Mlimi, empowering Malawians

Smart Cities & Governments

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Our work in this report is organized in the following way:

1. Introduction

The economy of Malawi, the southern Africa country, is predominantly based on agriculture. Indeed, agriculture accounts for 30% of GDP and generates over 80% of national export earnings. The sector employs more than 60% of the country's workforce and greatly contributes to food and nutrition security. Although there is potential for better production and productivity, the agriculture sector has been operating greatly below its capacity and faces many challenges. Indeed, Malawi is the third poorest country in the world with half the population living below the poverty line.
After some research, we have found that the main challenges faced in the agricultural sector in the country are:

1. Vulnerability to weather shocks;
2. Poor management of land, water and soils;
3. Low adoption of agricultural technologies;
4. Low access to finance and farm inputs;
5. Low mechanization and technical labor skills;
6. A limited irrigation system and weak linkages to markets.

Also, the majority of the country's agricultural research agenda is donor-funded, thereby creating a very precarious situation for sustainable technology generation and development for the economy and the sector in particular. Thus, indicating that a low-budget solution should be thought of, which we tried doing in our analysis here.

We thus have decided to implement a platform application that would use data and try helping solve some of these issues. Mainly, we will be focusing on solving 2 problems:

1. The vulnerabilities of the population to weather shocks;
2. Farming education, which include topics such as implementing community-based centers that initiate actions based on data.

1.1 Guide to our work

To help navigate our work, we here give an overview of the deliverables and where they fit in. For our submission, we have provided 3 files:

- *PDF report:* the full report explaining the problem, solution we came up with and our reasoning;
- *Prototype Model Jupyter Notebook*: as will be tackled in later sections, we have developed a prototype machine learning model to illustrate one of our solutions. This is an illustration that our proposition could be implemented;
- *Sample dataset*: for developing our prototype model, we had to merge datasets that we describe below, and this file is a sample of the main final dataset.
- *Javascript Google Earth Engine sample*: we have extracted data from Google Earth Engine, as described in the report and provide in this file a sample code used to do so.

In case any of the deliverables is not clear, we urge you to contact us for more clarification or elaboration. All the references used for our research are cited in the last section.

2. Vulnerability to weather shocks

So, we first look at how we can use data to help local communities alleviate the effects of weather shocks. We will give some background information, before focusing on one aspect of weather shocks (floods) and developing a complete prototype that could be implemented to deal with this problem using data.

2.1 Background information

Malawi has consistently been classified as one of Africa's most at risk countries to the effects of climate changes happening in the last years. This is mainly due to the heavy dependence of the country on rain-fed agriculture and also to its high risk of droughts and floods. Indeed, the majority of the population believes that droughts and floods have become more severe year after year and the climate conditions for growing crops have worsened. And between 1946 and 2013, floods accounted for 48% of major disasters, with the last two major floods happening in 2015 and 2019. Furthermore, it is estimated that the combined effects of floods and droughts cause losses of at least 1.7% the country's GDP every year. And because of shortages of food and higher local prices, the poverty headcount rate has been increasing by almost 1% per year. As a consequence, more Malawians are suffering financially and constantly battling famine and they believe that the most important problems their government should be focused on are food shortage, management of the economy, and agriculture (survey referenced in the last section).

2.2 Government's current response

The latest different governments have given priority to interventions which goals were to increase food security, for instance initiatives related to the implementation of fertilizer input subsidies for farmers. However, most of citizens do not consider these government's fertilizer subsidy program as the right response and want it to be removed. The government has also tried to resettle people living in areas prone to floods. However, planning has grossly been ineffective and the idea of giving people land without support is a scenario that could expose them to even more risks. The government has also attempted at installing a warning system but with failure. And flood risk management has mostly been delivered by NGOs who have organized search and rescue trainings, village contingency planning, as well as trying to establish group savings schemes.

But, despite these initiatives, the gaps in managing the risk of weather events are still very significant and should be addressed.

2.3 Our proposed solution

Because the threat of floods and other weather-related events cannot be totally eliminated, the best strategy to deal with this pressing issue is to incentivize the development of local communities. We thus propose here to develop an application that would help citizens and especially farmers alleviate the damages of weather-related events. There will be 2 main functionalities in this application:

1. *Warning System Mechanism*: We want to develop a Machine Learning algorithm able to detect upcoming floods and integrate it in a warning system that would help farmers better adapt. Our solution, we believe, will lead to improvements in community preparedness for extreme weather shocks (mainly focusing on floods here), in terms of both warning to the local farmers and a better understanding of the risks involved with a more appropriate responses to flood. The system will have as a goal to provide a prediction of the scale, the timing, potential damage, and location of the upcoming flood. Although our solution here is focused on flood predictions, a similar approach and reasoning can be applied to droughts and other weather shocks.

