Increasing Financial Inclusion in Mozambique

Stanford International Policy Studies Practicum Project Report 2015-16

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Executive summary

Financial inclusion in Mozambique is at a fairly nascent stage. Nearly 60% of the adult population in Mozambique does not have access to any sort of financial services (Source: Finscope 2014). GIZ, which is implementing the Sustainable Economic Development Program in Mozambique, commissioned Stanford International Policy Studies student team to undertake a practicum project to make policy recommendations to build an inclusive financial sector in Mozambique. In addition, GIZ also wanted the Stanford IPS team to identify districts that has a higher potential for financial services.

The project used Night Light Data as robust proxy for income, availability of electricity, Human Development and access to information and communication technology. In addition to Night Light data, the project also used data points such as population density and access to financial infrastructure. Using these different data points, districts were ranked for its potential to successfully roll out financial services Further, an optimization algorithm was developed that optimize the night light intensity and distance between financial service touch points to identity the most optimal geographic coordinate to locate financial service touch points within a chosen district.

Based on the analysis, the project identified that the top quartile of the most potential districts in Mozambique were located in the Northern region surrounding the Nacala corridor. This indicates a possible strategy for policy makers and financial institutions to prioritize the northern regions for financial inclusion in short to medium term. These are also the regions that currently have very low access to formal financial services. Therefore, focusing on these regions not only presents an eminent opportunity for financial institutions but also have the potential to amply social impact. The project proposes GIZ to engage with policy makers and financial institutions to develop polices, programs and financial products to cater to individuals and SMEs located in these districts.

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1. Introduction

1.1 What Policy Problem Are We Addressing?

The goal of our project is to increase financial inclusion in rural areas of Mozambique. We hope to incentivize local formally regulated financial institutions that currently operate in the country to extend their services to more remote areas of the nation.

According to a financial capability survey conducted by the World Bank in 2013,[1] 36% of adults in Mozambique have never used any financial products or services. In urban areas 46% of the survey respondents had a bank account, whereas in rural areas only 19% of respondents had one. More complex products such as investments in stocks and private pensions and are hardly used at all.

Increased financial inclusion is one of the major pillars of the economic development strategy for Mozambique. In 2013 the government adopted World Bank's "Mozambique Financial Sector Development Strategy 2013-2022" with the objective of ensuring that 35% of adult Mozambicans would have bank accounts by 2022.[2] Additionally, in June 2014, the Mozambican Government approved a modification in the Banking Law allowing financial institutions regulated by the Bank of Mozambique (BoM) to provide services through agents.

Enhancing financial inclusion, therefore, is at the top of the agenda for the country's government. Considering the significant amount of political will, the challenge is to galvanize the private sector to explore ways to extend their services to populations currently not served.

We focus on formal financial institutions in order to leverage the formal banks currently operating in the country. In addition to their significant advantage stemming from the opportunity to build on their current knowledge and infrastructure, these institutions are also regulated. Therefore, they are perceived as safer and more suitable service providers for the rural populations, which often suffer from low financial literacy rates.

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[1] Siegfried Zottel; Claudia Ruiz Ortega; Sarah Yan Xu. 2014. *Enhancing financial capability and inclusion in Mozambique: a demand-side assessment*. Washington, DC: World Bank Group, available at: http://documents.worldbank.org/curated/en/2014/08/20151823/enhancing-financial-capability-inclusion-mozambique-demand-side-assessment

[2] World Bank. 2013. *Mozambique - Financial Sector Development Policy Operation Project*. Washington, DC ; World Bank, available at: http://documents.worldbank.org/curated/en/2013/10/18412910/mozambique-mozambique-financial-sector-dpo

Rural areas are another priority of our project, as well as of the Mozambican government. Despite the country's strong economic growth, the rural areas continue to be largely excluded from the benefits of this expansion. As a result of the 1977-1992 civil war, agricultural production plummeted, which led to a widespread famine and large-scale relocation to urban areas in the south of the country and emigration abroad. Even today, the dilapidated infrastructure continues to hamper both economic growth and access to finance in the rural parts of the country. Moreover, the continued emphasis of public spending on mega-projects, has largely excluded the rural population from the benefits of the economic growth and exacerbates the imbalances between rural and urban areas in the country.

Despite the fact that approximately 70% of the population resides in the rural areas and more than 90% of the small, medium and microenterprises are located outside the capital, Maputo, factors such as the lack of basic infrastructure (e.g. roads, electricity etc.) limits the willingness of banks to expand their branches to these areas. This disadvantaged situation increases cost for the service providers; as such, precisely identifying most opportune locations for placement of bank branches could ameliorate some of the challenges faced by the banks.

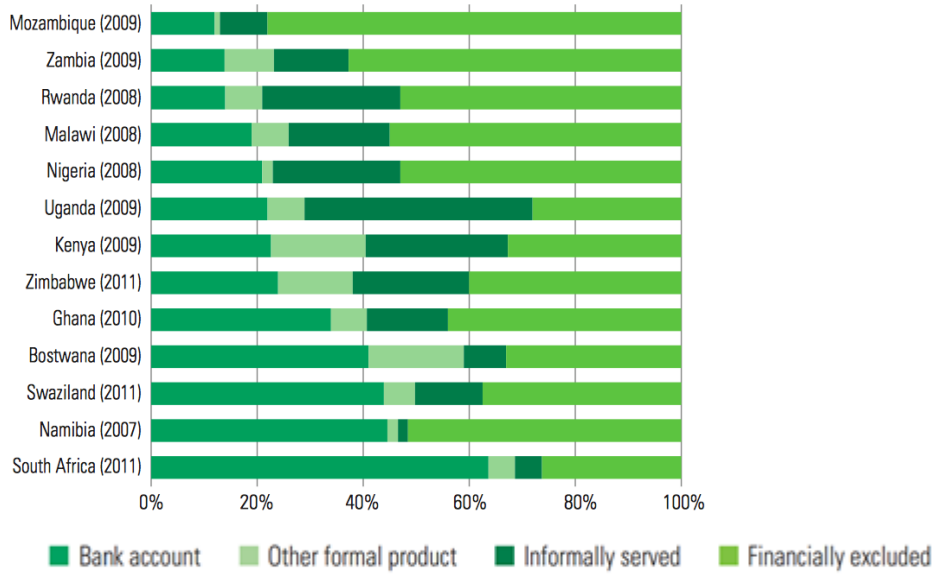
To address the problem, we have developed a replicable model that identifies geographical areas that present the most commercially viable opportunities for formal banks in terms of offering their services to rural populations. Our hope is that identifying the precise geographical locations within rural districts that present these opportunities will incentivize incumbent financial service providers in Mozambique to expand their services to these currently excluded or underserved communities.

1.2 Why Does Increased Financial Inclusion in Rural Areas of Mozambique Matter?

According to the German development agency *(Deutsche Gesellschaft für Internationale Zusammenarbeit, GIZ)* estimates, only 12% of the adult population in Mozambique has access to financial services provided by commercial banks, microfinance operators and other formal institutions; another 10% have access to financial services through informal savings and credit groups. In total 78% of the population is financially excluded. Financial inclusion is low in Mozambique even when compared to other Sub-Saharan countries (see Figure 1). According to World Bank, 34% of adults in Sub-Saharan Africa had a bank account in 2014, compared to only approximately 20% of adults in Mozambique.[3]

[3]World Bank. Financial Inclusion Data/Global Findex, available at: http://datatopics.worldbank.org/financialinclusion/region/sub-saharan-africa

Figure 1: Financial Inclusion in Africa



Source: African Development Bank

It has been proven through various research studies that poor people do not live in static poverty.[4] Every year millions of poor people move out of poverty by adopting better agricultural practices or by starting a small business. However, more often than not, it is the lack of fair opportunity to save the extra income earned, borrow affordable capital or protect themselves against income shocks, which traps them in the vicious cycle of poverty. Access to formal financial services not only helps them to capitalize on an economic opportunity to lift themselves from poverty, but also adequately insure themselves to endure an economic shock. Further, access to formal financial services helps poor people to better manage their finances, which allows them to afford basic necessities such as education, health, clean water and better sanitation facilities among others.

1.3 Who Is Our Client?

The *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) is an organization owned by the German federal government. Its mandate is to support the German Government in achieving its development objectives in the field of international cooperation for sustainable development. Its corporate objective is to improve people's lives on a sustainable basis.

[4] D. Collins, *et al*, (2009), *Portfolios of the Poor: How the World's Poor Live on $2 a Day*, Princeton University Press

The agency has been operating around the world for more than 50 years and has participated in a wide range of projects from economic development to sustainable energy and peace and security.[5]

GIZ's work has a global reach; the agency operates in 130 countries and has 90 local country offices. It employs nearly 17 thousand people and in 2014, the total business volume of the agency was 2 billion euro.[6]

Our team cooperates directly with the GIZ's office in Maputo. GIZ has had local presence in Mozambique since 1985 and has deployed approximately 100 million euro in the country. Sustainable economic development is one of the top priorities the German Government, and therefore GIZ, pursues in the country and financial inclusion is one of the pillars of its economic development initiative.

1.4 Why Does Our Client Care?

In the area of financial inclusion, GIZ recently launched an initiative called Pro-Econ, focused on improving regulatory and microeconomic conditions in Mozambique that would facilitate growth of a competitive financial sector. The goal of this intervention is that by the end of 2016, at least 10,000 people (including 5,000 women) gain access to financial services.

With respect to support to an inclusive financial sector, GIZ works both on macro and micro levels. On the macro level, GIZ is helping the Central Bank of Mozambique in developing relevant regulatory framework in areas such as agent banking and mobile money. On the micro level, GIZ works to link rural communities to the formal financial sector.

The goal of the micro-level efforts is to develop products and business models that are both profitable for the financial institutions and beneficial for the Mozambican population, especially in rural regions that so far have almost no access to formal financial services.

Our project is a piece of their micro-oriented efforts (see Figure 2). The specific aspect of the micro-level financial inclusion initiatives the client asked us to do is to present a compelling case to the local financial institutions for expansion of their services to rural populations. We aim to do this by developing a model that is able to reliably identify most suitable rural districts that offer financial institutions opportunities for expansion to low income communities.

