prices were typically cheaper than the prices available from Aphlis (Figure 3a). Therefore, for consistency across the analysis, we calculated a mean price per year per crop and applied the same value for all counties. Figure 3b depicts the top six crops and how many dollars are lost each year in processing them.

The Aphlis data estimates the tonnage loss per processing step. Unfortunately, the total tonnage loss listed is less than the sum of the estimated losses per processing step. Figure 3c shows this for maize, but the other crops had similar behavior. Again, to avoid inconsistencies, we scaled the losses per process step to add up to the total tonnage loss. Finally, we calculated the total losses per processing step for each crop, Figure 3d. This demonstrates which processing steps one should focus their energy on to reduce food loss. In particular, for maize, it's at the harvesting field drying step. This is a manual process referring to scattering of the grain at harvest as well as not harvesting all the grain. In a future analysis, this could be broken down by country as well.

Figure 3a: Price of Maize in African Countries Relative to Global Price

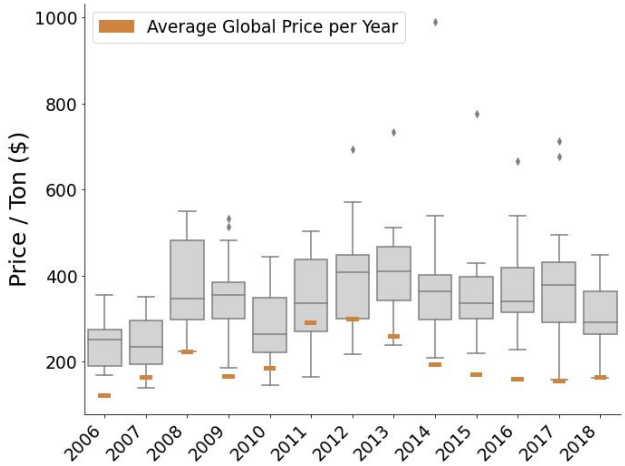
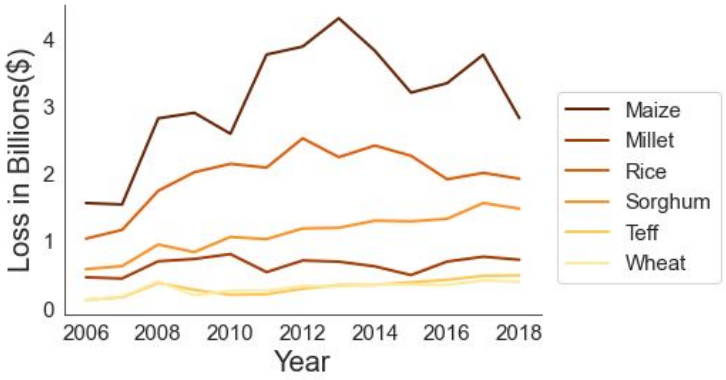


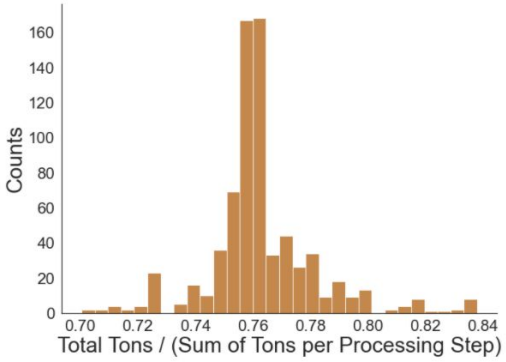
Figure 3b: Total Financial Loss per Crop in Africa

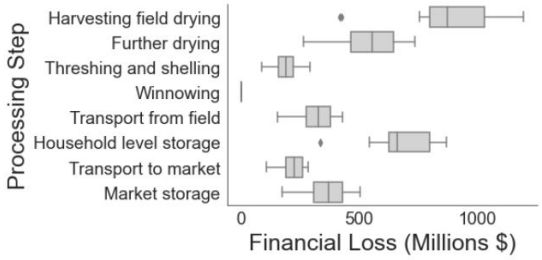


2 - Please view Appendix A for a comprehensive list of included crops

Figure 3c: Scale factor to resolve inconsistencies between the total loss per crop and the losses per processing step (for maize) (left)