2. *General Weather Forecast*: Furthermore, because the data used in the development of the Machine Learning model mentioned before include general weather data, we plan to have in the application a section for general weather forecasting (a more in-depth aspect of the data is analyzed in the next section). We believe that this access to weather information will drive the farmers' business decisions, helping them plan efficiently their seasonal crops, minimize costs when possible and maximize yields and profits.

Thus, these features will be part of our application "Mlimi" (meaning "farmer" in the local Malawian language), a platform that would allow weather risk assessments using new technologies (for instance remote sensing or crowdsourcing).
We next turn to explaining a little more about floods, taking a look at the data that will be needed, and we attempt to develop the Machine Learning model.

2.4 Warning System with a focus on floods, the main threat

Floods make development efforts very complicated and hard to implement at every level. They affect many sectors of the country's economy, ranging from agriculture to education, sanitation, education, and environment. Research have also highlighted that smallholder farmers tend to lose around 3% of their agricultural produce to flooding on an annual basis. The latest flood for instance happened in March 2019 and affected almost one million people (6% of the population), pushing them to leave their homes behind and lose their crops and possessions.
But what makes the effects of floods so harsh on the citizens is their vulnerability. With a growing population, a higher poverty rate, and smaller pieces of lands, a lot of citizens are pushed to set in marginalized areas of the country that are prone to flooding. Another variable affecting people's vulnerability is the poor housing and infrastructure coupled with a lack of economic diversification, and access to social services. This in turn have limited the way the population can prepare and address floods. And the most affected regions are located in the southern part of the country, and the regions of Chikwawa and Nsanje (particularly affected by floods) are the poorest ones in the country and the ones we will be focusing on here.
After some research, we found that the main causes of floods are the following:

- *Heavy Rains*: this is the first driver of flooding. Especially in Malawi where, as mentioned, rain is very variable. And with heavy rains, the drainage systems infrastructures are overwhelmed, and water levels rise into peoples' lands;
- *Overflowing Rivers*: for people living along rivers, there could be river overflows after heavy rains have raised the water levels;
- *Channels with Steep Sides*: flooding will occur when there is fast runoff into rivers, lakes, or other reservoirs. This happens when those channels are located on steep sides.
- *Lack of Vegetation*: vegetation can help in slowing runoff and prevent flooding but with a lack of vegetation, however, there are little barriers to stop water from running off.
- *Poor infrastructure*: poor drainage systems can lead to rapid floods, which is the case in most of Malawi.

These main causes gave us a good idea on the data that will be needed for developing the model for our warning system. We next turn to a detailed explanation on the data needed

2.5 Data needed

Forecasting flood can still be considered as a very exploratory project. Some of the biggest technical question include: can we collect enough information to give a forecast that is accurate enough to make a difference? Can we get information about what is going on? Where? What should be done?
To develop this predictive model, two types of data will be needed: historical data from previous flooded periods as well as real time data on the current situation for being able to issue warnings.

2.5.1 Historical Data

The model would first be developed on extensive historical data, which as highlighted in the previous sections should include information about:

1. *Weather-related variables*: rainfall, temperature, soil moisture, temperatures, humidity levels, air pressures, wind speed and directions, etc.
2. *Terrain information*: type of land, river typologies, slopes and elevations, type of vegetation, water levels at strategic points in the basins, etc.
3. *Infrastructure information*: what types of infrastructure is present, what buildings/constructions are present on the fields, etc.

Because the government itself has not much collected data on these aspects, external sources will be required to derive this data.

2.5.1.1 Source 1 of Data: Google Earth Engine

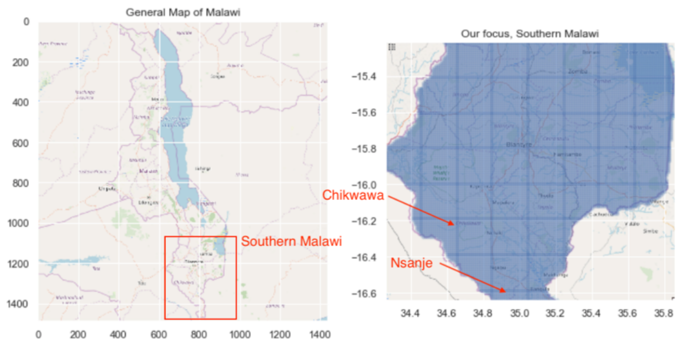
After some research, we have found that a major source for this type of data is Google Earth Engine. As they mention, their platform "combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers to detect changes, map trends, and

