LIVING ON THE EDGE: AGRICULTURE IN PERIURBAN MEXICO CITY

MASTER OF SCIENCE IN SUSTAINABILITY MANAGEMENT CAPSTONE FINAL REPORT

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EXECUTIVE SUMMARY

The Mexico City metropolitan region is in dire need of solutions for water and fresh food access. The current centralized water supply system fails to satisfy around one-third of the population, and rapid urban growth is continually adding to this problem.[1] The water infrastructure is in bad repair; it experiences a massive amount of loss through system leakages, and pipe breaches often cause water contamination.[2] The situation is even worse on the edges of the city: water access is intermittent and quality is unreliable; government-subsidized trucks regularly fail to deliver water and therefore residents often must purchase water from expensive private delivery companies, reinforcing periurban residents' status as citizens neglected by the municipality.[3] At the same time, there is an abundance of rainwater in the region, especially during its rainy season from May-September, creating a ripe opportunity for rainwater harvesting.[4] Central Mexico is also experiencing a nutritional crisis, with paradoxically high obesity and childhood malnutrition rates.[5] Paralleling the globalization and corporatization of the food chain, peripheral communities with a tenuous link to urban distribution systems and rural farmland often have little or no access to fresh produce.

Our two clients, Sistema Biobolsa and Isla Urbana, have been working to address these issues. They are interested in working together to further their missions; our task was to help them do so. Both have limited resources and staff; they need additional funding in order to hire more staff, but time and resources spent attracting funding takes away from time spent working in the field, where their projects have immediate impact. We decided to help by producing a research archive of sources relevant to our clients as well as a series of maps. The maps detail their installations to date and identify areas for future projects based on a rating system we devised by analyzing their data. Both of these tools streamline administrative work and allow the clients to better communicate with other enterprises, governments or communities to further their collective vision. Moreover, they are interactive and adaptable, so our clients will be able to change rankings or create new factors as they wish.We also gave the clients a complete bibliography, a Google Drive containing resource files including annotated PDFs referenced in the research archive, and a visual archive containing photos we took while visiting their installation sites in Mexico. This was a highly satisfying project, and we hope the tools we supplied to the clients will make a significant positive impact on the communities they serve.

[1] IRRI-Mexico, Porticus Diagnostic, 2013 (study).
[2] Badillo-Pina, Enrique Ordunez-Zavala, Ricardo Tejeida-Padilla, "Rainfall Use to Improve the Sustainability of the Hydraulic System in the Valley of Mexico," Proceedings of the 54th Annual Meeting of the ISSS, Waterloo, Canada (2010).
[3] OECD.org.
[4] *Statistics on Water in Mexico, 2010 edition.* National Water Commission of Mexico. Mexico, 2010: 24-25.
[5] Mejía-Rodríguez F, Neufeld LM, García-Guerra A, Quezada-Sanchez AD, and Orjuela MA. *Maternal and Child Health Journal* 18, no. 1 (2014):268-85. doi: 10.1007/s10995-013-1263-4.

INTRODUCTION

The Capstone project is the final course requirement for the MS Sustainability Management Program offered through The Earth Institute at Columbia University. The project expects students to use their analytical and communication skills acquired through other coursework at the University in a group setting to solve sustainability problems and management issues.

For this Capstone project, a group of eight students, with the assistance of a faculty advisor, were tasked with figuring out the most efficient ways to help two clients work together, and then carrying out those ideas. The clients are Isla Urbana (IU) and Sistema Biobolsa (SB), both social entrepreneurships that provide innovative, small-scale renewable systems in the periurban periphery of Mexico City ("Distrito Federal" or "DF") to help people gain access to resources which are otherwise difficult, costly, or impossible for them to access. IU manufactures, installs and services rainwater catchment systems, improving water access particularly within low-income periurban communities, reducing strain on existing infrastructure in the process. SB has developed an anaerobic biodigester for small-scale agriculture that converts a combination of animal waste and water into fertilizer and methane gas. Their systems each require significant amounts of water. There is much promise in these enterprises working together, since SB's biodigesters, and the farms in which they are located, are water-intensive, and IU's rainwater harvesting systems can collect and store the water during the rainy season in order to supply the biodigesters. Both of these enterprises are members of Instituto Internacional de Recursos Renovables of Mexico (IRRI Mexico), a non-profit organization that performs R&D and disseminates technology solutions with the aim of changing the way people relate to waste, energy and natural resources, and in the process generating economic independence, health and environmental sustainability.

In order to figure out what we could deliver, we first had to evaluate our clients and assess their needs. Our clients are both relatively new enterprises, with accordingly limited resources and staff. They need additional funding in order to hire more staff, but don't have the time or resources to attract the funding; a classic dilemma of small enterprises. In order to address this issue, our team sought to find ways to streamline the process of attracting more resources.

Grants play a central role in this process. They provide funding as well as credibility, creating a base for future funding and collaboration with governments, community groups, and non-profit organizations. Our clients' fieldwork also has the potential to contribute valuably to research initiatives in the area of periurban agriculture and to benefit from academic research findings. Understanding the research context can accelerate proof of concept and implementation, so that their constituencies benefit more quickly.

Finally, our clients could benefit from working in a wider community network, but again the process of communication with local government leaders is time-intensive and requires heavy documentation to prove efficacy.

Given all of these findings, we decided to produce a research archive of sources relevant to our clients designed to dramatically reduce the amount of time they spend doing research for all of these functions. A detailed description of this archive can be found later in this report. The archive includes scientific, sociological and field work documents, among others. Its purpose is to offer precedents and references for the structuring of future projects in urban agriculture; to provide a set of quick scholarly references for grant applications, lectures and reports; and to offer a structure into which future research can be placed as the knowledge base around IU/SB's shared projects grows.

In addition, we produced a series of maps detailing the clients' installations to date, as well as identifying areas containing conditions, both physical and social, which would lend themselves to future projects. The maps are also discussed in detail later in this report, and an extensive map archive is available in Appendix C.

BACKGROUND

WATER ACCESS

The current centralized water supply system in DF fails to supply around 35% of the population, including 1.3 million people whose homes are not connected to the water grid.[6] Rapid urban growth and increasing demand has resulted in water extraction rates at 182% of the sustainable level.[7] This is partly due to the fact that DF's water infrastructure experiences an estimated 40% loss through system leakages; furthermore, pipe breaches cause contamination of potable water during extreme weather events in rainy seasons.[8]

Water delivery to periurban Mexico City. *Photos by Andy Wanning.*

On the southern edges of DF, water access is intermittent and water quality unreliable. In the DF communities where Isla Urbana currently works, government subsidized water trucks regularly fail to deliver water; residents must purchase private

[6] IRRI-Mexico, 2013.
[7] Badillo-Pina et al, 2010.
[8] Badillo-Pina et al, 2010.

water from trucks that charge around $100 USD for each monthly truck delivery of 8,000 liters, equivalent to 10% of the average Mexican household monthly disposable income.[9] Communities often share this cost, surviving on around 200L/family per two week period.[10] At the same time, there is an abundance of rainwater in DF, especially during its rainy season from May-September, creating a ripe opportunity for rainwater harvesting.

FOOD ACCESS

Central Mexico, including DF, is also experiencing a nutritional crisis, with obesity rates above 30% despite childhood malnutrition.[11] Peripheral communities, served almost exclusively by tiny convenience stores, are essentially food deserts, with little or no access to fresh produce. Dense urban fabrics and poor roadbeds make traditional centralized approaches to food distribution inappropriate.