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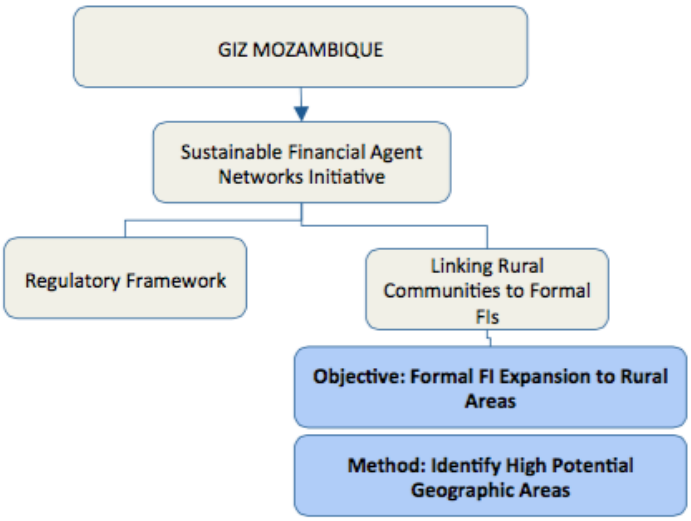
[5]GIZ, *About GIZ,* (12/ 31/ 2014), available at: https://www.giz.de/en/aboutgiz/profile.html
[6]GIZ, *About GIZ,* (12/ 31/ 2014), available at: https://www.giz.de/en/aboutgiz/profile.html

Figure 2: Structure of GIZ's RAMOZ Initiative and Our Project



1.5 Policy recommendation

Based on the analysis, it is evident that the most potential districts for roll out of financial services is in the northern region particularly concentrated around the Nacala corridor. This indicates that the financial services industry could ride on the recent resource driven boom that is underway in Mozambique. The districts surrounding the Nacala corridor have a higher potential for economic development. Financial institutions could fast track the process of economic development of these regions by rolling out operations in these areas. Financial Institutions particularly banks can focus on services individual customers as well as SMEs.

GIZ can demonstrate the potential that these districts present to policy makers and thereby influence them to design policies and programs to incentivize banks to service this area. Additionally, GIZ could work simultaneously with their partner banks, demonstrate the potential of these districts as identified in this project and help them design financial products and services that fit the needs of individuals and SMEs in the northern region.

2. Policy Problem in Detail

To address the problem of increasing financial inclusion in Mozambique, we conducted preliminary research to understand the context of the country particularly relevant to our problem. This section includes applicable details on economy, administrative division, history, population and the distribution of the population around the country. These factors all play an important role in shaping the current state of financial inclusion in the country.

2.1 Economic Situation and Poverty

In 2014, Mozambique's GDP grew 7.6% and the economic outlook for the country remains positive. Growth rates of 7.5% and 8.1% are expected in the years 2015 and 2016, which imply a favorable context for expanding the country's financial inclusion.[7]

Despite Mozambique's income expansion, its growth fundamentals show weaknesses that can constrain future economic development. The main drivers of the country's growth include large public spending, extractive industry and donor and investor flows. First, the public spending has been concentrated on national mega-projects and infrastructure. In some cases the effectiveness of these large government expenditures has been questioned. Second, the expansionary fiscal policy adopted since 2013 has led to a concerning deterioration of Mozambique's fiscal balance. Third, the extractive sector was the fastest growing industry of the country's economy in 2014. However, the export-oriented industry struggles with insufficient infrastructure that prevents efficiency of exports. And finally, another important factor propping the economy is strong donor and investor inflows. However, the increased government spending has led to deterioration of public debt position, which may concern both donors and investors. As major donors deal with their own financial issues and austerity programs in some cases, it is especially important for the country to remain attractive to investors. Thus, increasing skepticism about Mozambique's public finance may prove problematic and jeopardize some development projects that may otherwise benefit the country's population.[8]

Mozambique's growth has not been inclusive. A strong divide persists between the more affluent south and extreme poverty of the rural areas in the center and north. Despite the economic improvements, a large portion of the population still lives under extremely difficult conditions. 60% of the population lives on less than $ 1/day and more than 80% lives on less than $ 2/day. Mozambique continues to be one of the poorest countries in the world; the country ranks 178th out of 187 countries on the human development index (HDI). Financial inclusion strategies can play a major role in making the country's growth more inclusive, contributing to extend its benefits to the rural low-income population.[9]

Agriculture accounts for more than 25% of Mozambique's GDP and employs 80% of its population, with 88% of the farmers living in rural areas. In fact, agricultural production and farming is the most common source of income and sustenance in the country. Agriculture

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[7] A. Almeida Santos, *et al,* (2015), *African Economic Outlook - Mozambique,* AfDB, OECD & UNDP
[8] A. Almeida Santos *et al,* (2015), *African Economic Outlook - Mozambique,* AfDB, OECD & UNDP
[9] UNDP, (2015), *Human Development Report (HDR) Work for Human Development* - Mozambique

workers could benefit significantly from banking services. For instance, acquiring savings and insurance products could help smooth their income and address weather related risks and access to credit services could contribute to increase their productivity. However, the usage of formal financial services by farmers is extremely low.[10] Therefore, targeting this large portion of the currently unserved population in rural areas could be one of the possible avenues for increasing financial inclusion in the country and contributing to a more balanced economic expansion.[11]

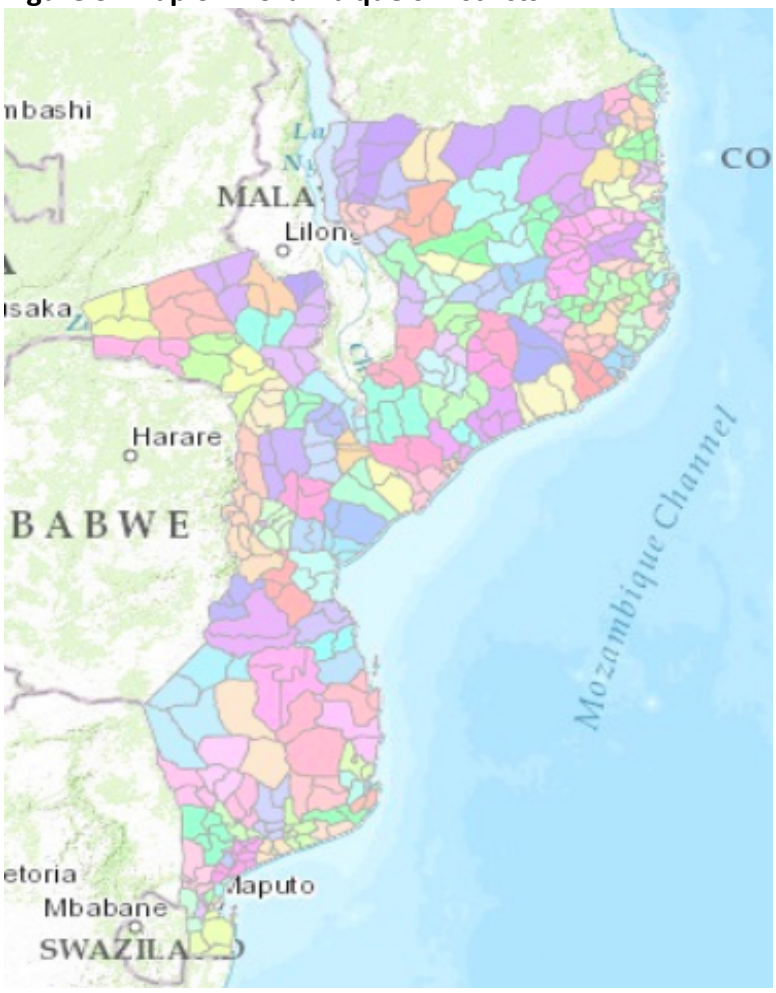
2.2 Administrative Division

The country is divided into ten provinces *(provincias)* plus the capital city, Maputo, which itself has a provincial status. The provinces are further subdivided into 151 districts *(distritos)* (see a map in Figure 1). Our analysis applies to 148 districts for which data was available. The districts are composed of 405 Administrative Posts *(Postos Administrativos).* Localities *(Localidades)* are the lowest geographical level of the central state administration. Since 1998, 53 Municipalities *(Municípios)* have been created in Mozambique.

In 2013, the government created 13 new districts in an effort to "consolidate new poles of development in order to fight against poverty" and to "bring the centres of political, administrative and economic decisions closer to the public".[12] The move was part of the strategy aimed at development of rural areas. The government suggested that these changes would "provide better assistance to people in the more remote areas".[13] Through this government bill, all provincial capitals became districts.

[10] FinMark Trust, (2015) *Finscope Consumer Survey Mozambique 2014*
[11] D. Chamberlain et al, (2015), *Making Access Possible (MAP) Report - Mozambique,* FinMark Trust, UNCDF
[12] *Mozambique: Bill Creating New Districts Passed,* 03/21/2013, retrieved from "All Africa", available at: web
[13] *Mozambique: Bill Creating New Districts Passed,* 03/21/2013, retrieved from "All Africa", available at: web

Figure 3: Map of Mozambique's Districts



Source: Data Basin

2.3 History[14]

The history of Mozambique is complex and rife with conflict. The transition from colonialism during the last quarter of the 20th century proved to be extremely difficult and the government was unable to establish peace and order in the country for nearly two decades. The country was unstable, grappling with a civil war that lasted for nearly two decades.

Living conditions in the country were extreme; approximately one million people died during this time due to starvation and a large number of people, particularly from the rural areas, relocated to larger urban centers or fled the country altogether. As a result of the conflict, the country was in economic shambles. With the surviving population concentrated in urban areas

[14] CIA–Central Intelligence Agency. *The World Factbook,* last access: 02/2016, available at: https://www.cia.gov/library/publications/the-world-factbook/

on the coast and approximately five million of displaced persons in the country, the agricultural production suffered. Famine ensued, exacerbated by the poor condition of country's infrastructure (devastated by the war) and El-Niño that struck the country in 1992.

The damage caused by ineffective governance and civil war has had lasting consequences. The country is still grappling with the legacy of the war, which to this day complicates integration of the rural population into the economic growth the country has experienced since.

While the country continues its political and economic transition, some military tensions remain in the nation's central region. Following a peace agreement, a general election was held in October 2014 that resulted in a curtailment of the power of the governing party, Frelimo. The success of the incumbent government and its development initiatives therefore is to some extent contingent on sustaining the September 2014 peace agreement and fostering of inclusive and diversified economic growth.

2.4 Population

The World Bank 2014 estimate of the total population of Mozambique is 27.22 million.[15] The population is expected to grow at 2.4% between 2012 and 2030, resulting in a total population of 38.9 million by 2030.[16] With 799,000 square kilometers of land, the average population density is relatively low at around 35 people per square kilometer.

Even though life expectancy among Mozambicans rose from 42.3 years in 1997 to a 52.94 in 2015, the country remains young in terms of demographics. The average age of the adult population is approximately 35 and the median 32 years.[17] A young population suggests a young labor force, an important factor facilitating economic growth. We expect the demand for financial services to grow commensurately with growing population and developing economy.

2.5 Geographical Distribution

The geographical distribution of the population remains imbalanced. Population is concentrated in a low number of urban centers with the largest urban enter being the capital city, Maputo. The current level of urbanization is 32.9%, with 67.1% of the adult population residing in rural areas.[18] Rural areas are characterized by low levels of assets and seasonal income, mostly from agriculture or individual businesses. There are also substantial differences in the levels of education between the urban and rural population. Levels of education and

[15] World Bank data, last access: 02/2016, available at: http://data.worldbank.org/country/mozambique#cp_wdi

[16] United Nations Population Division, *World Population Prospects data*, last access: 02/2016, available at: http://esa.un.org/unpd/wpp/DVD/

[17] FinMark Trust, (2015) *Finscope Consumer Survey Mozambique 2014*

[18] FinMark Trust, (2015) *Finscope Consumer Survey Mozambique 2014*

financial literacy of the rural population are very low. In rural areas only 10.4% of the adult population attended secondary school or higher.[19]

Such geographical distribution of the population poses critical challenges to the financial institutions when considering increasing the number of people served. High number of rural dwellers coupled with low literacy levels and large geographical distances are major factors keeping penetration of financial services in the country (and especially in rural areas) extremely low.