quantify differences on the Earth's surface". They indeed are one of the richest sources of public data with over 40 years of historical imagery and scientific datasets, which are updated and expanded on a daily basis. With advancement in Computer Vision, almost all the information cited above can be derived from satellite imageries. They give access to over 20 petabytes of geospatial data instantly available for analysis. The level of organization on their website is somewhat impressive. Through the Earth Engine Code Editor, a few lines of code specifying the required data for each point coordinates are enough to derive a bunch of statistics of these exact coordinates.
The only needed input to the Engine Code is giving the coordinates for which we want the data. Along this report, we have provided a sample Javascript code we used for extracting data from the website (google_earth_engine_data.js). We next briefly explain in more details how we extracted the data and which datasets we built to be used in our predictive model.

Extraction of datasets

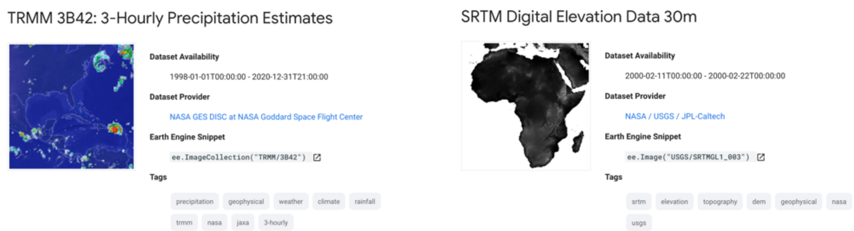
The step by step procedure to extract the data is as follows:

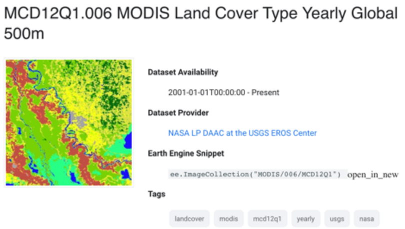
1. We need to define point coordinates (GIS data) for which we want the data. We found the coordinates of the Southern Region of Malawi divided into squares of 1km each side (from Zindi UNICEF 2030 Vision #1, cited in the references). They are is divided into almost 16,000 smaller squares as shown below (the blue area on the right map):

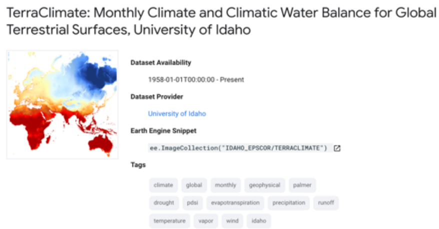


   This dataset also contained the percentage of the square that was flooded in 2015, which we used as our target in our model.

2. From the Google Earth Engine, we created an account, and had access to a rich variety of information. We chose the following datasets:







3. In the extraction code, we specified the timeframe we were interested in. We extracted mainly here for our use case data from weeks before the 2015 floods, to be able to analyze pre-flood patterns.

4. We then merged the 4 datasets together and obtained the final dataset we used for our predictive model.

Final dataset description

So, as can be seen from the images above, the final datasets contained information about the main causes of floods, and the dataset we built, especially had the following columns for each of the 16,000 coordinate points: Precipitation Levels for 17 weeks previous to the 2015 floods, Elevation, Evapotranspiration, Drought Severity Levels, Soil Moisture, Average Weekly Temperature Levels, Vapor Pressures, Wind Speed, and Type of Land/Vegetation. We have included this dataset with our submission, and it would be worth it to take a look at it.

2.5.2 Real-time Data

The historical data described in the previous section is needed in order to develop the predictive model. However, going forward and in order to implement such a warning system application, live stream data would be needed for the point coordinates. We will thus need sensors sending data to be able to provide meaningful warnings and give the desired lead time for action to the local population. Other than the data presented here, we would also need measurements of water levels at strategic points in local water basins (rivers, lakes) which would require constant monitoring too.

We are aware that these types of technologies could be costly or take time to deploy, but we tackle how we could implement this in the second part of this report.

Thus, we would just like to highlight that the data needed is now not available for the future deployment. But the historical data described above is what would be required in the years to come and the implementation of sensors could feed this data in real time.