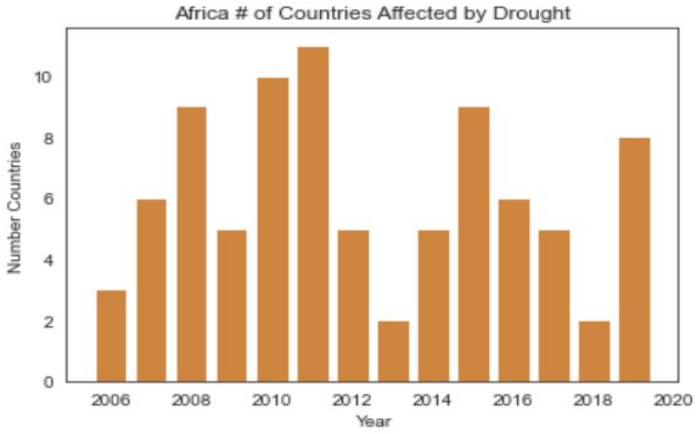
Figure 3d: Maize Financial Losses at Processing Step (right)





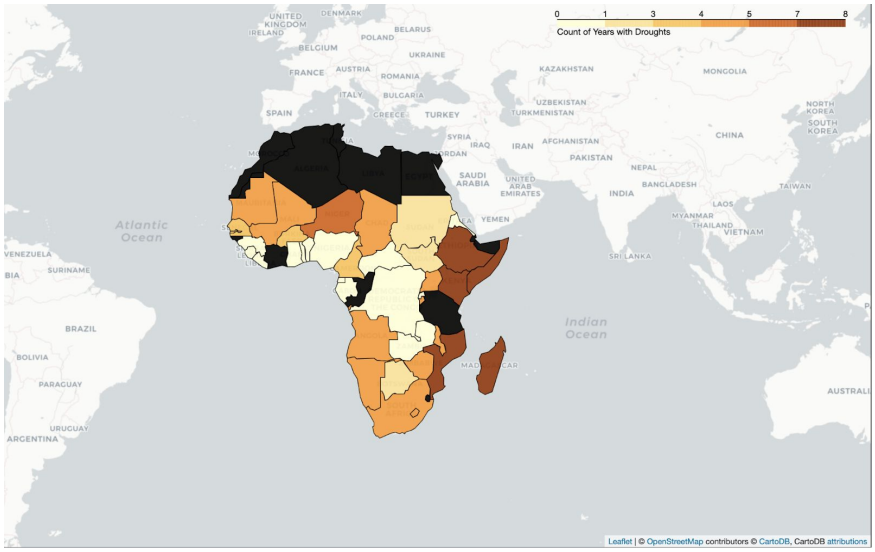
While Africa, given the variety of climates and temperate conditions, experiences almost all types of weather and natural disaster phenomena; we chose to focus our research on drought, as it is unequivocally connected to agriculture. Particularly in landlocked countries, the reliance on rain to ensure successful harvest is imperative.

Figure 4a: Amount of African Countries Affected by Drought



As Figure 4a shows, regardless of year, there are always African countries impacted by drought. In particularly dry years, such as 2005 and 2011, we see that over 10 countries (about 20% of total African countries in our study) are affected by drought. Given the expansive size of Africa, Figure 4b is also helpful to visualize the regions of the country that are most impacted by drought. We hypothesized that drought is a contributing factor to the crop losses and the financial losses detailed in Figure 3.

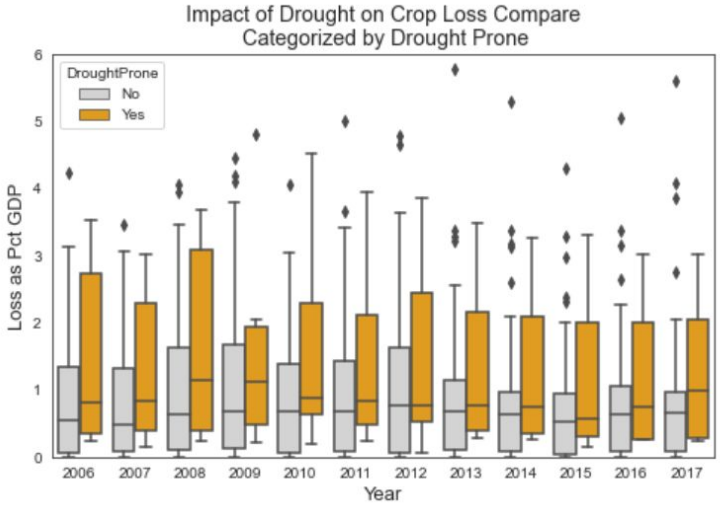
Figure 4b: Impact of Drought by African Country



In order to investigate, we compared drought prone countries with those less prone to drought and normalized losses by taking crop loss as a percentage of GDP. We performed a straight forward analysis of the mean, median, and quartiles which is represented in Figure 5. The data appears to show that crop losses are affected by drought but the results are not consistent across years. Drought Prone includes countries which had 4 or more drought years between 2006 and 2020. Loss as a percent of GDP was our best metric to normalize around, but has

some drawbacks, as some countries did not have reported GDP in our dataset. Additionally, it does not incorporate actual AFF and GDP and magnitude of crop loss. Based on our research and exploratory analysis, we conclude climate adversely impacts crop loss but that it is a contributing factor which is compounded by other factors related to infrastructure and stability. This needs further analysis and we discuss recommendations for exploring in the conclusion.