2.6 Financial Sector and Banking Industry

Mozambique is ranked 137 out of 148 by 2013-14 Global Competitiveness Report and the report cited access to finance as one of the main constraints for doing business. Financial Sector growth in Mozambique has remained slow despite its economic growth in the past decade. Access to financial services is very low in Mozambique particularly in rural areas. Competition in financial sector also continues to remain low.

There are very few local banks in Mozambique. The majority of the banks in Mozambique are foreign owned banks. Banks account for almost all the financial sector's assets, and the three largest banks account for 85 percent of total assets.[20] Financial Access among rural and low-income population continues to be a big challenge. According to the 2014 World Bank report Enhancing Financial Capability and Inclusion in Mozambique only 19% of the rural population in Mozambique have a bank account. According to 2014 Finscope report only 23% of the population is served by formal financial services.

Accordingly, use of the informal financial sector is relatively high. Finscope estimates that 27% of the adult population uses informal services, an 8 percentage point rise from 2009. It is very clear that the formal financial services have left behind a gap, which the informal financial services have filled in. According to the Finscope report, of those who use informal mechanisms, the vast majority belongs to savings groups, while remittance, credit and insurance services are also offered.[21]

As mentioned above, in general financial access continues to be low in the country but the problem is stark in rural areas. While around 70% of the population resides in rural areas, there are around seven times fewer bank branches serving these areas compared to urban ones.[22]

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[19] FinMark Trust, (2015) *Finscope Consumer Survey Mozambique 2014*

[20] IMF, (2010), Republic of Mozambique: Financial Sector Assessment program–Financial System Stability Assessment

[21] D. Chamberlain, (2015), Making Access Possible (MAP) Report - Mozambique, FinMark Trust, UNCDF

[22] D. Chamberlain, (2015), Making Access Possible (MAP) Report - Mozambique, FinMark Trust, UNCDF

However, there have been several initiatives planned to increase the financial access in the country. In 2015, the World Bank approved a US$25 million credit in support of the Government of Mozambique's Financial Sector Development Strategy, which aims at promoting greater financial inclusion and market stability. In 2013 the Council of Ministers approved the Financial Sector Development Strategy, which committed to ensure that 35% of adult Mozambicans have bank accounts by 2022.[23]

2.7 Status of Information and Communication Technology

Globally, electronic and mobile banking present a huge potential to financially include the unbanked population. One of the major reasons for this renewed hope is the high prevalence of technology among the low-income population. Therefore, it is important for the project to conduct a quick exploration of the status of information and communication technology in Mozambique. The recent economic growth in Mozambique has also lead to growth in the country's growth in its Information and Communication Technology. As the "mega projects" continued to develop, there was an increase in the demand for better information and communication technology in Mozambique.

2.7.1 Telecommunication and Mobile Communication

Telecomunicações de Moçambique (TDM) is the monopoly in the fixed-line segment. However, the mobile sector is quite competitive. Mcel and Vodacom Mozambique were the two mobile network operators in Mozambique until 2011, when Movitel, a new player entered the market and launched operations in 2012. Mobile penetration in 2012 was 48% while fixed teledensity was at 0.38%. The entry of the third mobile operator disrupted the market, leading to lower prices, better voice and data coverage, and higher traffic volumes.[24]

2.7.2 Mobile and Broadband Internet

Due to the availability of cheaper handsets, most of the Internet access in Mozambique happens via mobile phone. Similar to the trend observed in most emerging markets, majority of the population in Mozambique have leapfrogged to a mobile Internet market skipping the PC based Internet market. However, the price of broadband Internet continues to be very high. The 2012 RIA ICT Survey[25] indicates that 52% of respondents find the use of Internet "too expensive" and only 11.1% use it. Therefore majority of Mozambicans rely on mobile Internet,

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[23] D. Chamberlain, (2015), Making Access Possible (MAP) Report - Mozambique, FinMark Trust, UNCDF

[24] Francisco Mabila, *What is happening in ICT in Mozambique: A supply- and demand- side analysis of the ICT sector,* 2012

[25] 2012 Research ICT Africa Survey is nationally representative survey conducted in Mozambique that included 1200 individuals and 500 informal businesses

which tends to be cheaper than broadband Internet access. The 2012 RIA ICT Survey data for Mozambique indicates that 68.7% of individual users rely on mobile phone handsets to access the internet, 56.8% rely on 3G dongle modems, 10.6% use wireless broadband (TDM's WiMAX) and only 3.9% use ADSL connections.[26]

2.7.3 Media, Social Networking and Email

Prevalence of media and social networking presents additional opportunities for financial institutions to cater to the low-income population. For instance, companies such as Lenddo, which operates in Mexico, Coloumbia, and the Philippines uses social network data to generate credit scores for the unbanked population that lack traditional financial history. Therefore, performing a quick scan of prevalence of media, social network and email among Mozambicans was pertinent to the project.

Radio is the most popular mass media communication channel in Mozambique although television penetration is continuing to increase. One of the main reasons for radio's popularity is that the content is presented in multiple vernacular languages and in addition, cost of radio set is cheaper when compared to TV sets. Further, given the limited electrification of rural areas in Mozambique, radio consumes relatively less power than TV set, which adds to its popularity in rural areas. The 2012 RIA ICT Survey found that radio listeners account for 53.8% of the population while those who watch TV are 43.3%. Other emerging media resources are social networking applications, where Facebook leads, which is used by the 58% of internet users and, 64.36% of internet users have an email address.[27]

3. Research Design

To address the problem of increased financial inclusion in Mozambique, we have developed a methodology that identifies geographical areas that present the most commercially viable opportunities for formal banks in terms of offering their services to rural populations. Our hope is that identifying the precise geographical locations within rural districts that present these opportunities will incentivize incumbent financial service providers in Mozambique to expand their services to these currently excluded or underserved communities.

We built a series of interactive web-based tools that allow GIZ and the financial providers to quickly and reliably identify strategically optimized locations for expanding financial services.

[26]Francisco Mabila, *What is happening in ICT in Mozambique: A supply- and demand- side analysis of the ICT sector,* 2012

[27]Francisco Mabila, *What is happening in ICT in Mozambique: A supply- and demand- side analysis of the ICT sector,* 2012

The tools are visualisations that allow users to rank district appropriateness by several relevant factors and then identify attractive areas within districts. The tools rely heavily on Nighttime Lights (NL) data, and allow the user to select suitable areas within the country to allocate financial service provision. Broad research results (discussed later) link NL data to not only income and economic activity levels, but also to the depth of shadow economy, electricity consumption and income inequality. Considering these variables are all highly relevant when addressing the problem of financial inclusion, we believe NL data is allows us to choose an innovative and robust process to address the problem. In addition to NL data, the tools include other important variables sourced elsewhere (financial infrastructure, access points and population density) to rank the districts and to select best suitable areas within districts. These locations are local to the point that specific longitude and latitudes are presented.

3.1 How Are We Addressing the Problem?

The creation of the tools themselves have applied the following process:

1. Identification of factors that affect the suitability of financial service development.
2. Identification of provinces and districts that rank high by these metrics.
3. Within the districts, identification of specific areas for expansion opportunities.

The tools have been specifically created to allow flexibility of output. That is, the tools have been built to carefully identify districts of strategic interest for the financial providers (through the aforementioned process), but the user retains agency over how those districts are identified (by applying an interactive process and selecting a variety of filtering variables). The tools make heavy-use of USAF Defense Satellite Program Nightlight data (see Night Light data section for explanation), particularly at the intra-district identification stage. The major advantage of using this dataset is that its granularity allows us to look at areas within the district, beyond the level of detail allowed by traditional (typically country-level) data.

3.2 Steps of the Analysis

Stage 1: Identify Factors to Consider

Our first step was to employ statistical learning techniques across countries to identify factors explaining the variation in financial inclusion at the global level. Looking at global level data allows us to identify common factors that explain the success of financial inclusion programs in other countries. We applied both parametric and tree-based learning algorithms in this setting. We have also researched case studies and within-region/country studies in a qualitative fashion to identify within-region/country-level factors worthy of consideration. Once identified, we cross-referenced this list of driving factors with data available at a district level in

Mozambique.

Unfortunately, our findings from the statistical learning phase failed to reveal many variables that were available at a representative district level within Mozambique, so the output from this was limited. Further, we discovered that a large proportion of the variation in country-level data was due to general income levels. This prompted us to put larger weight on the NL data, which is a good proxy for this. The advantage of NL data is that it allows for extra-granular analysis of geographies, incorporates information about the shadow economy, which official data does not take into account, and also provides information on relevant variables for financial inclusion such as electrification rates, human development and levels of ICT development.

The main discovery in this step was to learn that the data was rather uni-dimensional, meaning that large proportion of the variance in the data was explained by a single variable: income. This became our basis for using the NL data as a proxy for income.

In addition to the information gathered in the stage 1 of our analysis, we asked our client to suggest variables relevant to financial inclusion. Based on input from GIZ, we collected district-level data on population, population density, and financial access points (i.e. bank branches). These variables became inputs for stage 2 of our process.

Stage 2: Rank Districts

We selected these three variables based on a Financial Sector Deepening Program's report on Mozambique,[28] which our client shared with us.

Using these variables, we developed a prototype of a software tool that allows us and the users to rank districts, and to identify those suitable for expansion. This is done in an interactive way, such that users can decide which factors are substantively the most important to consider. The tool provides simple ranking plots for district comparison alongside scatterplots to see how districts compare across different dimensions. This allows users to identify districts based on suitability metrics of their choice.

For the purposes of our project, we will take input from our client to decide what dimensions should be most heavily weighted in the district-ranking stage.

[28] Financial Sector Deepening Program, (2015), *Mozambique Report 2014*

Stage 3: Within-District Location

Once specific districts are selected in the second stage, users are able to identify areas within districts by making use of the NL data. Maps based on the NL data and the inputted districts are created to get a visual sense of the level of economic activity within a given region (as approximated by the NL data). Finally, based on this visualization, an algorithm to optimize the location of a given number of banks is applied to the map.

Once individual districts have been identified as having high potential, we are able to look within the districts at a pixel (30 arc-second (0.86 km^2)) granularity and identify specific areas of interest for establishing financial institutions.