The effective use of water for food production is also impeded by economic and social factors. Increased economic opportunity in Mexican cities is traditionally linked to decreases in urban agriculture.[12] Rates of agriculture and animal husbandry also decline among generations born in the city among emigrants from rural areas.[13]

CLIENTS

Isla Urbana addresses Mexico's water crisis by manufacturing and installing rainwater harvesting systems. These systems capture precipitation collected on roofs and filter it, enabling regular household use. This provides water access to communities beyond the existing municipal water system, while reducing strain on existing infrastructure and reducing the need to increase the capacity of centralized water systems. These communities, particularly indigenous and low-income periurban ones, are typically left to rely on both government and private delivery of expensive bottled water. Isla Urbana currently services areas on the periphery of Mexico City such as Quiltepec and Xochimilco. Isla Urbana has already provided more than 130 million liters of potable water.[14]

Sistema Biobolsa addresses the issue of fresh food availability and environmental health (among others) by manufacturing and distributing small-scale anaerobic biodigesters that convert animal waste into methane gas and organic fertilizer. The methane alleviates the financial burden of purchasing propane for cooking, while the fertilizer enhances crop yield and soil quality. The biodigester design mimics that of a cow's stomach, stimulating bacterial growth in order to create methane. In effect, the system

[9] OECD.org.
[10] IRRI-Mexico, 2013.
[11] Mejia-Rodriguez et al, 2014.
[12] Losada, H., J. Rivera, J. Cortes and J. Vieyra. "Urban Agriculture in the Metropolitan Area of Mexico City," Field Action Science Reports 5, no. 5 (2011): 2.
[13] Losada et al, 2011; Badillo-Pina et al, 2011.
[14] islaurbana.org.

creates a natural closed-loop system, using the waste as a resource. This has the added benefits of reducing the amount of waste left on the farm—or reducing the cost of having someone truck away the waste—as well as reducing the need for chemical fertilizers, which are also costly and cause extensive damage to the soil and the region's waterways.[15] Currently, the organization reaches small-scale farmers primarily on the outskirts of Mexico City, though also in select areas throughout the country.

WORKING TOGETHER

Our clients both use the same manufacturing plant in Mexico City to build the geo-membrane found in each of their systems. Through repeated interactions and common interests, both saw the vision of a symbiotic relationship potential in a co-creation project, recognizing that each had access to a market share the other did not. As we saw in our visit to DF and confirmed in our mapping project, there is not much overlap in their locations. By working together, their technologies could spread to new places neither could go without the other, amplifying the impact of each system and reaching a greater portion of the population.

The potential for working together is primarily due to the fact that SB's biodigester systems require large amounts of water to mix with the animal waste; in addition, the users, generally working farmers, need water for irrigation, feeding the animals, and other normal farm functions. Isla Urbana's systems can greatly broaden their access to water, storing as much as needed during the rainy season to be able to use during the dry season. Conversely, other families on small plots of land with access to Isla Urbana's rainwater harvesting systems might have the means to develop a small farm, and thus access methane gas for cooking through Sistema Biobolsa's biodigesters.

As Sistema's Biobolsa's motto goes, "No Hay Desechos, Solo Recursos," or, "There Is No Waste, Only Resources." Encouraging this partnership with Isla Urbana has the potential to increase land productivity and reduce labor intensity, resulting in greater economic stability. This will, in turn, liberate capital by providing alternatives to purchased commodities (water, fuel, food) that currently drain household income, and by turning waste (greywater, animal waste) into valuable resources.

RESEARCH ARCHIVE

METHODOLOGY

We first needed to define the term "periurban" in order to define the scope of our project. What were its characteristics—who lived there, and what was its environment like? Moreover, where exactly was it? This mission led us down a complex path, allowing us

[15] Sharpley, Andrew N., Richard W. McDowell, and Peter J. A. Kleinman. "Phosphorus Loss from Land to Water: Integrating Agricultural and Environmental Management," Plant and Soil 237 (2001): 287.

to shape our final deliverables as we continued to learn more about this unique ecosystem. Our previous research experiences guided our team to examine both the qualitative and quantitative features of urban agriculture, as well as an efficient means of communicating these two focal points. We felt that certain characteristics of urban agriculture lent themselves to be collated in data form, mapped, and analyzed for local meaning. We also understood that certain contextual qualities and social identities wouldn't get included with a strictly quantitative approach, requiring a more conditional and context-dependent lens. We kept all these concepts in mind as we developed our final products, a research archive and an interactive series of maps.

A research archive distinguishes itself from a traditional bibliography by setting out to select, correlate and preserve works in an organized compendium. Each week, as we struggled to peel back layers and refine what we mean by "periurban," new layers and interconnections emerged, adding depth to our scope (Box 1).

At our weekly meetings, team members presented their findings and we discussed the merits of including specific pieces in the structure of our archive. Through our preliminary research of periurban agriculture, we brainstormed its contextual implications on a local and global scale. We wanted to capture applicable indicators and proxies related to the subject, and demonstrate the relationship between the social, economic, and environmental impacts on the natural and built environment. This typology ultimately led us to classify each source with a series of keywords, leading to the materialization of the "condition" within the periurban context. We first decided to focus on five exploratory indicators: entrepreneurship, nutrition, community, culture, and gender. More specifically, our goal was to explore:

- Entrepreneurial benefits resulting from the implementation of urban agriculture;
- Health impacts of urban agricultural outputs;
- Synergies between community and urban agriculture;
- Cultural and historic relationships to urban agriculture; and
- Gender challenges and opportunities in regards to urban agriculture.

During this phase we realized the true value in collecting this information and creating a system that would allow our clients to have access to vital data with minimal effort required on their part. As we aimed to provide an extensive yet balanced and organized archive of information, we created guidelines to optimize efficiency. For each of our research sources, we uploaded original and annotated sources in portable document format (PDF). In addition, we created cover sheets that consisted of the article title and standardized citation, a general summary, a summary of its relevance to IRRI, and a list of indicators, detailed below. In order to provide our clients with an adequate sample of sources for each keyword, we analyzed and tracked the indicator statistics on a weekly basis, tabulating not only the number of keywords but also interconnections between the keywords themselves. Our comprehensive system served as a quality check, and helped form a roadmap for future queries.