Figure 5: Comparison of Impact of Drought on Crop Loss in Africa[2]



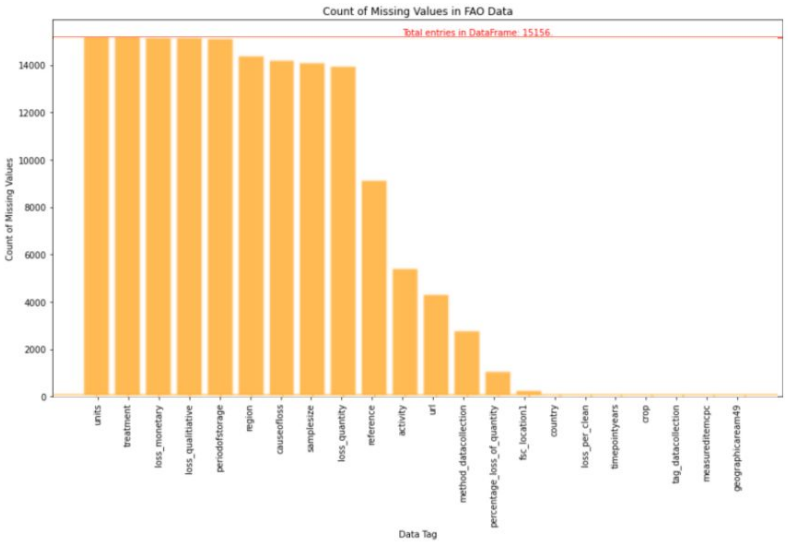
2 - Please view Appendix A for a comprehensive list of included crops

What Issues Exist with the Data?

As previously mentioned, our initial starting point for research was with the FAO Food Loss data. This dataset is supported by the United Nations, so, on the surface, appeared credible. After initial review, however, it was clear that while the data present in the dataset might be accurate, it was far from complete.

Figure 6: Missing Values in FAO Dataset

See Appendix 3 for full list of data tags



As Figure 6 shows, the maximum amount of missing values per category expands the entire dataset. Even more concerning than the amount of missing values, was the considerable amount of duplicate entries (that were not indicated as such by the data source in a transparent way). The data included 1,081 duplicated reports - about 7.1%. In short, it became evident that we'd need to utilize an alternative source for food loss data or else risk having a very skewed analysis and no opportunity to be conclusive. It is worth noting that we are not able to explain, conclusively, why this data is spotty.

Conclusions, Recommendations, and Next Steps

Conclusions

Surprisingly, data sources from reputable groups, such as the United Nations and FAO published reports based on incomplete and flawed data. This, of course, calls into question the accuracy of our analysis. Additionally, it's shocking how much food is lost due to production error or waste and how many people are still classified as "hungry" worldwide. While our preliminary research can't conclusively provide a solution, it does provide justification for further exploration of how food that becomes waste could be more purposefully distributed to alleviate hunger.

Recommendations

Based on the analysis we were able to perform, it is clear that more comprehensive and reliable data needs to be collected. Regulatory agencies that operate in international spaces and across jurisdictions could work to provide stronger guidance and incentives to support these efforts.

Next Steps

When reviewing the catastrophes and climates in Africa it was apparent that this continent has countries in almost every type of climate zone. The data we gathered on droughts was a snapshot of what happened in select countries but to give real justice to the issue, again, more accurate data is required for a deep dive. Rather than a binary drought or no drought for select countries it may be more beneficial to dig into the state or province level and assess additional catastrophic events.

Throughout the analysis as previously mentioned, there were not only many gaps within the various datasets we attempted to source from but there were also inconsistencies, duplicate reporting and estimations rather than actual data. To add integrity and accuracy, a dedicated study should be conducted to gather accurate data rather than aggregations and estimations.

Within the data there were additional fields that we were unable to adequately address. For future action we would like to review the loss process attribution to get a good idea of where in the supply chain the majority of losses are coming from, and one step further would be to perform a root cause analysis on the losses.

Looking at the data from Africa and trying to compare to other countries around the world was not a fair comparison. As mentioned, we saw a diverse range of climates from Desert to Tropical

to Arid land which makes it hard to pinpoint any exact causes from such a high level view. This data could help prove correlation between geographical properties and food loss during farming and harvesting which was the highest lossage specific processing step.