First the district of interest is mapped using the NL data. This creates an intuitive visualization of the district, where the pixels are colored by the NL intensity. We then create an algorithm to optimize the location of financial institutions within that district. The optimizer is a modified K-means clustering algorithm. This popular algorithm works by finding the best K clusters of data across the sample space, by maximising the distance (usually Euclidean) between clusters (or alternatively minimising the distance within clusters). After the algorithm has converged, every data point is assigned to the cluster with the nearest mean.

This approach is appropriate for our problem since we are essentially facing a tradeoff between a distance metric[29] (closeness of institution), and an income metric. The modification to the clustering comes by weighting the inputs to cluster on. To calculate the weights, raw light scores are taken for each pixel and the following transformation is applied to them.

$$w_{ij} = e^{(\gamma L_{ij})}$$

w_{ij} = Weight of pixel at latitude i, longitude j

γ = Tuning parameter

L_{ij} = Luminosity of pixel at latitude i, longitude j

The purpose of this transformation is to allow flexibility in how the algorithm specifies location. The bounds of the function are such that adjusting the tuning parameter (gamma) transforms the clustering algorithm from focusing purely on the geographic location to the case (i.e. placing the institutions equidistant on the map) to the case where it clusters solely based on

[29]Distance to a financial institution is an important metric to consider. One, we do not want the financial service outlet to be located too close to an existing outlet in which case we are not really solving the problem of financial exclusion. At the same time, locating an outlet too far away from any sort of financial infrastructure will pose operational challenges such as liquidity management.

the luminosity data. The function takes an input of the number of institutions that can be established and returns the optimal location within the district based on the modified clustering algorithm.

3.3 Advantages of Our Approach

As mentioned earlier, the main objective of this study is to demonstrate the latent potential for banking products in the rural low-income markets of Mozambique. Through this study, we are demonstrating the potential primarily by handling the NL data, which is proved to be a robust proxy variable for income by various academic studies. However, it is still a substitute measure but not a real measure and therefore, the results of this study is not conclusive for banks. Nonetheless, given the constraints with respect to data availability and time availability to collect primary data, this study can be a good starting point leading to further in-depth research studies on districts identified through this analysis.

- This approach allows us to look at intra-district and intra-provincial levels, where data is otherwise unavailable.
- The quality of data on Mozambique obtained through traditional means is likely relatively low.
- Unavailability of data more broadly has been a challenge. We were unable to match variables identified through cross-sectional (country-level) analysis to district-level data within the country.
- Of the data that was available at both district level within Mozambique and at national level elsewhere, the variation was seen to be fairly one-dimensional. Data reduction techniques (PCA) showed that a large proportion of the variation in this subset of relevant variables was explained by one single factor and that factor was most likely (we cannot say with certainty, since it is latent information) variation in income. Therefore using more granular data, which is a proxy for income, is an appropriate strategy.
- While we obtained access to a highly detailed survey, it was representative at the provincial rather than district level.

3.4 Data Description

Stage 1 Data

Stage 1 data largely came from the World Bank's Findex dataset. The data covers over 140 countries and is generally seen as the most comprehensive database on financial inclusion. It is based on interviews with over 150,000 adults and provides details on their saving and borrowing behaviour as well as how they react to financial events. While the dataset is

nationally representative, it does not unfortunately provide information for Mozambique. There were many relevant variables available in this dataset for looking at country-level data ranging from the penetration of financial services across age groups to the propensity to borrow from informal lenders.

We also consulted survey data from the FinScope Survey, which was conducted in 2014 and recently published by the Ministry of Finance and FinMark Trust. The survey was a comprehensive survey conducted across the country on a nationally representative sample of close to 4000 households. The survey asked adults about their financial behaviours, basic financial literacy and use of financial services.

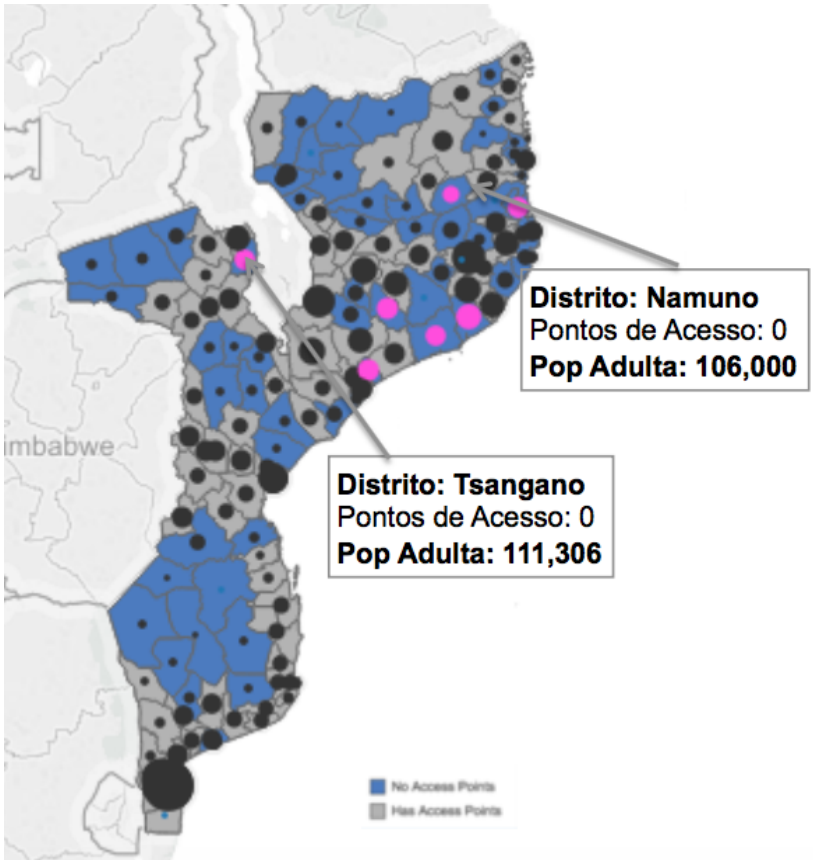
Stage 2 Data

Stage 2 data includes three variables that we used for ranking, plotting and filtering the 156 Mozambican districts to select an imputed list of districts for the analysis in stage 3. The variables are district population, district population density and district-level metric of financial access.

We selected these three variables based on a Financial Sector Deepening Program's (FSD) report on Mozambique,[30] which our client shared with us . The report builds on data collected by 2014 Finscope Survey. The authors created district-level maps that visualize these three variables and their combinations. For example, below is a map that depicts population size as well as access points.

[30]Financial Sector Deepening Program, (2015), *Mozambique Report 2014*

Figure 4: FSD Mozambique Map of High Potential Districts



Source: Financial Sector Deepening Program, (2015), *Mozambique Report 2014*

We adopted these variables for analysis in our stage 2. To further build on the work done by the authors of the Financial Sector Deepening Program's report on Mozambique, we identify specific within-district locations best suited for an introduction of a new access point. The identification of a specific location is done in stage 3 of our process and utilizes NL data.

3.4.2 Population

We sourced district-level population data from the Mozambican Statistical Institute *(Instituto Nacional de Estatística (INE)).* The latest country-wide census was performed in 2007; however, the population data was then updated by the INE based on projected population growth. We accessed the projected population data through the INE's website and used 2013 district-level population projections as one of the variables in our analysis.

The population data are used as an input in stage 2 of our analysis. If the users believe population data to be a relevant variable to selection of district suitable for expansion of financial services, they can choose to rank and plot the 156 Mozambican districts in terms of

population count. This allows the users to create an imputed list of districts to be used in the final stage of the analysis.

3.4.3 Population Density

We sourced district-level population density data from the Mozambican Statistical Institute *(Instituto Nacional de Estatística (INE)).* Population density is defined by INE as the relevant area (i.e. area of the district) measured in squared kilometers, divided by the population count residing within this area.

In our analysis, this variable is used to distinguish rural and urban areas. While the INE provided some guidance on a "density threshold" that would delineate rural populations from urban ones, our analysis considers density as a continuous variable.

Similar to the population data, the density data are used as an input in stage 2. The density data can be used to rank, plot, filter and sort the districts to choose the most suitable ones to be analyzed in the final stage.

3.4.4 Access to Financial Services

We sourced district-level data on access to financial services from the Mozambican Statistical Institute *(Instituto Nacional de Estatística (INE))*. The original data, however, comes from the Central Bank of Mozambique. We defined access to financial services as a sum of access points in a district. Such access points include bank branches, credit unions, microfinance institutions, insurance companies and currency exchange offices. However, it was true for all districts that the only data available was on bank branches. Thus, this variable effectively reflects only the number of bank branches in a given district. Considering that the purpose of our analysis is to incentivize formal financial institutions to expand their services, we consider bank branches (a possible competition) as a good proxy for levels of financial access in a given district.

In our analysis, this variable is used to identify areas with lowest levels of financial access. Similar to the population and density data, the financial access data are used as an input in stage 2 and can be used to rank, plot, filter and sort the districts. The final list of selected districts advances to the final stage of the analysis.

Stage 3 Data

3.4.5 Night-Lights Data

The primary source of data for our analyses is the USAF Defense Satellite Program Nightlight data, in addition to data such as population density and financial services access points from

the National Statistical Institute of Mozambique. Satellites from the program circle the earth roughly every two hours and record the intensity of light from Earth. The data is filtered by the National Geophysical Data Center to remove the effects of, amongst other things, cloud cover, auroral activity and fires and then daily estimates are produced. Annual numbers are then created from this daily data, which is the dataset we use. The data is at the level of every 30 arc-second (which roughly equals 0.86 squared kilometer), making it incredibly granular. Effectively this is a digital reading of the true light intensity coming from the earth.

The level of granularity with which the NL data is collected makes it uniquely suited to spatial and/or intra-regional analysis where data is otherwise unavailable, or the quality of that data is poor (often due to limited capacity). In that sense, the data is ideally suited to our analysis of Mozambique. It has been shown throughout the literature that intra-region comparisons are likely to yield better results than cross-country comparisons and the data provides information that is otherwise unavailable to us through other sources (see footnotes 32-38). The NL data is measured with error, which provides some limitations to our approach.

3.5 Current Research on NL Data

3.5.1 NL Data, Income & Economic Growth Theory

The relationship between NL data and economic activity has been widely covered throughout the economic literature (see Croft 1978,[31] Elvidge et al. 1997,[32] Sutton and Costanza 2002,[33] Ebener et al. 2005,[34] Doll, Muller, and Morley 2006,[35] Sutton, Elvidge, and Ghosh 2007,[36] and Ghosh et al. 2010).[37] The link between NL data and economic growth was more recently presented in Henderson et al. (2012),[38] and indeed was one of our primary motivators for using the data.

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[31] T.A. Croft, (1978) *Night-time images of the Earth from space.* Scientific American, 239

[32] C. D. Elvidge et al. (1997). *A technique for using composite DMSP/OLS "city lights" satellite data to map urban area.* Remote Sensing of Environment, 61(3), 361-370.

[33] P. C. Sutton & R. Costanza. (2002). *Global estimates of market and non-market values derived from nighttime satellite imagery, land cover, and ecosystem service valuation.* Ecological Economics, 41(3), 509-527.