2.5.3 Conclusion on Data

This section on data, we believe, shows that even if the government had not made efforts in collecting data previously, many sources like the one used here give access freely to such data and with more time and resources, more accurate and detailed data could be extracted. However, to be able to build better and stronger models in the future, the implementation of sensors sending those data in real time will be necessary.

Because we are not experts in the field of flood predictions, there might be other important variables not mentioned here but we believe that for our purpose, which is indicating the type of data needed as well as their sources, those variables could be enough.

2.6 Modeling prototype

As mentioned above, the data described here would be used into a machine learning model to predict future floods. We here have attempted to implement a prototype of a simple model to highlight what we mean. And we have used the data described and extracted in section 2.5.1. This prototype can be found in the submitted notebook "prototype_model.ipynb" and the necessary documentation is referenced there.

The prototype achieved a somewhat very decent score with the data we extracted, which we believe is a clear indication that such an approach, if given the proper resources and time could be feasible and scalable.

2.7 Challenges

One of the biggest problems towards the implementation of this warning system and weather forecast application is that there's only limited involvement of local communities. This has led to projects not being implemented in all affected areas. And often projects reflect the donor's agenda rather than needs on the ground. Also, the government will need to invest funds into the implementation and maintenance of the mentioned sensors. This is indeed another major challenge as for now, the government is highly decentralized, so planning, implementation and maintenance of projects is not very easy smooth.

Going beyond the application described so far, and as mentioned in the introduction, we also plan to use data to improve the farmers' situations through "mobility units" that we describe next. This other part of the proposed solution also addresses some of the challenges just mentioned now and try setting the foundations towards better involvement between communities.

3. Farming Education

So, we first looked at how we can use data to help local communities alleviate the effects of weather shocks. We focused on one aspect of weather shocks (floods) and developed a complete prototype that could be implemented. Now, we turn to a more theoretical part of the solution and see how data can be used to alleviate other bigger problems and help in the implementation of our application *Mlimi*.

3.1 Background information

Farming in Malawi faces unique challenges, a main one being soil fertility. With naturally low fertility, the best farming practice is to utilize an area for 2-3 years of farming and then leave it fallow for 15 years. However, this leaves plots of unused land for many years, so fertilizer is often used as a work-around. Malawi has also seen a decrease in Maize yields in the past years due to subsidy removal and issues with importing fertilizers from abroad. Previous programs have attempted to address this issue by distribution of fertilizer and seeds to households, but ultimately has failed due to incorrect application of fertilizer. This highlights the need for farming- specific education in the region.

Access to education is a significant factor for food security in Malawi- this includes both formal primary and secondary education, as well as agriculture specific education. The Malawi government is aware of the importance of farming education, and their formal education system places a focus on this. Some of the government's listed goals for learners are to "Develop a positive attitude towards manual work" and "Understand the role of agriculture in Malawi's economy". Previous research on the Malawi education system has suggested that a stronger link between education and agricultural practices could have a positive impact on both food security and overall educational outcomes.

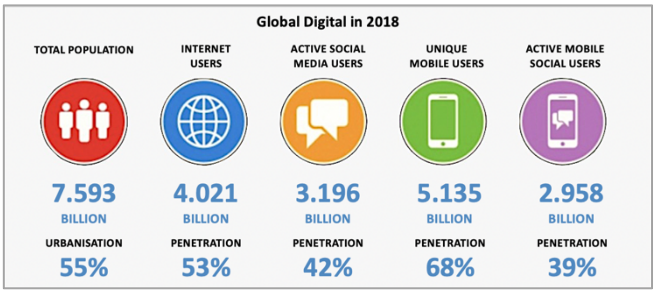
Farmers in Malawi have limited rights, increasing barriers to successful agricultural production. Little legislation surrounding agriculture makes it difficult for farmers to coordinate amongst themselves and follow best practices. Although agriculture is a main product in the country, organization both on a governmental level and amongst farmers unions are bare bones. This has also led to a lack of research and education on sustainable agriculture practices, leading to a loss of biodiversity. This use of a few main crop strains has reduced resilience and crop fertility. Current institutions are not adequately addressing this issue, and this has led to an almost complete elimination of historically local crops.