To put this into perspective on how large and diverse Africa is, we compared the total landmass of Africa vs some countries of the world (Figure 7a) (Desjardins, J. 2020). To show how enormous this continent truly is, Figure 7b shows Africa, overlaid with various world countries.

Figure 7a: Africa Landmass vs World Countries

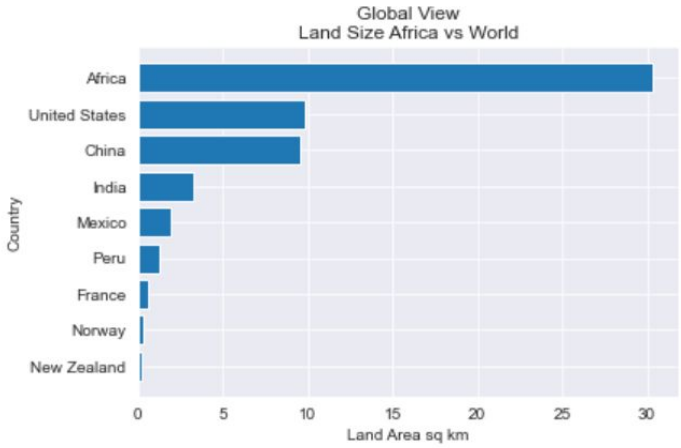


Figure 7b: Africa with World Country Overlay

Using what we learned about the extreme size of Africa, we believe that there can be many more insights gained with some additional data. Some examples are if there may be a correlation with food waste during transportation and the distance between shipping endpoints. Some of the data on the national and regional infrastructure may help to pinpoint causes of food waste.

Statement of Contributions

Ram Ben-David: General Coding, Data Downloading, Data Cleaning & Preparation, Data Analysis, Data Visualizations and portions of the written report and presentation.
Jordan Meyer: General Coding, Data Cleaning & Preparation, Data Analysis, Data Visualizations,
Justin Peabody: General Coding, Data Cleaning & Preparation, Data Analysis, Data Visualizations, contributed to portions of the report
Julie Oxenhandler: Found food loss (FAO) and country stability data sources (The Fund for Peace); drafted written analysis for the report; created PowerPoint template; general data exploration

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Appendix A

1 - List of African Countries

Angola,In Scope
Benin,In Scope
Botswana,In Scope
Burkina Faso,In Scope
Burundi,In Scope
Cameroon,In Scope
Central African Republic,In Scope
Chad,In Scope
Congo,In Scope
Côte d'Ivoire / Ivory Coast,In Scope
Democratic Republic of the Congo,In Scope
Equatorial Guinea,Not in Scope
Eritrea,In Scope
Eswatini,In Scope
Ethiopia,In Scope
Gabon,In Scope
Gambia,In Scope
Ghana,In Scope

Guinea,In Scope
Guinea-Bissau,In Scope
Kenya,In Scope
Lesotho,In Scope
Liberia,In Scope
Madagascar,In Scope
Malawi,In Scope
Mali,In Scope
Mauritania,In Scope
Mozambique,In Scope
Namibia,In Scope
Niger,In Scope
Nigeria,In Scope
Rwanda,In Scope
Senegal,In Scope
Sierra Leone,In Scope
Somalia,In Scope
South Africa,In Scope
South Sudan,In Scope
Sudan,In Scope
Tanzania,In Scope
Togo,In Scope
Uganda,In Scope
Zambia,In Scope
Zimbabwe,In Scope
Egypt,Not in Scope
Morocco,Not in Scope
Algeria,Not in Scope
United Republic of Tanzania,Not in Scope
Guinea Bissau,Not in Scope
Libya,Not in Scope
Tunisia,Not in Scope
Republic of the Congo,Not in Scope
Swaziland,Not in Scope
Djibouti,Not in Scope
Western Sahara,Not in Scope
Somaliland,Not in Scope

2 - List of Crops

Barley, Not In Scope
Fonio, Not in Scope
Maize (corn), In Scope
Millet, In Scope
Oats, Not in Scope
Rice, In Scope
Sorghum, In Scope
Teff, Not in Scope
Wheat, In Scope

3 - FAO Data Fields (Figure 6)

geographicaream49
country
region
measureditemcpc
crop
timepointyears
loss_per_clean
percentage_loss_of_quantity
loss_quantity
loss_qualitiative
loss_monetary
activity
fsc_location1
periodofstorage
treatment
causeofloss
samplesize
units
method_datacollection
tag_datacollection
reference
url