[34] S. Ebener, C. Murray, A. Tandon & C. Elvidge. (2005). *From wealth to health: modelling the distribution of income per capita at the sub-national level using night-time light imagery.* International Journal of health geographics, 4(1), 1.

[35] C. N. Doll, J. P. Muller, & J. G. Morley. (2006). *Mapping regional economic activity from night-time light satellite imagery. Ecological Economics,* 57(1), 75-92.

[36] P. C. Sutton, C. D. Elvidge, & T. Ghosh. (2007). *Estimation of gross domestic product at sub-national scales using nighttime satellite imagery*.International Journal of Ecological Economics & Statistics, 8(S07), 5-21.

[37] T. Ghosh, R. Powell, C. D. Elvidge, K. E. Baugh, P. C. Sutton, & S. Anderson (2010). *Shedding light on the global distribution of economic activity.* The Open Geography Journal, 3(1).

[38] J. V. Henderson, A. Storeygard, & D. N. Weil (2009). *Measuring economic growth from outer space* (No. w15199). National Bureau of Economic Research.

Since GDP is often poorly measured in many developing countries, the authors suggest the use of NL data as an alternative. They note that NL data is uniquely suited to spatial analysis of economic output, since users are able to map it to c.1 km square grids and aggregate them to city or regional levels. Data at this level of granularity is rarely available elsewhere, and even if it were, its reliability is questionable due to measurement problems.

The primary purpose of the paper was to present a methodology for using the NL data for growth estimates. They estimated both a coefficient which links growth in NL intensity to a GDP growth proxy and also the optimal weights to be applied when combining this proxy with traditional measures of growth to estimate 'true' growth. They suggest that for countries with poor data collection (of which Mozambique is one), roughly equal weights should be applied.

In summary, this paper supports the use of NL data for attempts to make intra-regional inferences, where data is either poorly collected or even unavailable. This can certainly be applied to our case.

3.5.2 Shadow Economy & Lights

In any country, some portion of economic activity is likely to go unregistered with the tax authority, and therefore this part of income typically remains unaccounted for in traditional ways of measuring economic output. Because of its informal nature, there are inherent measurement difficulties with shadow economy. Erroneous business and policy decisions can be produced as a result.

When thinking about a shadow economy, one often pictures street vendors and small family-run shops in developing countries. A typical member of a shadow economy tends to be a self-employed entrepreneur. While these workers produce goods and earn income, their activities are not fully reflected in the official GDP measures. Generally, the proportion of self-employment as a part of total national employment decreases as the level of development in a country increases.[39] However, even in developed markets, a number of self-employed workers are not able or willing to register with the tax authority.

The estimated proportion of national shadow economies varies widely. According to Schneider and Enste, shadow economies are much larger in developing and transition economies than in

[39] R. L. Porta, & A. Shleifer. (2014). *Informality and development (No. w20205).* National Bureau of Economic Research.

developed countries. While the estimates for OECD countries' informal sector range from 8% - 30%, the level for African countries is estimated at 39% - 76% of the total economy.[40]

Literature Review

Ghosh *et al*. attempted to use NL data of 2000-2001 to estimate the size of the informal economy in Mexico. The authors selected Mexico because of the transition the economy was undertaking during that time. The researchers assumed that the traditional estimates of GSP, GDP and GNI included most of formal the formal economic activities. Therefore, any surplus economic activity as measured by the patterns of NL above the official measures could be attributed to shadow economy and remittance inflow into Mexico. The authors found that Mexico's level of lights (and therefore economic output) exceeded the official figures and concluded that *"the informal economy in Mexico may be larger than the existing official estimates (12 percent of GDP)..."*. The authors suggest that this approach provides an objective and independent measure of the volume of informal economy in the country.[41]

Similarly, Harati and Hardy in 2013 compared the official GDP estimates to the levels of economic activity predicted by NL data. The authors argue that regardless of registration with the government, economic activity requires light. As a result, the official figures tend to underestimate total size of the economy. Therefore, studying the differences between the size of the economy predicted by lights and the size reported by the official figures *"produces a new measure of the in formal share of total economic activity for each country"*.[42]

Finally, Tanaka and Keola perform a similar analysis of formal and informal sectors in Cambodia, discovering that nearly all (96%) of non-farm establishments do not formally register with the government. Using NL data, the authors were able to demonstrate that during the studied period, both sectors of the economy grew, however, the informal sector grew faster and thus became a larger portion of the country's economy.[43]

Implications for Mozambique and our Project

The size and growth of an informal economy is particularly relevant in developing countries with a high proportion of self-employment. Mozambique is categorized as a developing

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[40] F. Schneider, & D. Enste. (2000). *Shadow Economies around the World Size, Causes, and Consequences.*

[41] T. Ghosh, S. Anderson, R. L. Powell, P. C. Sutton, & C. D. Elvidge. (2009). *Estimation of Mexico's informal economy and remittances using nighttime imagery.* Remote Sensing, *1*(3), 418-444.

[42] R. Harati, & M. Hardy. (2013). *ILLUMINATING THE SHADOW ECONOMY: Using lights from space to estimate a new measure of informal economic activity*. Mimeo.

[43] K. Tanaka, S. Keola, & 田中清泰. (2015). *Shedding light on the shadow economy: a nighttime light approach.*

country. A large proportion, approximately 50%, of its citizens are self employed.[44] Particularly in rural areas relevant to our study, only 5% of Mozambicans are formally employed.[45] According to Mozambique Labour Market Profile 2014, the informal employment in Mozambique is concentrated in the subsistence farming sector and the estimated growth of the informal sector was around 8% in 2014.

Data reporting on developing countries vary widely by the source. According to USAID and ILO, 75% of economically active Mozambicans operate in the informal sector.[46] In contrast to that, the figure reported by the Ministry of Planning and Development figure was only 41%. At the same time, the Mozambique's National Institute of Statistics suggests that 87% of Mozambique's working population is employed in the informal sector. The most recent official estimates suggest that the informal economy absorbs 95% of the labour force.[47]

Aside from the difficulties in measurement, as Tanaka and Keola point out, formal and informal economic activity tends to cluster in certain regions in a country resulting in large inter-regional differences in economic activity. It follows, that country-level aggregations obscure the true inter-country variations in economic activity and its formal/informal nature.[48]

Income is an important variable for banks and financial institutions to consider before entering a market. Higher income presents higher demand for financial services. Mapping the invisible Market report by Accion showcases the link between markets with relative higher income in developing countries and access to financial services. The report demonstrates that consumers with sufficient incomes make them attractive to a wider range of financial services providers. In addition, as consumers gain income, they are also more likely to demand more and better formal financial tools.[49] Further, the report also underlines the importance of including the invisible or the shadow economy which calculating the income propensity of a market particularly in markets like Mozambique where the official figures are not accurately measured. Therefore, we suggest that using NL data in lieu of official estimates presents a superior method relevant to our project.

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[44]F. Tarp, & S. Jones. (2013). *Jobs and Welfare in Mozambique.* UNU-WIDER working paper, *4*(2013).
[45]F. Tarp, & S. Jones. (2013). *Jobs and Welfare in Mozambique.* UNU-WIDER working paper, *4*(2013).
[46]B. Byiers. (2009). *Informality in Mozambique: Characteristics, Performance and Policy Issues.* USAID, Washington, DC.
[47]Danish Trade Union Council for International Development Cooperation. (2015). *Mozambique Labor Market Profile 2014*
[48]K. Tanaka, S. Keola, & 田中清泰. (2015). *Shedding light on the shadow economy: a nighttime light approach.*
[49]Elisabeth Rhyne and Sonja Kelly. (2013), *Financial Inclusion 2020 Project: Mapping the Invisible Market,* Accion 2013

3.5.3 Electricity & Lights

Access to electricity offers many benefits from health to increased productivity or access to technology. For example, in the United States, the Rural Electrification Act of 1936 brought about significant improvements in a variety of quality of life indicators such as childhood survival rate, access to clean water or reading achievements.[50]

Health benefits of electrification are well documented. According to a study done by United Nations Foundation,[51] introducing microgrids to rural populations in developing countries helps mitigate some of the detrimental effects of kerosene use that include structural fires and severe burns, respiratory diseases, potential links to tuberculosis and cataracts, and child poisoning from unintentional ingestion of kerosene.

Electrification has also been shown to have a positive impact on labor productivity and total factor productivity (TFP) growth.[52] On a rural level, Fan, Jitsuchon and Methakunnavut[53] have shown that rural electrification has a second largest impact on agricultural productivity. Electricity comes second only to agricultural research and development. A study of microgrids in rural Kenya demonstrates that access to electric tools results in 100-200% increase in productivity per worker which corresponds to income growth of 20-70%.[54]

Increased economic activity is another benefit of electrification. A study performed in Tanzania demonstrated a connection between electrification and a shift from non-family full-time employees, rather than defaulting to family members as an employment source. This survey of 320 connected and nonconnected SMEs in Tanzania also revealed that 90% of connected SMEs saw their income increase upon electrification and 85% of them tied this increase to gain of electricity access. 80% of these businesses experienced increase in sales volume and the

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[50]Jude Clemente. *The Statistical Connection Between Electricity and Human Development.* 09/01/2010, last access: 02/2016, available at:
http://www.powermag.com/the-statistical-connection-between-electricity-and-human-development/

[51]Daniel Schnitzer, Deepa Shinde Lounsbury, Juan Pablo Carvallo, Ranjit Deshmukh, Jay Apt and Daniel M. Kammen, *Microgrids for Rural Electrification*, IEEE Transaction of Smart Grid, 2014.

[52]Z. Bogetic, & J. W. Fedderke. (2006). *International benchmarking of South Africa's infrastructure performance.* World Bank Policy Research Working Paper, (3830).

[53]S. Fan, S. Jitsuchon, & N. Methakunnavut. (2004). *The importance of public investment for reducing rural poverty in middle-income countries: The case of Thailand,* SGD Discussion Paper, no. 7, Development Strategy and Governance Division, International Food Policy Research Institute, Washington, DC.

[54]C. Kirubi, A. Jacobson, D. M. Kammen, & A. Mills, (2009). *Community-based electric micro-grids can contribute to rural development: evidence from Kenya.* World development, 37(7), 1208-1221.

number of clients.[55] Additionally, a research performed in 11 African countries concluded that electricity access in combination with generator use causes employment growth.[56]

Access to electricity not only creates new economic opportunities, but it also extends and magnifies current ones. For example, without electricity, many workers are forced to end their productive day with sunset. Having electricity therefore increases the possible number of productive hours in a day.