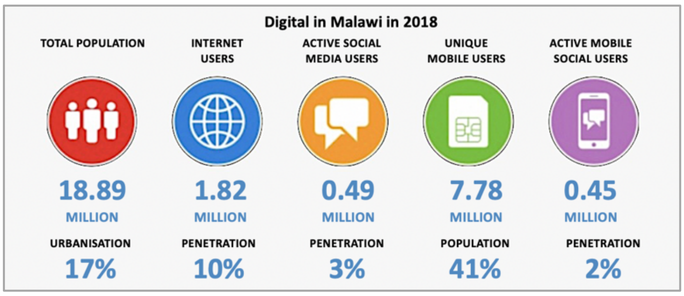
3.2 Government's current response

While the Malawi government has attempted to offer subsidies to small farmers to support agriculture, the programs backfired. The most recent iteration, called the Farm Input Subsidy Program (FISP) gave coupons to farmers to purchase reduced- rate fertilizer and farm equipment. While the program was set to increase purchasing power of the poorest and female- led households, mid-income and educated farmers ended up with the most coupons because they were more successful at bargaining with village chiefs. This highlights that a "teach them to fish" education- based agriculture program may be more effective than a simple government subsidy that has historically failed.

3.3 A note on Digital Access

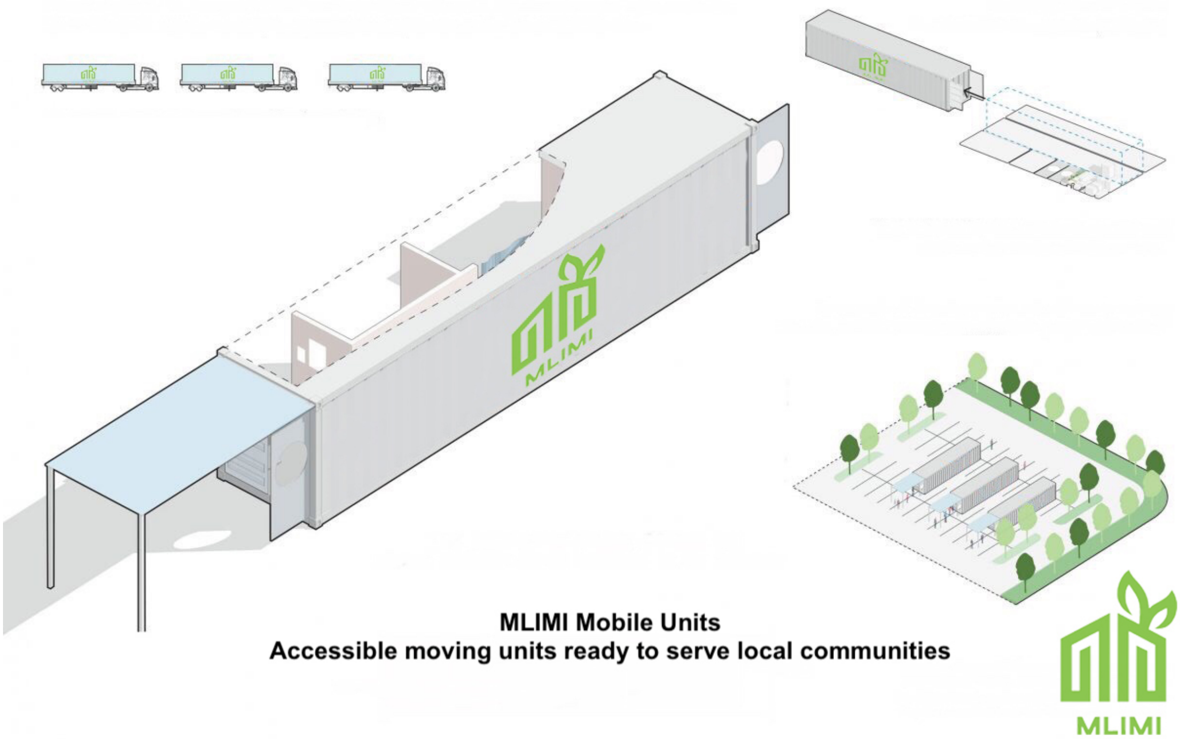
According to the Inclusive Internet Index 2020 Malawi is ranked 97/100 (where 100 is the worst) for internet penetration in the country (this rank was in all criteria other than readiness, where it performed 84th). The main barrier for accessible Internet is not its adaptation within the community but rather its high cost. Although the number of people with access to the internet is increasing (from 9.6 % in 2016 to 13.1% in 2018), it still remains low. In a country where GDP per capita is 47 times lower than the world's average, spending money on the internet is considered a luxury. In fact, in a report by the International Telecommunications Union (ITU) it is stated that on average Malawians use over $12 a month on mobile phones (over half of average monthly earnings). Additionally, the number of Malawians that have a mobile phone might be overstated because extremely high costs for calls between different operators causes mobile phone users to buy more than one sim-card– one per each operator. Considering this, the population having mobile phone might be significantly less than the official 41%.