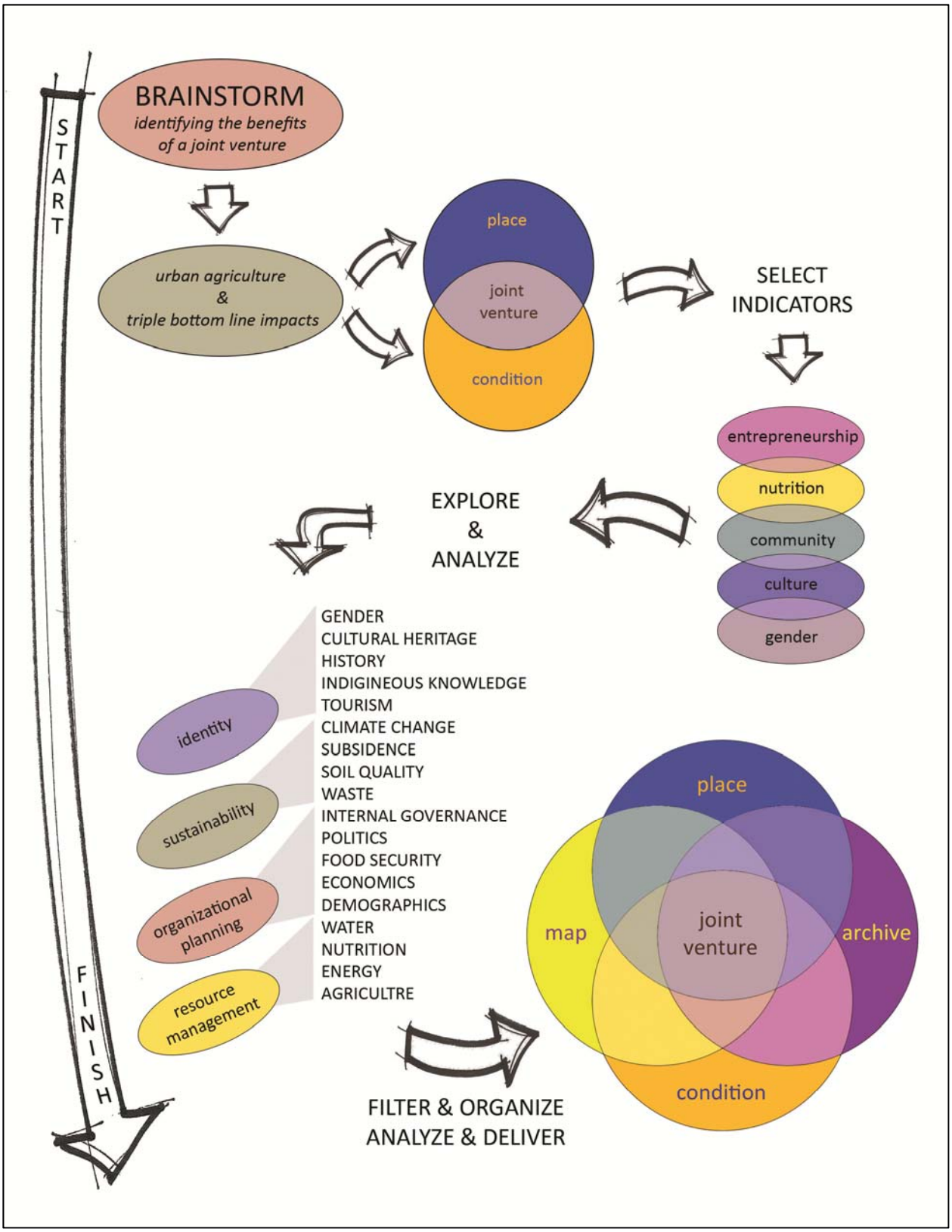

Figure 1. *Research Archive methodology.*

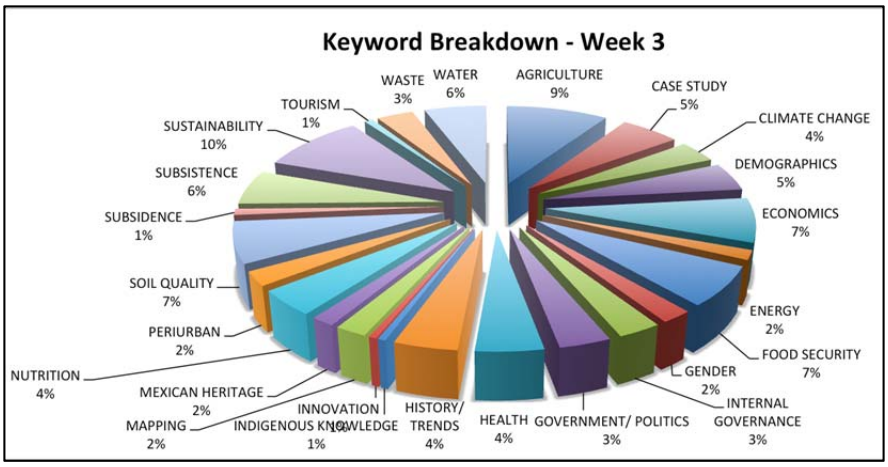

Figure 2 *(left)**.** An early compilation of 25 keywords and how frequently they appear relative to each other in the literature we surveyed, as of week 3 in our process.*

Figure 3 *(below). Graph showing in color the top quartile of research archive keyword connections*

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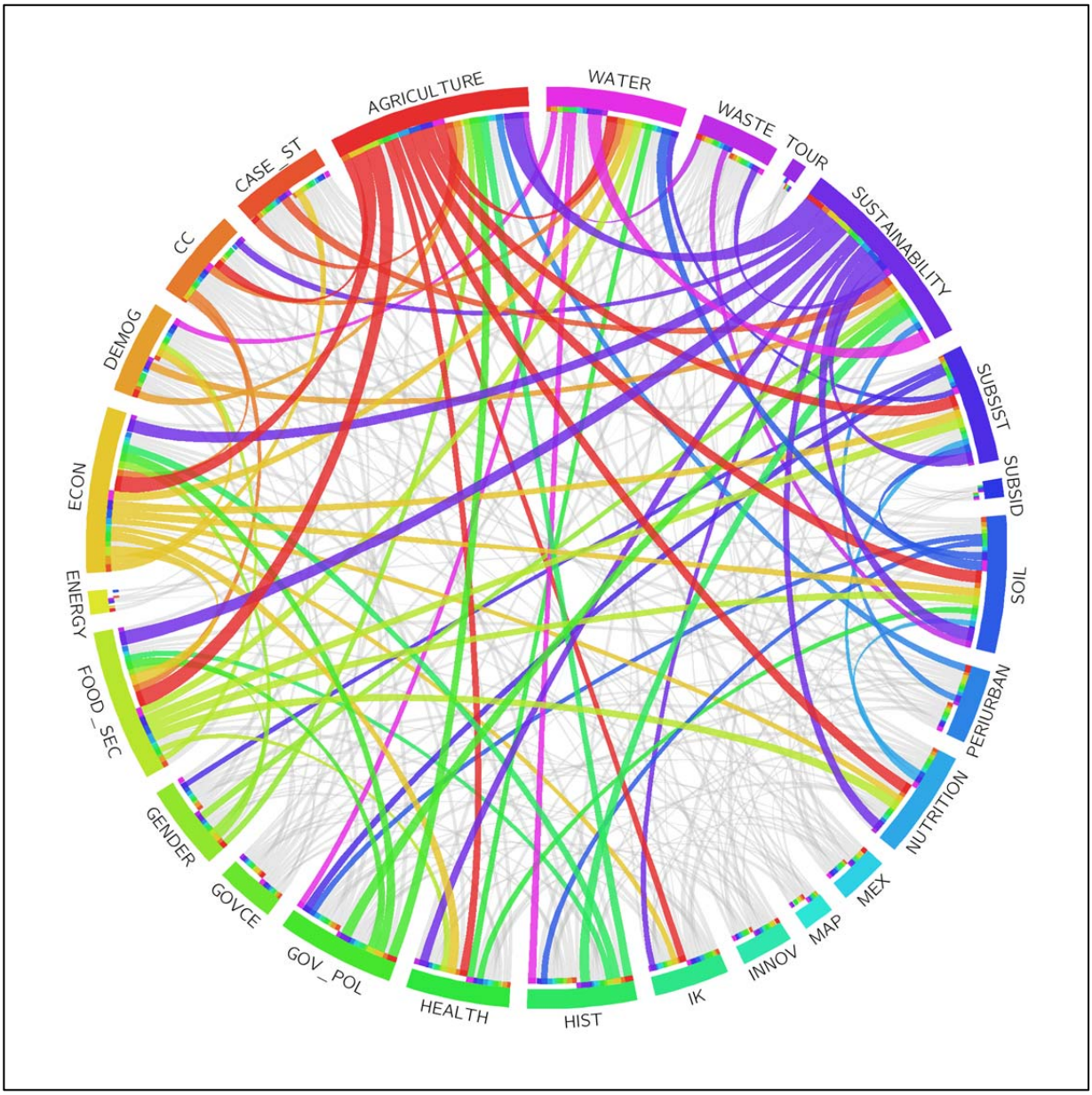

ORGANIZATION

The archive is in the form of a Microsoft Excel spreadsheet, as well as a Google Drive spreadsheet. Excel proved to be the best technology, short of building a database, for collecting and filtering multiple keywords. The information can be sorted in a variety of ways, such as by publication year, author, topic, or keyword, creating a quick and easy-to-use resource at our clients' fingertips. A duplicate structure exists in Google Drive, allowing for simultaneous use by numerous users, and real-time synchronization. The clients' familiarity with both software types allows them to easily update the resource. We included several features within the archive, as briefly mentioned above, to ensure its ease of use and accessibility:

- *Keywords.* We identified keywords as we worked, and settled on 25 topics ranging from water to tourism to indigenous knowledge (see Figure 3 above). As mentioned before, the selection of these keywords stemmed from our initial brainstorming session that generated the foundation that we continuously expounded upon: Place + Condition. (see Figure 1 above).