Another important benefit offered by electricity is access to information technology and the internet. A study of internet-adoption in low-income countries found evidence that increasing distribution of electricity significantly increased the number of internet users.[57]

Other benefits demonstrated by academic research include increased private investment in India,[58] positive effect on women's labour force participation in Guatemala, [59] and higher social and economic benefits for rural communities in Kenya.[60]

Literature Review

Min *et al*. evaluated merits of using NL data in detecting rural electrification in developing world where access is limited and difficult to measure. The authors argue that this method is superior to traditional ground-based data collection because of its comparatively low price. Another benefit is its consistency over time, as the data is collected and stored every night. Comparing the NL data with data originating from traditional method, the authors found strong evidence that satellite imagery can reliably identify electrified villages.[61]

Similarly, a study of rural electrification in Vietnam compared NL data and ground-based survey data on electricity infrastructure and use. The study performed in 200 villages in rural Vietnam

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[55]ESMAP - Energy Sector Management Assistance Program (2005): *Study to Promote Productive Uses of Electricity in Rural Electrification Projects in Tanzania.* DataVision International Ltd.

[56]M. Goedhuys, & L. Sleuwaegen. (2010). High-growth entrepreneurial firms in Africa: a quantile regression approach. *Small Business Economics*, *34*(1), 31-51.

[57]L. Hosman & L.E. Armey (2015) *The Centrality of Electricity for Internet Uptake in Low-Income Countries T*elecommunications Policy, ISSN 0308-5961

[58]D. F. Barnes, & H. P. Binswanger. (1986). *Impact of rural electrification and infrastructure on agricultural changes, 1966-1980.* Economic and Political Weekly, 26-34.

[59]L. Grogan & A. Sadanand. (2009). *Electrification and the Household.*University of Guelph, Economics Department, Guelph, Ontario.

[60]C. Kirubi, A. Jacobson, D. M. Kammen, & A. Mills. (2009). *Community-based electric micro-grids can contribute to rural development: evidence from Kenya.* World development, 37(7), 1208-1221.

[61]B. Min, K. M. Gaba, O. F. Sarr, & A. Agalassou. (2013). *Detection of rural electrification in Africa using DMSP-OLS night lights imagery.* International journal of remote sensing, *34*(22), 8118-8141.

determined the magnitude of one point increase in NL brightness. The study equated one point increase to 125 - 200 additional streetlights, or 550 - 700 additional electrified homes.[62] Therefore, the study suggests that using NL data has a potential to improve quality of electrification measurements.

Finally, Hosman and Armey established the importance of electricity access with respect to increased internet usage. The authors also utilized NL data to avoid the inconsistencies in traditional electricity and energy data reporting and to leave out reliance on vague definitions of electricity access.[63]

Implications for Mozambique and our Project

Despite abundant natural resources such as coal and gas, Mozambique is one of the poorest African countries in terms of electricity. In 2012, only 23% of the population enjoyed access to electric grid.[64] The situation is further complicated by the fact that nearly 70% of the population lives in rural areas to which electricity grid is more difficult to extend.

In a bid to support economic development in rural districts, the government has led initiatives to extend electricity infrastructure to these parts of the country. The procurement process is subject to political drivers and involves countless decisions regarding tariffs, subsidies and prioritization of geographical areas. Despite the efforts, the network remains under-maintained and inefficient, resulting in unreliability and significant energy losses.[65]

The national electrification efforts are concentrated on capitals of the rural districts. As such, rural administrative posts continue to be largely excluded from the national grid. In fact, some studies suggest that national electricity network may not be extended to rural administrative posts (outside district capitals) for next 25 years.[66] However, off-grid networks are in some sense filling the void. They tend to predate national grids by many years, creating electricity

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[62] B. Min, & K.M. Gaba. (2014). *Tracking Electrification in Vietnam Using Nighttime Lights.* Remote Sensing, 6(10), 9511-9529.

[63] L. Hosman & L.E. Armey. (2015) *The Centrality of Electricity for Internet Uptake in Low-Income Countries T*elecommunications Policy, ISSN 0308-5961

[64] Marcus Power. «Mozambique needs a community-driven approach to electrification». *The Conversation.* 11/10/2015, last access 02/2016, available at: http://theconversation.com/mozambique-needs-a-community-driven-approach-to-electrification-50213

[65] Marcus Power. «Mozambique needs a community-driven approach to electrification». *The Conversation.* 11/10/2015, last access 02/2016, available at: http://theconversation.com/mozambique-needs-a-community-driven-approach-to-electrification-50213

[66] «Hybrid mini-grids for rural electrification in Mozambique». *3E*, last access 02/2016, available at: http://www.3e.eu/hybrid-mini-grids-rural-electrification-mozambique/

demand and customer base.[67] In 2014, more than 2000 stand-alone electricity systems were operating in Mozambican public spaces and 50 mini-networks were powering rural centers. While we applaud this advancement, simple access does not necessarily equate consumption, especially considering that usage of some of these alternative networks depends on fuel costs (i.e. diesel).

Presence of off-grid electricity and alternative energy access introduces complexities to already hardly consistent measurements of electricity access. There is no generally-accepted agreement on what "electricity access" or "being electrified" means. The International Energy Agency has no consistent definition for electric power access and no standardized method for data collection.[68] The World Bank electrification rate captures access of households to electricity (a measure including off-grid access), however, the data is based on household surveys. According to the World Bank, the household surveys are a better measurement than the data provided by national power utilities. In addition to low quality of data, national utilities employ various definitions of electrification, which makes cross country comparisons difficult.[69]

This is yet another example of how the use of two gridded data products derived from censuses, satellite imagery, and spatial analysis can provide useful and valid proxy measures.

Considering the lack of standardization in the measurement of electricity access, NL data appears to be a suitable proxy for measuring electricity access. In addition to consistency, NL data offer district-level an approximation for electricity consumption,[70] which is particularly relevant to our project.

Rural dwellers are limited in their possibilities of earning income, therefore, we expect that rural areas that are lit suggest (1) economic conditions that allow purchase of light and (2) economic activity that makes the light investment attractive. Thus, using NL data allows us to identify rural areas where services of formal financial institutions may be demanded. Further, the new age digital financial inclusion heavily leans on technology. Usage of technology is helping financial service providers reimagine the whole financial services delivery landscape. Using mobile phones and other emerging payment technologies, financial institutions can

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[67] H. Ahlborg, & L. Hammar. (2014). *Drivers and barriers to rural electrification in Tanzania and Mozambique–Grid-extension, off-grid, and renewable energy technologies.* Renewable Energy, 61, 117-124.

[68] T. Ghosh, S. J. Anderson, C.D. Elvidge, & P. C.Sutton (2013). *Using nighttime satellite imagery as a proxy measure of human well-being.Sustainability,* 5(12), 4988-5019.

[69] World Bank, Sustainable Energy for All (SE4ALL) database from World Bank, Global Electrification database, last access 02/2016, available at: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

[70] T. Ghosh, S .J. Anderson, C. D. Elvidge, & P.C. Sutton. (2013). *Using nighttime satellite imagery as a proxy measure of human well-being.Sustainability,* 5(12), 4988-5019.

remotely perform almost all basic transaction from opening bank accounts to transferring funds. However, the full potential of the technology cannot be realized in areas that have an intermittent access to electricity. One of the flagship projects of our client, RAMOZ Initiative, aims at increasing financial inclusion by promoting a network of agents who will offer financial services via electronic and mobile channels. Therefore, availability of electricity is an important prerequisite for such programs. In addition, lack of infrastructural facilities especially electricity increases the operational expenditure for financial institutions in rural areas. Moreover, prioritizing areas with better electricity connectivity can result in higher success in rolling out financial services.

3.5.4 Human Development & Lights

Human Development Index - Introduction of the Variable

Financial capital combined with poor human development lead to poor outcomes. Banks that offer microcredit loans for small businesses and income generating activities have a higher incentive to operate in regions that have a relatively higher human capital development. Inequality of wealth and income distribution affects human happiness and wellbeing of a population.[71] The Gini Index is an attempt to capture some of the inequalities that exist. However, there are some challenges associated with this measurement. First, the Gini coefficient measures income inequality using country data, which results in lack of intra-country variance. Second, as mentioned previously, the quality of country data is highly dependent on the level of development and institutional capacity of a given country. Some researchers set out to alleviate these problems by using NL data.

Literature Review

To address the measurement problems inherent in the Gini Index, Elvidge *et al.* combined NL data with gridded population data to develop a Night Light Development Index (NLDI). The NLDI measures the level of equality in the distribution of outdoor lighting, which the authors connect to income inequality. The authors posit that NL has been well researched as a proxy for income. Therefore, combining NL data with the dimension of population distribution offers information about income distribution. In this way, the authors were able to estimate within country inequalities in income distribution. The study presents NLDI for 4,550 subnational units, primarily states and provinces.[72]

Implications for Mozambique and our Project

[71] C. D. Elvidge, K. E. Baugh, S. J. Anderson, P. C. Sutton, & T. Ghosh. (2012). *The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data.* Social Geography, 7(1), 23-35.

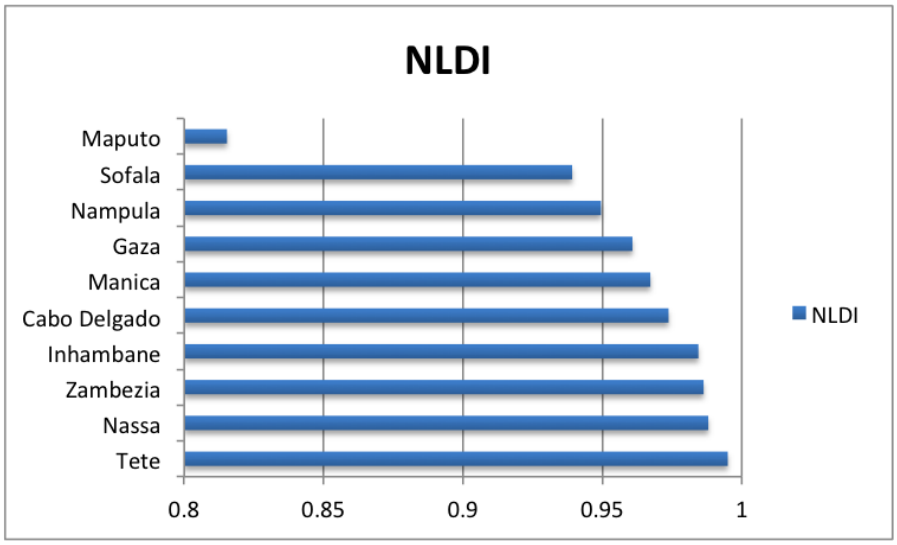
[72] C. D. Elvidge, K. E. Baugh, S. J. Anderson, P. C. Sutton, & T. Ghosh. (2012). *The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data.* Social Geography, 7(1), 23-35.

We expect areas with lower inequality to offer a more attractive and a safer market for formal financial institutions because of the negative impact of income inequality. For example, inequality has been tied to lower political and economic stability, increased political and decision making power concentration, inefficient use of human resources and increased risk of a crisis.[73]

The authors of NLDI provided subnational level data for Mozambique. The data captures inequality on a provincial level but not a district level. It offers an additional (supporting) dimension of analysis to our project.