3.4 Our proposed solution

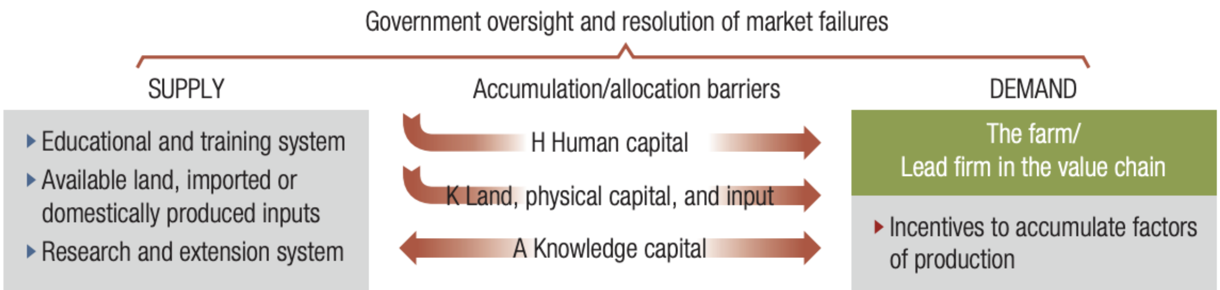
Our initial proposal is to provide a mobile agriculture unit for the Nsanje District (the southernmost state in Malawi). An additional unit could be considered for expansion to other districts after feedback from the initial unit is received. Nsanje has been selected because of its status as a remote and poor region of the country. The temperature in this area reaches above 50 degrees Celcius in summers and is subject to flooding. Previous research in Malawi has suggested that educational training for agriculture is a key aspect in moving the country towards food security. The mentioned mobile agriculture unit would look something like this (we have used as a reference a design of mobile units done by the NHS and adapted it here with our logo):



MLIMI Mobile Units
Accessible moving units ready to serve local communities

Our mobile community agriculture unit will serve rural areas with both agriculture education and supplies such as fertilizer and farming equipment. This mobile unit would also serve as a data center for information collected by IoT sensors on weather and soil conditions. While ideally every farmer would access this information through a phone app or computer, this is expensive and inaccessible. However, mobile coverage is increasing in Malawi and receiving information about harvesting crops and weather patterns through

SMS is an increasingly viable option. Providing a data hub allows a centralized location for a variety of agriculture needs. Mobile centers mean that a larger community of farmers can be served, as the center can be relocated based on seasonal needs. A physical center also offers the benefit of hands-on learning and the ability to meet with other farmers.
We believe that Integrated Soil Fertility Management (ISFM) is the best methodology to use for educating farmers. ISFM is a data-driven approach to improving agricultural outcomes. It integrates both use of fertilizers and a variety of farming techniques to increase yields. ISFM is an ideal methodology to educate farmers in Malawi because it provides both opportunities to introduce data-driven solutions such as soil testing, and less costly and more labour- intensive practices such as crop rotation with legumes. Previous data on agriculture in Malawi indicates that this is the most cost- effective way to produce long-term returns.
ISFM includes combining both organic and inorganic fertilizers with farming best practices such as planting dates and weeding practices. Several studies have concluded that a combination of organic and inorganic fertilizers work as the best blend to increase yields. While this fertilizer blend is effective in increasing crop yields, if many farmers can't afford the fertilizer in the first place, they will never have larger yields, creating a vicious cycle of inaccessibility. Previous programs such as the above- mentioned FISP have attempted to subsidize costs, but this was not a community- driven approach and resulted in an inequitable distribution of subsidies. A potential solution to this would be a more local seasonal credit program that would provide farmers with resources at the beginning of the growing season, to be paid back after harvest.



Source: World Bank.

3.5 Data needed

Although the solutions mentioned in the above sections are ambitious and stretch the limits of what is feasible today in Malawi, with the right framework, life can be improved for 1000's of farmers. Crucially, the success of these goals will be incumbent on the effective collection and use of data. In remote areas of the world, the availability and reliability of data often comes into question. Malawi faces this same predicament, but through these projects, the hope is to use what is available to create a climate that recognizes the power of data and builds upon itself.
Below are descriptions and analysis of the data resources available or needed to tackle the various solution implementations.