- *Cover sheets.* The cover sheets summarize salient points within the article and lay out a perceived utilization by one or both clients. Our goal was to allow our clients to quickly identify whether the source would be valuable to their immediate task. The following key information was included:

    - *Title*. The full title of the article;
    - *Summary*. For quickly ascertaining the value of the source to our clients' projects;
    - *Relevance to IRRI*. So our clients can quickly see the utility of the source—this is especially useful if relevance cannot be gauged by the title or keyword;
    - *Citation*. Useful for starting related searches if more information is required on a similar topic, or an up-to-date version is required;
    - *Keywords*. Topics covered in the document which are relevant to our clients; these keywords corresponded to those in our archive and bibliography.

- *Annotated documents.* Along with each cover sheet, we delivered annotated documents, in which we highlighted the most important points and phrases. This annotation should make it easier to skim the articles, some of which are quite lengthy, for salient content. The highlighted passages correspond directly to the choice of keywords and key data points. Again, we aimed to streamline our clients' processes by providing a quick snapshot of the information encompassed within each resource.

- *Original documents.* We included the original documents as well for easy accessibility in case the clients wanted to read the original version, or needed the original for other uses. The bibliographies contained there also point to further sources on the subject if necessary.

- *Bibliography.* All of the aforementioned materials are included in a comprehensive bibliography in Google Document spreadsheet format containing the following columns: citation; year; a brief content summary; links to the document maintained within the clients' Google Drive, as well as the original source; whether or not it's appropriate for the archive; and a checkmark indicating the keyword applicable to the source.

- *Comprehensive Google Drive folder.* This contains all of the materials our group archived and filtered throughout the semester. The login and password have already been given to the clients.

- *Visual archive.* Five of our team members were able to travel to Mexico and visit our clients' installation sites. We took hundreds of photos, and made these available online in two easily accessible Dropbox accounts for our clients to use in marketing, academic, funding or other materials in perpetuity, as long as they credit the photographer. These photos are organized chronologically in folders and labeled by photographer, as well as the name and date of the installations we visited during three days of field trips. The following installation sites are included:

    - *Quiltepec community* – one biodigester and 3 rainwater harvesting systems;
    - *Xochimilco community* – two rainwater harvesting systems;
    - *Xochimilco trajineras & flower market* – potential high-impact marketing site;
    - *Farm in Puebla owned by Sergio Hernández Romero* – one biodigester;
    - *Farm in Puebla owned by Florentino Méndez Jiminez* – one biodigester;
    - *Farm in Puebla owned by Carolina Zaraté* – one biodigester;
    - *Sistema Biobolsa office in Puebla* – showing raw installation materials.

Visual Archive Images. *Left: Quiltepec (Photo by Jess Bollinger). Right: Hernández farm (Photo by Jamie Hardy).*

FINDINGS & OUTPUT

Our group researched and examined over three hundred sources, reviewing data and studies done by various international institutions, community groups, governments and private companies. The final 72 documents were selected for the archive based on their contextual merit as well as their ability to isolate unique facets of issues raised by a potential joint venture. Each piece and corresponding cover sheet details an innovative approach to an issue, and outlines the framework for its resolution within its global context as well as the role both organizations can play towards formulating a solution.

The following three examples serve to demonstrate the robustness of our literature review for the archive and the rationale behind their inclusion.

First, we selected an article from *The New Yorker*, "The Inventor's Dilemma: Annals of Design" by David Owen, because it defines the sociological, low-tech approach behind both Isla Urbana and Sistema Biobolsa's organizations.[16] Using the analogy of an eyeglass, Mr. Owen determines that the issue is often not the technology, but overcoming the political and economic barriers that impede its usage. Both Isla Urbana and Sistema Biobolsa understand the resource technologies that exist as well as the political and economic landscape in periurban Mexico City. This article supports their sociological aptitude in creating tools that can operate within this specific slice of the market.

Next we selected a study done by the United Nations titled, "Gender, Water and Sanitation Case Studies on Best Practices," due its broad scope of scenarios and outcomes.[17] While the eighteen studies were undertaken across Central America, Africa and Asia, each case details the goals, stakeholder forums, and engagement activities at each site, as well as the outcomes for overcoming gender barriers at the conclusion of the project. Isla Urbana and Sistema Biobolsa both focus on increasing the role of women, from their initial outreach to installation to maintenance. This collection of studies can serve to provide context for previous projects as well as for their successes and failures.

Finally, we selected a brief article by Christopher Morehart, "Sustainable Ecologies and Unsustainable Politics," in which the author argues against the belief that a return to rustic, historical agricultural practices in Mexico City would revitalize the aquifers or the economy.[18] While he is not contradicting the benefits of periurban agriculture, or the tangible increases in natural resources it could bring, he does raise the temporal considerations relative to both capitalism and ecology that require examination when taking this approach. Within the research archive, while we selected many articles that offer evidence to support a joint venture, we surveyed the existing literature for counterarguments as well.

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[16] Owen, David. "The Inventor's Dilemma: Annals of Design," The New Yorker, Vol. 86 No. 13, May 17, 2010.
[17] United Nations, "Gender, Water and Sanitation Case Studies on Best Practices," Office of the Special Adviser on Gender Issues and Advancement of Women, United Nations 2006.
[18] Morehart, Christopher T., "Sustainable Ecologies, Unsustainable Politics: Chinampa Farming in Ancient Central Mexico," Anthropology News, April 2011.

USAGE

The organization of the research archive mirrors the idea behind its usage, allowing users to focus in and isolate particular facets of an issue, while also allowing them to expand out and juxtapose many issues simultaneously, relative to the broad scope of the joint venture. This can be done physically by filtering keywords, and intellectually by considering the ideas provoked by the compilation. The design of this system will give our clients the broadest range of applications, while allowing them to narrow in for refined quests.

RECOMMENDATIONS

The Capstone group considered numerous approaches, criteria and other factors to support the use of the research archive by our clients.

GRANT FUNDING

Grant-making organizations seek proposals that demonstrate an intimate knowledge of research within a field and proven results that are supported by qualitative and quantitative findings. The research archive can be used to save time on the search for relevant scholarly information to support the activities undertaken by Isla Urbana and Sistema Biobolsa. Our clients will have an accelerated means to examine selected papers, important case studies, data, syntheses, or concepts; this helps to increase their capacity to provide vital, up-to-date information. Moreover, the research archive will support our clients in finding out how their work fits into global trends.

INNOVATION

Another purpose of this tool is to provide a competitive advantage to our clients in developing further innovations from a more comprehensive scholarly knowledge base. For example, some resources reference provocative new concepts which will be applicable or relevant to improving their biodigester/rainwater catchment systems. Other materials may suggest an opportunity for investment in innovative strategies that are scientifically proven, and easily incorporated into IU's/SB's practices. In addition, keywords can serve to locate these innovations more easily and expand into sectors beyond agriculture.