Figure 5 shows 2011 NLDI data for ten Mozambican provinces. The NLDI is inversely correlated to electrification rates. As NLDI values rise, electrification rates fall and estimated income inequality rises. According to this analysis, districts in the provinces of Tete and Niassa may be the most problematic in terms of electrification rates and inequality inequality. Thus, any consideration of expansion of financial services to either one of these districts would require extra caution and additional level of feasibility study.

Figure 5: NLDI Mozambique



Source: The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data[74]

[73]M. E. Dabla-Norris, M. K. Kochhar, M. N. Suphaphiphat, M. F. Ricka, & E. Tsounta. (2015). *Causes and consequences of income inequality: a global perspective*. International Monetary Fund.

[74]C. D. Elvidge, K. E. Baugh, S. J. Anderson, P. C. Sutton, & T. Ghosh. (2012). *The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data.* Social Geography, 7(1), 23-35.

Ratnasiri and Arora (2011) present a body of evidence that indicate a direct correlation between human capital and economic development. Further, the report also indicates a strong relationship between financial development and human capital. Most importantly, physical capital combined with poor human development may produce low growth and poor development outcomes.[75] Therefore, banks that offer microcredit loans for small businesses and income generating activities have a higher incentive to operate in regions that have a relatively higher human capital development.

3.5.5 Information and Technology & Lights

Technology Development Index (IDI) - Introduction of the Variable

Access to technology and information is another dimension of human well-being and population equality. It is also correlated with economic development, productivity gains, technology development, growth of service sector, increased employment, better education performance and higher women labor participation rates.[76]

The Information and Communication Technology Development Index (IDI) was developed by a United Nations agency, The International Telecommunication Union, with the objective of measuring the development of countries with respect to Information and Communication Technology (ICT) use, access, and skills.

Literature Review

Authors Ghosh *et al.* attempted to build on the The International Telecommunication Union's IDI. The close relationship between IDI and GDP was previously established. To create an IDI map, the authors used NL data in combination with LandScan population grid. Unfortunately, the approach failed at the desired level of fine resolution. However, the authors were able to produce a state-level IDI map for Southeast Asian Countries.[77] The authors plan to further develop the method combining NL images and the LandScan population grid because they believe it will provide important, quick and efficient information relevant to ICT access and distribution on a subnational level.

Implications for Mozambique and our Project

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[75] Rashmi Shyama, & Ratnasiri Arora. (2011). *Financial Development, Financial Inclusion and Human Capital: How Close is the Link? A Study of India*, Griffith University, 2011

[76] T. Ghosh, S. J. Anderson, C. D. Elvidge, & P.C. Sutton. (2013). *Using nighttime satellite imagery as a proxy measure of human well-being.Sustainability,* 5(12), 4988-5019.

[77] T. Ghosh, C.D. Elvidge, P.C. Sutton, K. E. Baugh, D. Ziskin. *Estimating the Information and Technology Development Index (IDI) Using Nighttime Satellite Imagery.* In Proceedings of the Asia Pacific Advanced Network, Hanoi, Vietnam, 9–13 August 2010.

The increasing penetration of technology within the low-income population, particularly via mobile phones, is presenting a new opportunity for financial institutions to reach out to this market using technology. Usage of technology within the low-income population offers many other advantages from a financial inclusion perspective. Access to technology enables consumers to generate data, which can be used for alternative credit scoring and credit sanctioning. Further, many countries such as India are digitally including citizens by offering Unique IDs and e-KYC authentication which reduces customer acquisition cost for financial institutions. However, such digital inclusion programs are possible only with communities that have reasonable access to technology. Finally, through technology, financial institutions can effectively communicate with their consumers and engage in financial literacy and consumer protection programs.

4. Analysis and Discussion

To demonstrate the capability of tool we developed, we present a shortlist of districts that we deem suitable and attractive for financial inclusion efforts in the country. It is important to note, however, that significant amount of value of the tool we developed lies in its flexibility and usability regardless of the users' views and believes about the major drivers of success of financial inclusion efforts. Therefore, our analysis presents only one possible result based on variables we believed to be the major drivers of success of financial inclusion initiatives.

4.1 Analysis

Stage 2: Rank Districts

For the purposes of our analysis, we selected two district-level variables that we deemed most relevant to our objective of increasing financial inclusion in the rural areas of the country: (1) number of branches in the district and (2) population density. The rationale behind selecting districts completely lacking any bank branches is twofold. One, considering that the dwellers in such district have no opportunity to reach any banking institution, the potential for large social impact is significant. Two, districts where no banking institutions are present offer less competitive market environment than districts with established bank presence. The reason we selected population density as the second variable is again to maximize social impact. Higher density (yet still rural) areas present an opportunity to both serve a high number of customers as well as increase the probability of commercial success of financial service offerings.

The data used in our analysis excludes all "city districts". As mentioned above, the recent administrative changes resulted in creation of new districts, some of which are simply the province capitals. All of these districts and all districts associated with the city of Maputo are excluded from our data.

As the first step, we filtered the data to selected only districts completely lacking any access to financial services. Out of 128 districts for which data is available (after the abovementioned exclusions), 66 districts in 9 provinces have 0 bank branches.

The second step was to further exclude areas that are rather urban than rural. We adopted and adjusted the OECD population density threshold that suggests that population density above 150 people/km2 signifies urban population. We adopted this definition to Mozambique, where a large majority of the country is rural and as such, the OECD definition would render all of the country with the exception of the Maputo City rural. To adjust for the country-specific circumstances, we lowered the urban threshold to 100 people/km2. This step eliminated two districts from the list where population density was significantly above the average of the entire sample. While the two eliminated districts has population density above 100 people/km2, the district with the third highest population density has mere ~60 people/km2.

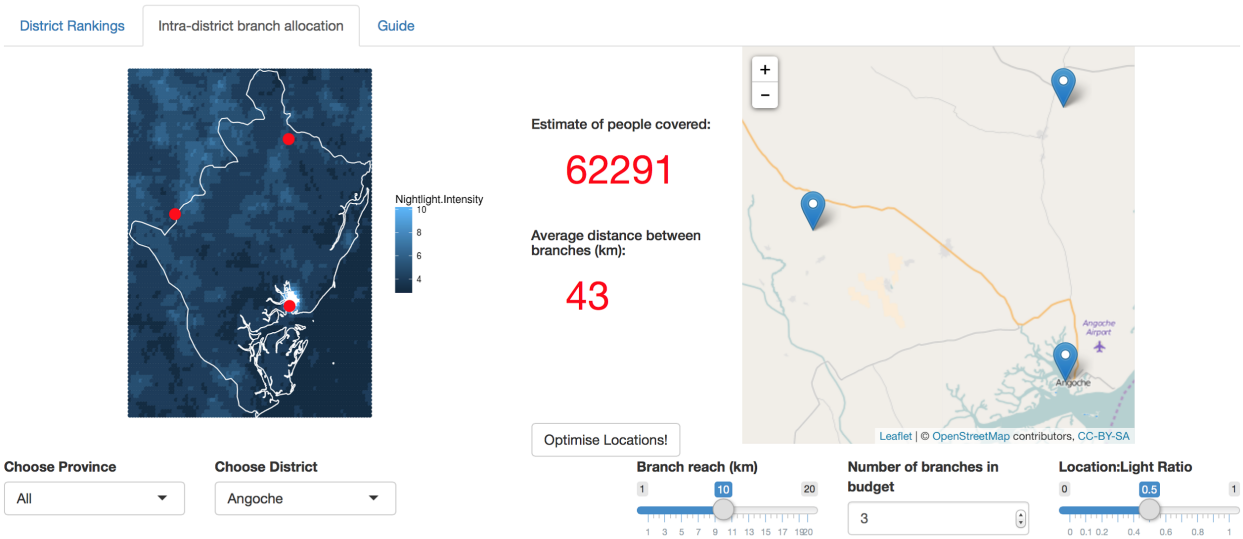
Stage 3: Within-District Location

To further prioritize districts with the largest potential for a successful adoption of financial services, we ranked the remaining 64 districts by average light intensity in the district and selected only the top quartile for further analysis. This final imputed list counted 12 districts in four provinces (Cabo Delgado, Nampula, Niassa and Zambezia). The average light intensity of these districts ranged from 5.01 in Pemba to 4.64 in Lugela (see Table 1). This range is rather narrow when compared to the range of the average light intensity of all 128 districts. The average light intensity of the entire dataset ranged from 11.47 to 3.24. The narrow range of average light intensity of our final list of districts reflects the fact that all of these districts are rural. However, among the rural districts, this list includes districts with potentially the highest economic activity, rates of electricity consumption, ICT penetration and level of shadow economy (all of which is approximated by the highest level of light intensity among the rural districts).

Table 1: List of Recommended Districts

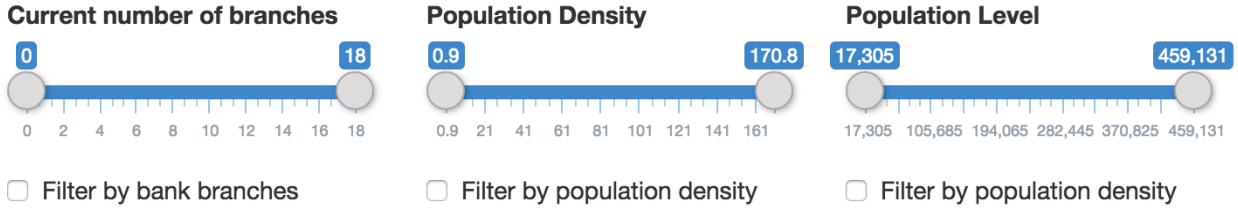
District	Average Light Intensity	Province	Population Density	Number Bank Branches
Pemba	5.01	Cabo Delgado	46.8	0
Ribaue	4.96	Nampula	36.3	0
Namuno	4.91	Cabo Delgado	33.4	0
Lalaua	4.86	Nampula	18.2	0
Mecuburi	4.85	Nampula	24.2	0
Murrupula	4.78	Nampula	52.1	0
Mecanhelas	4.78	Nassa	43.7	0
Mueda	4.74	Cabo Delgado	10.9	0
Memba	4.71	Nampula	56.1	0
Muecate	4.71	Nampula	25.9	0
Namarroi	4.66	Zambezia	45.8	0
Lugela	4.64	Zambezia	24.1	0