3.5.1 The Data for the operation of mobile data centers

With education and data resources standing as a huge impediment to farmers in Malawi, the mobile data centers are geared towards dispersing information directly to the communities in need. In order to map the most efficient positions for these data centers it would be beneficial to have data, mapping all of the different farms and crops that are being grown. A good example of such a dataset can be seen in California where they have detailed statistics on each farm.
(https://databasin.org/maps/new#datasets=6cc5b24e401043a899a6db6eef5c86db)
While Malawi does have some data resources pertaining to the agricultural resources this data is limited and gives only a high-level overview of farming trends, including number of farms in each region, the most popular crop, etc. These resources can be found here: http://www.fao.org/countryprofiles/index/en/?iso3=MWI
What is needed is not only more in-depth data, giving specific GIS location data of various growing areas, but also better dispersion of data collected, like crop prices (https://malawi.opendataforafrica.org/jxkvmfe/malawi-agriculture-sheet). This will allow for a model to triangulate the most effective positioning of the mobile centers and for them to serve as an education resource.

Additionally, because of the overall lack of data collection in the area, the data centers can serve the dual purpose of data dispersion and collection. During the growing seasons of 2002 and 2003 the CEEPA conducted an African agricultural survey, interviewing 9,500 households across sub-Saharan Africa. Households were chosen randomly in districts that are representative for key agro-climatic zones and farming systems. The data set specifies farming systems characteristics that can help inform about the importance of each system for a country's agricultural production and its ability to cope with short- and long-term climate changes or extreme weather events. Although this data is from over 15 years ago, it is still relevant and can still serve as an example for how information can be collected by the data centers. The full survey questions and data can be found here: https://figshare.com/articles/CEEPA_African_agricultural_survey/2069738

By utilizing first data to derive the optimal locations for these data centers, they can be positioned to help the largest number of people and collect the most data. In this way, data would be used in order to collect even further data in a cycle that could bring about a culture of data in agriculture.

4. Business Aspect

In this section, we try assessing the business impact of implementing such solutions mentioned in our approach.

4.1 Our competitors

There are several programs operating in Malawi that offer agricultural training and data driven approaches, but none are using an integrated approach of IoT data and education to holistically improve outcomes. Nonprofits like Farm Africa work to help farmers increase yields and find markets to sell their products. There are also a slew of tech companies working to integrate data solutions for farms. Esoko works by collecting and profiling data for farms in remote African communities. The World Bank has also been involved in Malawi, working through their Agricultural Productivity Program for Southern Africa (APPSA) to improve agricultural technologies in Malawi, Mozambique and Zambia. There are also several programs to connect farmers with resources, such as Trotrotractor that connects farmers and tractor operators, and ThriveArgic, which allows people to invest in smallholder farms.

While these products all offer invaluable resources to local farmers, they do not focus on educating farmers with best practices on a mobile platform. Many of these services either require farmers to have access to a mobile device or travel to a stationary center. Our approach offers a more accessible and sustainable approach that combines technology and more labor-intensive methods to increase yields. Many of these companies are working on a non-for-profit basis and work better as a cooperative effort than by competing between themselves. Our proposal serves to build on the work previously done by other companies and work cooperatively to advance agriculture in Malawi.

4.2 Cost-Benefit Analysis

We try assessing here the financial impact the implementation of our solutions could have for the region of Nsaje alone. We tried our best in making reasonable assumptions.

4.2.1 Cost-Benefit Analysis for the Flood Warning System

As mentioned above, the impact of floods and droughts are about 1.7% of the country's GDP, or an estimated $120 million. Given that we know that floods have been representing around 48% of weather shocks in the last years, we could estimate the impact of floods at about $57.6 million. With an area of 1.6% of Malawi's territory, Nsaje would as an estimation suffer losses of $943,000 due to floods on a yearly basis.

Now, an early warning system for predicting floods, if implemented properly could help reduce the financial damage by approximately 10-20% (deduction made from the "Quantifying the Benefit of a Flood Warning System" report). Thus, this could represent a yearly cost saving of around $141,450 for the region of Nsaje.

This only somewhat represent material value that could be saved, not mentioning the non-material values like lives and injuries that would come with an accurate warning system.