NETWORKS

Sharing detailed research data generated by the scientific community, governments and the general public will increase awareness of actors working towards a sustainable society. Collaborative methodologies for realizing projects and measuring outcomes will benefit this emergent field. Our clients have the ability to serve as key actors bringing expertise in their fields (biodigesters and rainwater harvesting) to the larger community. Many of the issues addressed by our clients occur in varying degrees globally, and the archive can host work undertaken by

Box 1. *An example of how to use the research archive.*

Imagine this…

Let's say you come across a call for proposals on food resiliency, and want to explore research on the connection between sustainable agriculture and food security in a periurban context. How can the research archive help you?

The archive can target your search.

- Open up the research archive file in Excel.
- Scroll to the right to **Food Security** in the top row of keywords.
- Click on the small down arrow that appears in the **Food Security** cell; your goal is to select only those sources which have an **X** in the **Food Security** cell. You will see several boxes with checkmarks to the left of them—you want to clear them, so press **Select All**, which should clear all of them. Then, select **X**.

The archive should now only show you entries labeled with **Food Security**.

As you browse the titles, you become interested in innovative ways others around the world have approached the issue, and want to see if there are any articles in the archive that include keywords for both **Food Security** and **Innovation**.

- Click on the small down arrow in the **Innovation** cell and follow the steps above to select only **X**. You will be presented with a much shorter list of sources that relate to both topics.

You then want to see the most recent literature, so you sort these results by date.

- Click on the small down arrow in the **Year** cell and select **From Largest to Smallest** or **Descending**; the most recent articles will appear at the top.

You look at the results listed in front of you, and find one with an intriguing title.

- Click on **Annotation** to pull up the cover sheet we have created.
- Read the **Summary** and **Relevance to IRRI** sections.

You are now convinced that this article is worth exploring.

- Scroll down within the **Annotated** file past the cover sheet to see a version of the document in which we have highlighted relevant passages.

You can use these highlighted sections as pull-quotes for your proposal. If you find a source particularly relevant to your interests, you can read the original version in its entirety.

- Click on the **Original PDF** link in the research archive to see an unannotated version of the document.

Once you have thoroughly explored a document, or decided it is not useful for your current purpose, you can look at the cover sheet for other keywords you may not have considered at first.

- Adjust your filtering to release either **Food Security** and/or **Innovation** to pursue new threads and discover other sources.

In this way we have created an interactive living database that can be expanded or narrowed as the search demands. Furthermore, if you find other relevant sources, you can simply add them to the bottom, fill in all of the columns as we did, and these will become part of the searchable archive for the next project.

similar organizations and communities around the world. In this way, it could be used as a platform for future collaboration with outside groups. This will help maintain awareness of existing efforts and avoid future redundancies, thus increasing efficiency all around.

COMMUNICATION

As an efficient platform for communicating impacts, the archive can provide the documentation and credibility to work with local governments. In addition, effective research data related to the lack of access to basic necessities in poor areas, such as water scarcity and food security, can ensure more productive guidelines for work.

Taking advantage of articles on history and trends will help our clients to enhance educational outreach to their customers, stakeholders and future SB/IU generations. It is important for our clients to garner support and increase awareness of their technologies among potential clients; for that reason, the articles can help support their social work and create a new way to transmit sustainable concepts to Mexican communities.

MAPPING

METHODOLOGY

One challenge to a joint venture between Isla Urbana and Sistema Biobolsa is identifying locations where technologies would work. Anecdotally, we knew that Isla Urbana had focused primarily on the outskirts of Mexico City, while Sistema Biobolsa had operated across a broader area of Mexico's more rural areas. Based on our previous analysis defining the periurban, there is presumably an overlapping area between these two territories where both companies could work together. We set out to identify this area via a mapping study using ArcGIS software.

The first step in our methodology was to identify the points where Isla Urbana and Sistema Biobolsa have existing installations. Each company provided a spreadsheet containing data that had been collected at the time of each of their installations, most of which included GPS coordinates. The vast majority of installations could be successfully located on the map. However, some could not be due to either missing GPS coordinates or errors in the coordinates that could not be resolved. Nevertheless, we were able to successfully map 840 Isla Urbana installations and 1,044 Sistema Biobolsa installations, and subsequently created separate GIS layer files for each company. These layers are visualized below in Figures 4 & 5.