Screenshot of the application

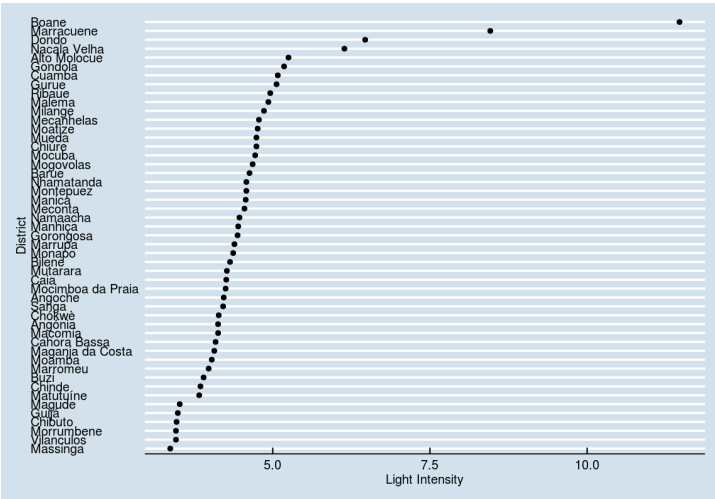


4.2 Demonstration of the Application

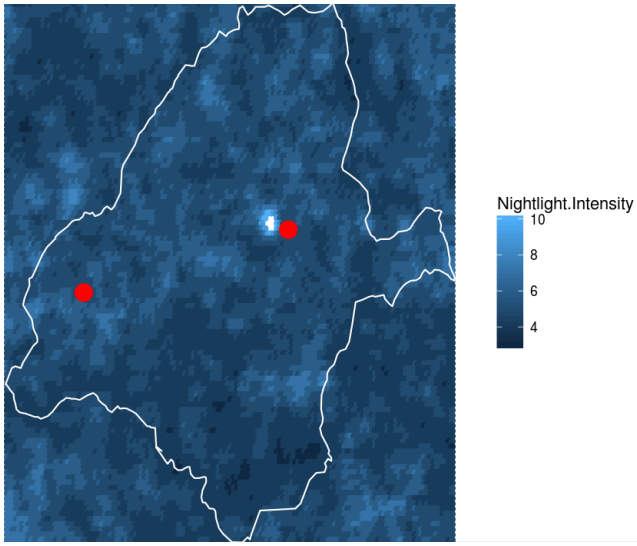
1. Choose Filters



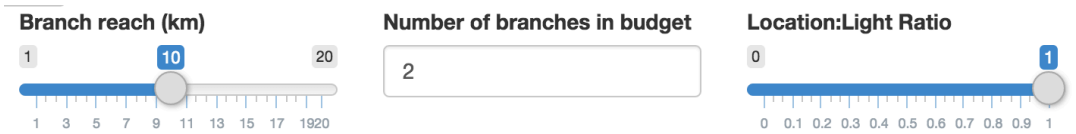
2. Rank districts by their average light intensity



3. Look within one particular district:



4. Choose assumptions on branch reach, the number to build and the weight applied to location versus light.



5. Optimize allocations and calculate coverage

Estimate of people covered:

18219

Average distance between branches (km):

63

4.3 Discussion

In addition to the quantitative analysis, we took into account qualitative aspects relevant to the districts we identified as most attractive. All of the most attractive districts fall into the geographical area of four neighbouring provinces in the north of the country (Cabo Delgado, Niassa, Napula and Zambezia) (see map in Figures 6 and 7).

Figure 6: Map of Recommended Districts

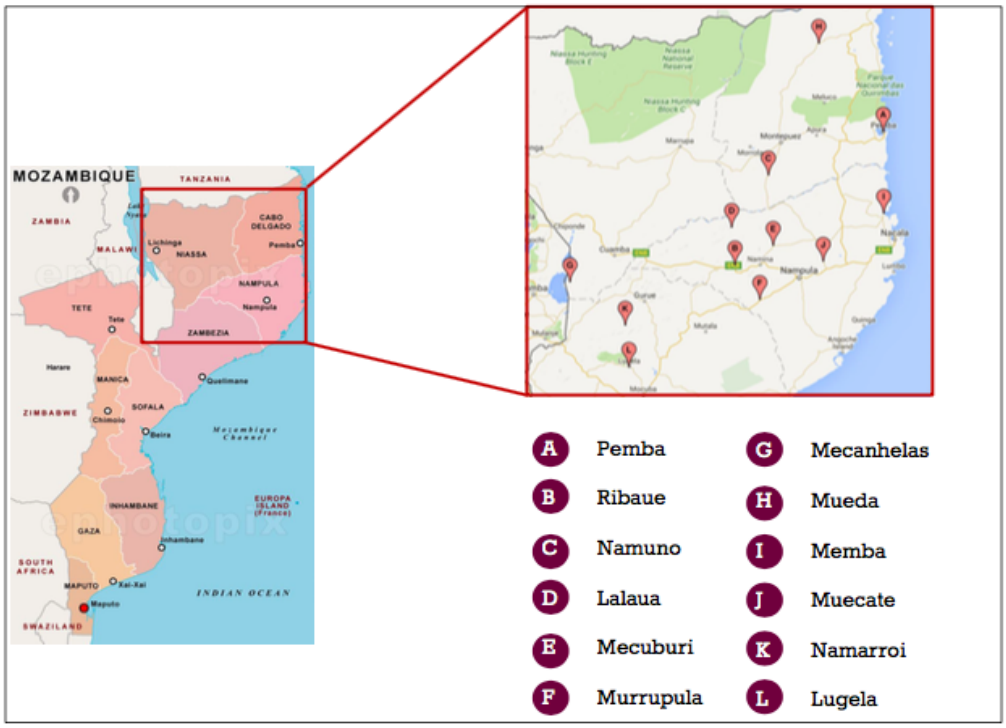
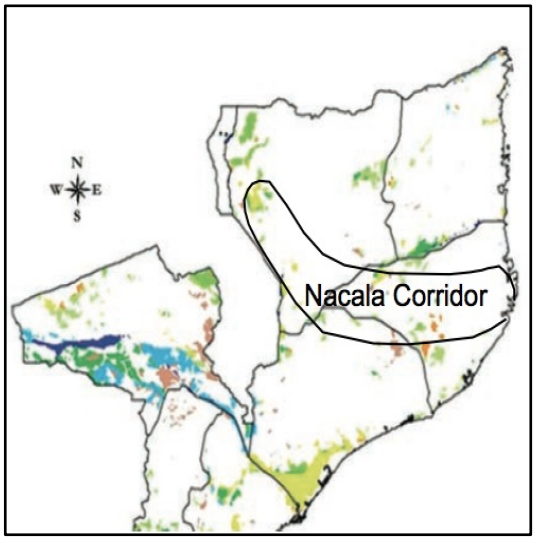


Figure 7: Map of Nacala Corridor



The economy of this region is driven by extractive industry and transport of commodities along the (east-west) Nacala corridor. As a result of these activities, the area is richer in infrastructure than other areas of the country. The Nacala corridor includes a major railroad allowing the transport of commodities from ports of Nacala, Pemba and Ibo on the eastern coast of the country to the western border with Malawi.

In addition to the economic corridor infrastructure, we examined presence of other infrastructure such as airport or a major road and availability of fixed telephone line or mobile coverage in the selected districts (see Table 2). There is some evidence, that districts that lie along a major road are more attractive than others. Out of the 12 shortlisted districts, eight have a major road passing through them, including the top three most attractive districts on our list. Another aspect common among the most attractive districts was a proximity to a large city. Out of 12 most attractive districts, ten lie in a proximity of a major city.

Table 2: Infrastructure in Recommended Districts

District	Province	Proximity Coast (less than 100 km)	Coast	Frontier	Proximity Large City	Airport	Major Road	Fixed Telephone Line	Mobile Telephone Coverage	Large Agricultural Enterprises
Pemba	Cabo Delgado	NA	yes	no	yes	yes	yes	yes	yes	5
Ribaue	Nampula	no	no	no	yes	no	yes	yes	yes	1
Namuno	Cabo Delgado	no	no	no	yes	no	yes	yes	no	0
Mecuburi	Nampula	no	no	no	yes	no	no	NA	NA	0
Lalaua	Nampula	no	no	no	yes	no	no	yes	no	0
Murrupula	Nampula	no	no	no	yes	no	yes	yes	yes	2
Mecanhelas	Niassa	yes (lake)	yes (lake)	yes	yes	no	no	yes	no	0
Mueda	Cabo Delgado	yes	no	yes	no	yes	yes	yes	yes	0
Memba	Nampula	yes	yes	no	yes	no	yes	yes	no	0
Namarroi	Zambezia	no	no	no	yes	no	no	yes	no	0
Muecate	Nampula	no	no	no	yes	no	yes	yes	no	1
Lugela	Zambezia	no	no	no	no	no	yes	yes	no	0

The clustering of most attractive districts along the major corridor, coupled with the presence of other infrastructure elements such as major roads, proximity to a large city, presence of a fixed telephone lines as well as cell phone coverage offer an intuitive explanation of the results of our quantitative analysis.

5. Conclusion

Based on two drivers relevant to financial inclusion, number of bank branches and density of population, we selected a list of 12 districts that present greatest opportunity for expansion of financial inclusion in Mozambique. Our quantitative analysis identified districts in four neighboring provinces in the north part of the country. We suspect the area is more attractive than the rest of the country due to higher economic activity and a greater availability of infrastructure such as railroads, major roads, telephone lines as well as proximity to regional cities. Based on our analysis, we recommend prioritization of these 12 districts when allocating resources aimed at increasing financial inclusion in the country.

5.1 Policy Recommendations

Despite economic growth and recent positive regulatory changes in the banking industry, financial exclusion remains a major problem in Mozambique. While the solution to this problem has to be comprehensive and will likely require years of policy work, infrastructure building, economic growth and institutional development, our project identified a practical approach the private sector can use to increase supply of financial services in the country. Financial institutions operating in Mozambique can use this approach to expand financial services to rural areas of the country.

The tool we developed can be conducive in this process as it allows users to select a set of variables they believe to be major drivers of financial inclusion in the country, rank the districts based on these variables and consequently optimize the precise location of a bank branch within each district based on NL data.

Policy implications of our analysis are based on the combination of both quantitative and qualitative analysis. To identify districts presenting the most attractive opportunities in terms of introduction of financial services in Mozambique, financial institutions in the country should use their knowledge of the financial industry and the country context to first identify the major drivers of success of financial service offerings in the country (such as number of bank branches in a given district and/or district population density). Once the institutions assemble a list of most attractive districts, the organizations can use our app to identify the most opportune branch location(s), considering their internal budget.

We expect efficient and successful deployment of private capital with the objective of increased financial inclusion should have positive impact on both the rural dwellers in Mozambique who will be able to enjoy the benefits of financial inclusion (discussed above), and on the wider economic conditions and economic equality in the country.

5.2 Concluding implications for GIZ

Based on the analysis, it is evident that the most potential districts for roll out of financial services is in the northern region particularly concentrated around the Nacala corridor. This indicates that the financial services industry could ride on the recent resource driven boom that is underway in Mozambique. The districts surrounding the Nacala corridor have a higher potential for economic development. Financial institutions could fast track the process of economic development of these districts by rolling out operations in these areas. Financial Institutions particularly banks can focus on services individual customers as well as SMEs.

GIZ can demonstrate the potential that this region present to policy makers and thereby influence them to design policies and programs to incentivize banks to service these areas. Additionally, GIZ could work simultaneously with their partner banks, demonstrate the potential of these districts as identified in this project and help them design financial products and services that fit the needs of individuals and SMEs in the northern region.