From the investment side of the equation, the government will need, as mentioned earlier, to implement IOT sensors to be able to extract real time data to feed into the model to provide the most accurate predictions. With a total area of 1,942 squared kilometers, the area of Nsaje could be divided (like we did in building our model) by squares of 1 km by 1 km and each square would have one IOT censor installed to extract the weather data we have mentioned throughout. After some research, we believe that such IOT sensors would cost around EUR1500 (from allMETEO website, referenced in the last section). With 44 squares of 1 squared km each, this would mean that a total of EUR66,000 would need to be spent to purchase those sensors. Furthermore, a team of expert would be needed for the maintenance and installation of those sensors, and thus an estimated annual sum of $36,000 would need to be spent on salaries (team of 3 with montly salaries of $1,200). Thus except the first year in which the sum for the sensors would need to be paid for, subsequent years could be estimated to have costs of around $50,000 overall.

Although these are very basic assumptions and a lot more variables should be considered, we believe that it is a good approximation of the costs and benefits of developing our warning system application. We next try to ssess the impact of the mobile units.

4.2.2 Cost-Benefit Analysis for the Mobile Unit

Malawi farms are producing on average just 45% of what the best farms in the region are producing. In order for farmers to bridge this gap, they need more fertilizer (and supporting import policies by the government), as well as local services to learn about farming (as provided by our unit), and an increase in activity between farmers to encourage seed trading and tool availability.

The average Malawian farm produced, on average, only 45 percent of the output of the best-practice farms in the Malawian sample. In southern Malawi, 99% of farmers grow Maize, but only 16% use the ISFM growing model. To highlight the importance of this methodology, in a recent study on Malawi farms, "ISFM options gave a return to labor of $1.35 per day compared to $0.25 per day". Compared to other fertilizer methods, it offers a very high return to scale. The estimated cost of IFSM fertilizers is around 50 cents per kilo (compared to 35 cents per kilo for conventional methods). Although this represents a 30% increase in input prices, it provides the opportunity of farmers to grow 45% more. Because the fertilizer increases plant productivity, it also increases return to labor, meaning less work for more food.

Nsanje, the southernmost region in Malawi, has a population of just under 200,000, meaning that at least 120,000 of these citizens are reliant on agriculture for work. A migration to the ISFM model could save the region an estimated $42,768,000 in terms of returns to labor.

Now looking at the investment side, the mobile unit truck and container would cost an estimated $150,000. Delivering training and also making sure the highest number of farmers are reached would also require a significant team and efforts. With a team, educative material, and utilities for the mobile unit, we estimated that one mobile unit would need a further investment of $100,000 yearly to be effective. Although a large sum, with the proper use of data and the good insights generated from the unit, we believe that the benefits outweigh the costs and the solution is reasonable.

5. Conclusion

The report has highlighted how we have come up with a solution to 2 main problems we have noticed in the agricultural sector in Malawi, and in particular in the southern region of Nsaje:

1. The vulnerabilities of the population to weather shocks
2. Farming education and information

To the first problem, we have highlighted how the implementation of our platform application, Mlimi, would include a warning system that would be able to predict weather shocks. In particular, we have developed a prototype machine learning model to highlight the prediction of floods in the whole of Southern Malawi. We have also detailed what data was needed for such an application and where it could be found for historical data and how it could be generated in the years to come. We have also highlighted that the platform could have more functionalities like helping in overall weather predictions, which would ultimately lead to better crop management and oversight. Finally, for this first solution, we noted that the main challenges would derive from a lack of involvement from local communities as well as from the unorganized government in place.

The second part of our solution, a more theoretical one, which tackled the second problem mentioned of farming education tried to provide solutions that could help in the implementation of the warning system application. We have thought of designing mobile units that would serve rural areas with both agriculture education and supplies. This mobile unit would also serve as a data center for information collected by IoT sensors on weather and soil conditions. And in this way, because the digitalization rate are very low in the country, those mobile units would be able to give access to more information for farmers. This would furthermore insure they are included into the economy and get the most out of their crops. We then highlighted the type of data needed to develop such units and program as well as example that have already been established.

Finally, we looked at the costs and benefits that would come out of our solutions. We highlighted that the benefits outweighed the costs based on our assumptions and thus we believe that our solutions could be a good first step towards making Malawi and especially Nsaje a smarter region through the use of data and analytics. It is true that with poor infrastructures and many other problems, Malawi might not be prioritizing the implementation of the “smart city” concept. However, with the drop in prices of the mentioned technologies as well as the rapid advancement in machine learning and that lead to better forecasting, now more than ever data might be the answer to the country’s pressing needs. By starting with centralizing data from the agricultural sector, the foundations could be used and expanded to other sectors and thus improve the processes of the Malawian Government.

By implementing smart solutions like Mlimi, we believe developing cities will be able to better bridge the gap with their sister smart cities.

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