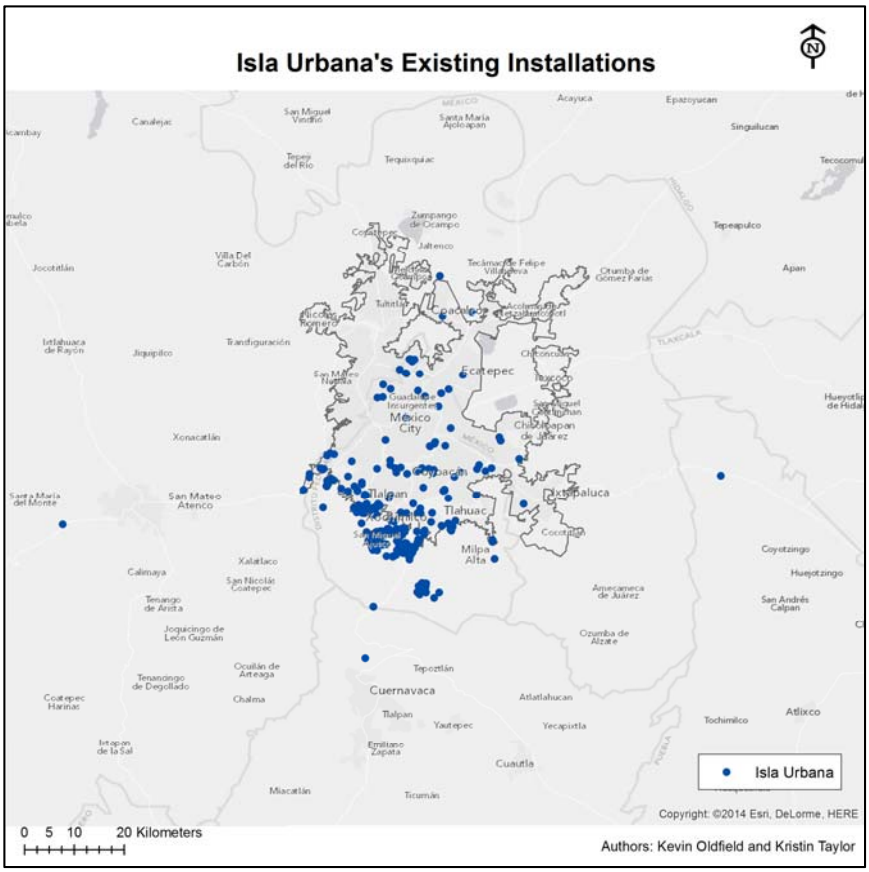


Figure 5. *Isla Urbana installations within the Mexico City periurban region.*

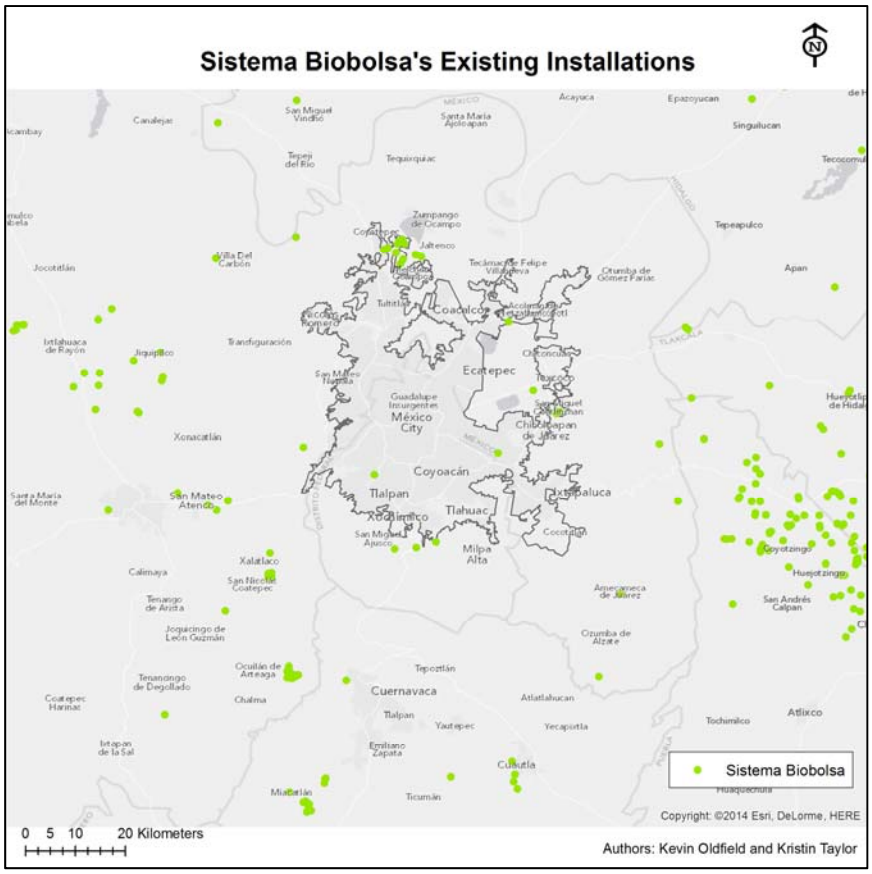


Figure 6. *Sistema Biobolsa installations within the Mexico City periurban region.*

Next we wanted to learn as much as we could about these particular locations, specifically regarding their suitability for periurban agriculture. We aimed to answer questions such as: how densely populated are these areas? What is their dominant land use? What are their climatic conditions? What are their socioeconomic conditions? How accessible are their municipal services? Mexican census data proved to be a valuable resource in answering these questions, providing mappable data related to population density, housing density, unemployment, and access to water and gas utilities. We obtained additional mappable data in the form of average annual rates of precipitation, and land use areas. The variables we ended up considering are listed below, along with a brief explanation of their relevancy to Isla Urbana, Sistema Biobolsa, and a potential joint venture between the two.

- *Population Density* Calculated based on census data (total population divided by area). The two companies currently work in areas with generally differing population densities. Isla Urbana works in areas with medium densities; dense enough that local groundwater sources are overloaded requiring the importation of water, but not so dense that the area is in a city center and likely to be served by a municipal water system. Sistema Biobolsa works in lower density areas where agriculture is dominant. The overlapping area we were looking for is likely at the low end of Isla Urbana's population density range and at the high end of Sistema Biobolsa's, in smaller towns or on the outskirts of larger cities.

- *House Density.* Calculated based on census data (total of inhabited houses divided by area). As with population density, Isla Urbana works in medium densities where water must be imported, but there is enough roof area per person to collect an adequate volume of water. The areas containing Sistema Biobolsa installations require lower house densities so that there is enough open space for agriculture. Again, the area where both systems could be applicable would be at the low end of Isla Urbana's range and the high end of Sistema Biobolsa's.

- *Precipitation*. Average annual precipitation rates for Mexico come from CONABIO (Mexican National Commission for Knowledge and Use of Biodiversity). Precipitation rates are important for both companies because they both rely heavily on water. Isla Urbana helps customers collect rainfall for domestic water use, while Sistema Biobolsa's clients could use this rainfall to feed their systems and water their crops. Both companies likely find a moderate amount of rainfall ideal. Areas with low precipitation rates will not have enough rainfall to support either rainwater harvesting or agriculture, while areas with very high precipitation rates may be too wet for agriculture and water may be so abundant that a rainwater harvesting system is unnecessary. Though the latter is a nuanced assumption, we thought it most effective to focus on drier areas at this stage, and the clients can tweak this rating if they want.

- *Land Cover*. We obtained Mexican land cover data, prepared by the Geographical Survey Institute, from Columbia University's Digital Social Science Center. This map is based on satellite measurements and shows the dominant land cover throughout Mexico. The land cover types include Forest, Grassland, Wetland, Barren, Mixed, Agriculture, Built, and Water. We anticipated that Isla Urbana's installations would mostly be located in built areas, while Sistema Biobolsa's would be in areas marked as Agriculture. We investigated these data in hopes of confirming these expectations and exploring any interesting and unexpected outcomes.

We intersected each of the above datasets with the Isla Urbana and Sistema Biobolsa installations to determine the characteristics of the locations with installations. For example, what range of population densities do Isla Urbana installations most commonly fall in? What is the most likely type of land use area for a Sistema Biobolsa installation to be found in? The statistics from this exercise are found in Appendix D.

Now that we knew the types of areas where the two technologies had already been installed, we were able to use that information to identify new areas that would be suitable for Isla Urbana and Sistema Biobolsa installations, both separately and in combination.

We were able to achieve this by ranking each area in each dataset from most desirable (=4) to least desirable (=0) for an Isla Urbana or Sistema Biobolsa installation based on existing installations. The rankings are included with the statistics in Appendix D. Maps of each dataset reclassified as being most to least desirable for Isla Urbana or Sistema Biobolsa are included in Appendix C.

Finally, after rating all the datasets for suitability for Isla Urbana and Sistema Biobolsa individually, we combined them to create decision maps highlighting the best and worst areas for shared or joint installations. These dataset overlaps are revealed in decision maps, created for the companies individually, as well as a combined map showing the best potential areas for a joint installation. These three maps are included as Figures 7, 8 & 9 below, and are discussed further in the next section.

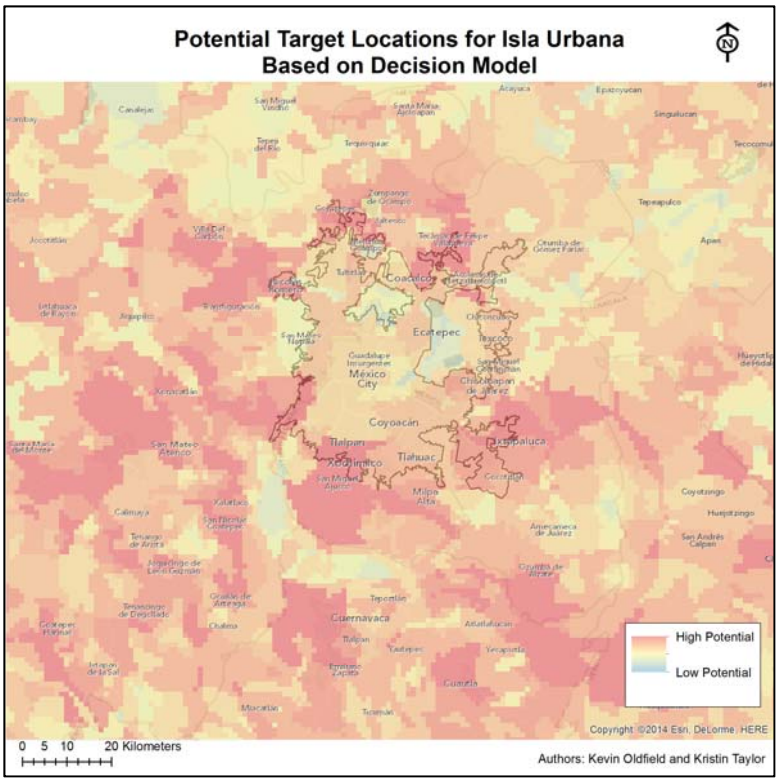


Figure 7. *Potential Target locations for Isla Urbana in the Mexico City periurban region.*

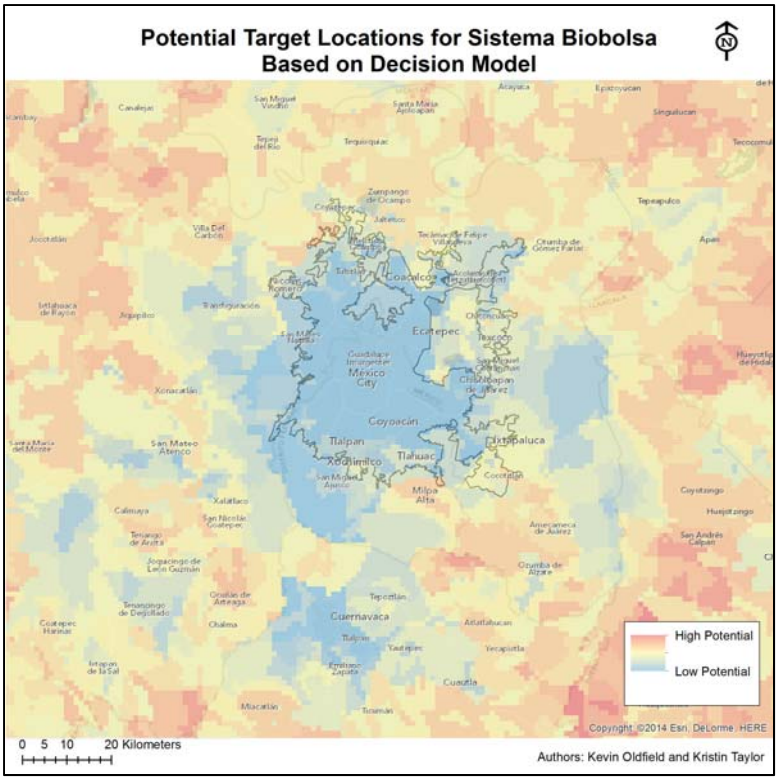


Figure 8. *Potential Target locations for Sistema Biobolsa in the Mexico City periurban region.*

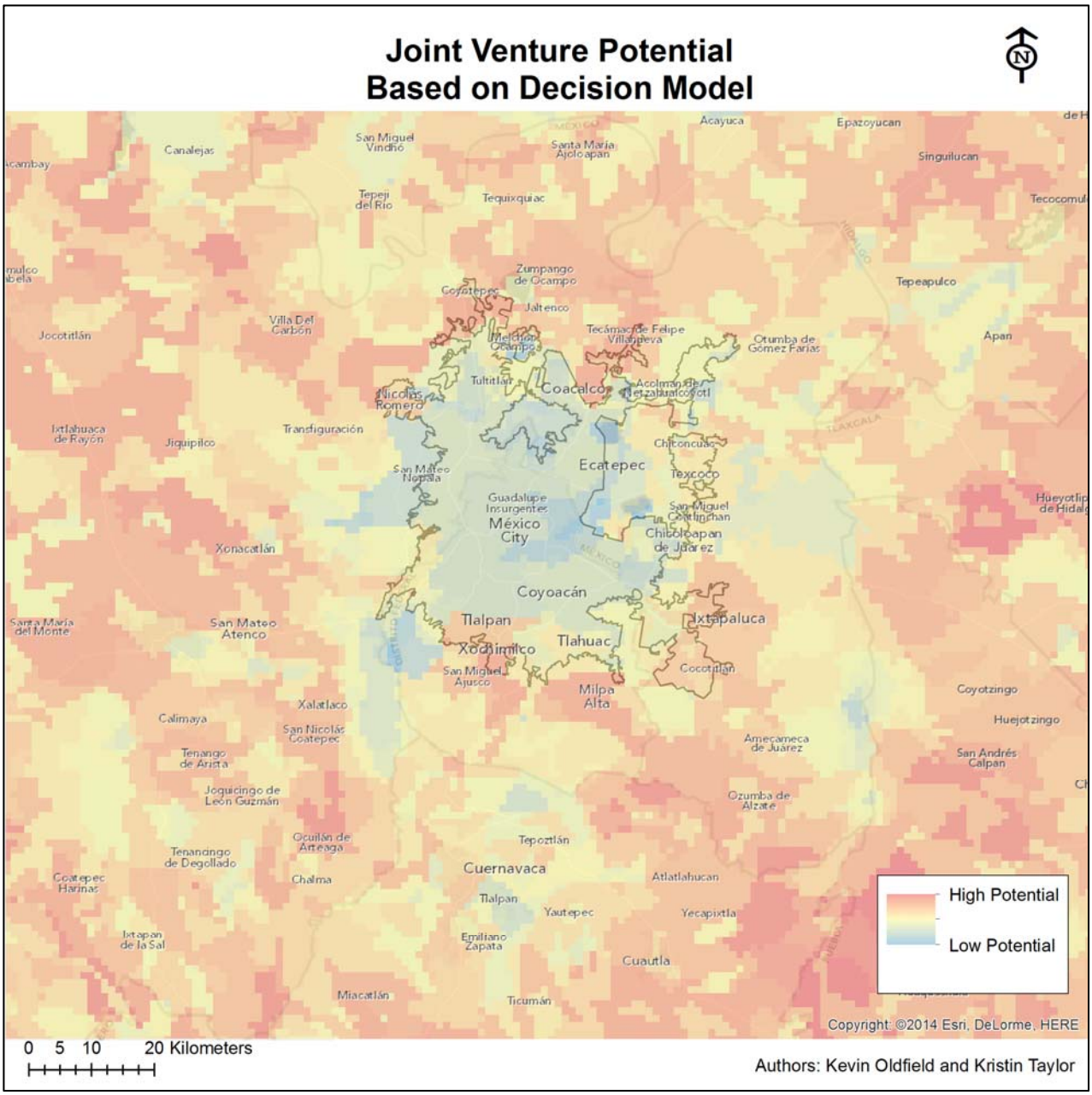


Figure 9. *Potential Target locations for both clients in a joint installation in the Mexico City periurban region.*

FINDINGS/OUTPUT

The maps seen above can be used by Isla Urbana and Sistema Biobolsa to identify areas they should focus on, based upon their potentials for project impact, need and success. They highlight the parts of periurban Mexico City that have desirable population and house densities, precipitation rates, and land covers. The individual maps can be used by the enterprises separately to identify potential good locations, while the combined maps

show where joint installations would be most promising. To add further value to these maps, the following socioeconomic variables were also incorporated into the ratings:

- *Unemployment Rate*. Included in the census data. Isla Urbana and Sistema Biobolsa were both founded by social entrepreneurs, with the primary goal of helping Mexico's disadvantaged citizens. Areas with higher unemployment rates are likely to be disadvantaged areas. These areas may not fit the ideal conditions for Isla Urbana or Sistema Biobolsa installations, and unemployment is an imperfect proxy for poverty rates for a variety of reasons, but due to the social motivations of these companies, these areas may be more attractive to examine further.

- *Availability of Municipal Water*. Calculated based on census data (houses with water connection divided by total houses). There is both a social and a technical aspect to this variable. Isla Urbana focuses on areas in Mexico City that are not well served by the municipal water system. People in these areas spend a greater proportion of time and money obtaining water. Rainwater harvesting provides a social good by freeing up people's time and budgets. It also has the technological and sustainability benefit of providing a decentralized source of water without the expensive expansion of municipal water systems. Therefore, Isla Urbana's technology will do the most good in areas with low availability of municipal water.

- *Availability of Natural Gas*. Calculated based on census data (houses that cook with gas divided by total houses). The same argument for the importance of the availability of municipal water to Isla Urbana applies to the availability of gas for Sistema Biobolsa. Among the benefits provided by Sistema Biobolsa's technology is access to an improved cooking fuel. Cooking with gas, as opposed to wood or charcoal, is cleaner, less labor intensive, healthier, and more efficient. For Sistema Biobolsa to maximize the social benefits of their technology, they should start to focus on areas that do not already have access to a natural gas grid. This is another nuanced assumption that can also be adjusted by the clients within the mappable data as they see fit.

Incorporating the above factors into the maps, along with the four variables previously described, enables us to highlight not just the areas where our clients' technologies are feasible, but also where they will have the greatest positive impact on people's lives. Additional benefits and uses for these maps are discussed further in the next section.

RECOMMENDATIONS/USAGE

Since our recommendations of future installations are based on conditions at current installation sites, the simplest use for these maps is as a self-study. Isla Urbana and Sistema Biobolsa both likely already intuit a good idea of where their technologies are most

Box 2. *An example of how to use the maps and research archive.*

Imagine this…

- *Interaction.* You are an IU or SB representative who meets the director of a large NGO at an annual convention. This particular NGO focuses on climate change research/initiatives in developing countries with a specific focus on promoting biogas cookstoves.

- *IU/SB's goals.* When communicating with the director, your goal is to find a new avenue to generate funding in order to strengthen the urban agriculture sector of Mexico City. You plan to do this by increasing installations of your combined technologies and educating the community on the benefits of doing so. Hearing about this particular NGO's goals reveals a mutual opportunity. The challenge, then, is to effectively communicate the efficiency of this potential partnership. The maps and research archive are the perfect tools for this.

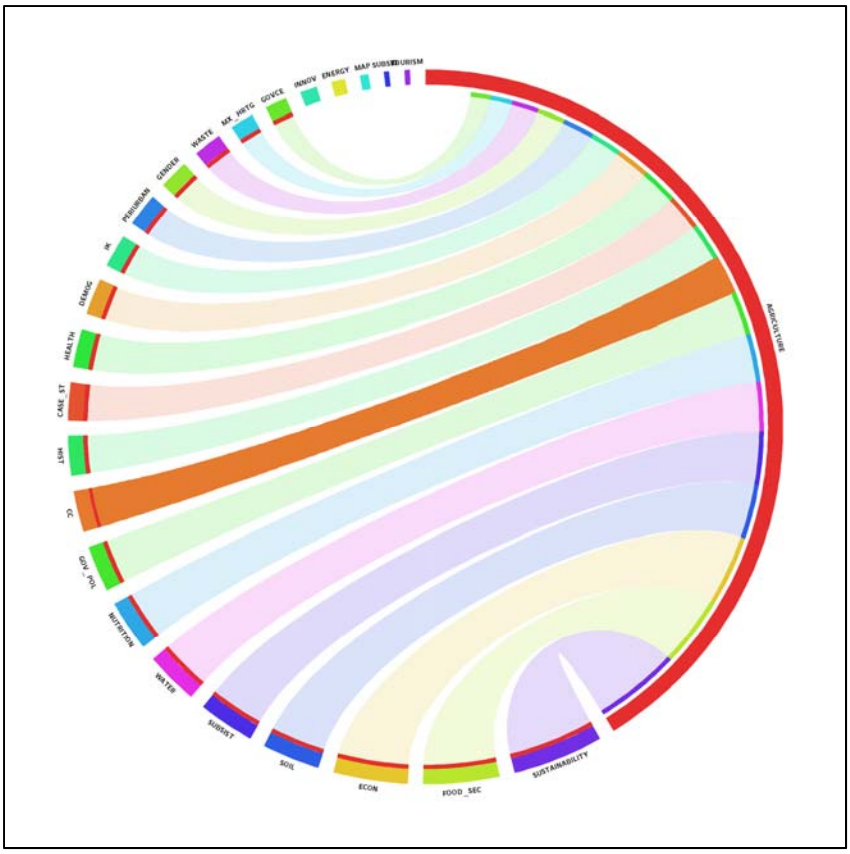


Figure 10. *Graph showing research archive keyword connection frequency between Agriculture and Climate Change.*

- *Use of maps*. The maps illustrate areas of mutual opportunity by using relevant decision layers such as area population density (number of people potentially affected by the use of "dirty" stoves that can lead to poor indoor air quality) and areas with limited access to both municipal gas lines and water (those areas with minimal access to water can result in sanitation issues, adding to the indoor air quality problem above). Selecting these decision layers directly associated with the potential partner's mission illustrates the opportunity to be found in a triple partnership; it creates one collective package that would fund the installation of numerous biogas cookstoves, having additional financial incentives for the installation of your rainwater collection systems and biodigesters

- *Use of archive.* In addition to locating ideal locations for implementation with the maps, you can use the research archive to better understand and communicate about the potential partner's products, to better relate with them and their focus, and to help identify their target market. For instance, you can easily locate articles by sorting for keywords **agriculture** and **climate change** in order to properly prepare your team for a meeting with the NGO director.

successful; with these maps, however, they can see numbers to back up their intuition. Furthermore, these numbers now give our clients concrete descriptions of the types of areas they could focus on beyond the Mexico City region, with more detail than they could have possibly known without a mapped analysis. Because we are providing them with all of our backup data, they can now alter our rating systems based on their own irreplicable experience to look toward the future. Most importantly, the maps show that there is an overlap in the two companies' target areas and that a joint venture is indeed feasible.

The fact that the numbers are visualized in a map form makes them easily accessible for a variety of audiences. Our clients can bring these maps to communities and be able to visually show why those communities would be good candidates for installations. Because they are visual representations of data, the maps can communicate to illiterate or less educated stakeholders in a way a text-heavy pamphlet cannot. They can also bring these maps to local governments, NGOs, or other potential funding sources and show why they are interested in pursuing a project in a particular area. The intent of these maps is to help our clients identify where their best potential customers are, and they are easy-to-use, useful tools which present this knowledge to outside stakeholders in pursuit of this goal.

MAP FLOWCHART

Maps allow our clients to adopt new channels of communication with local and national governments, and bring the opportunity to show critical environmental and basic service issues concentrated in underserved areas of Mexico City. For instance, maps indicating the optimum levels of land use, population density, and lack of precipitation in relation to IU/SB's systems can be used to show the feasibility of adopting these technologies to address the issue of food deserts, wherein there isn't enough fresh produce available. They can use these maps to easily convey to local politicians how their technologies can help grow more local food, an important component to food security and sovereignty in the face of the prevailing globalized and corporatized model that created the conditions that led to food deserts in the first place.[19]

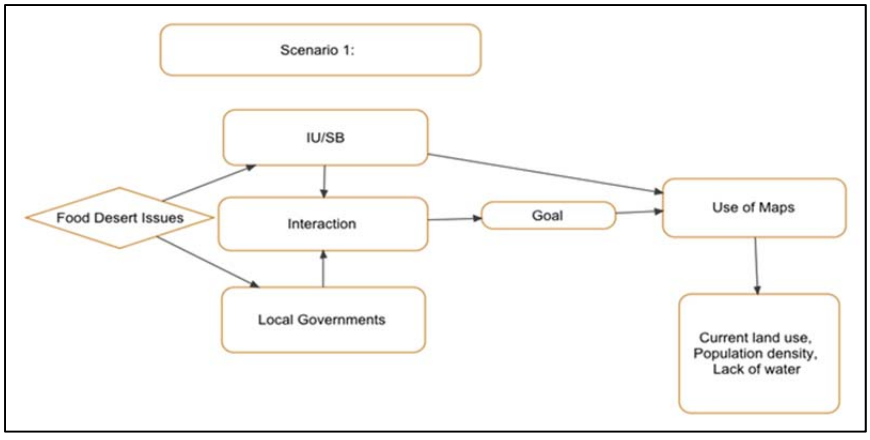


Figure 11. *Food desert issues can be targeted through the use of the decision maps.*

[19] Rosset, Peter. "Food Sovereignty in Latin America: Confronting the 'New' Crisis," *NACLA Report on the Americas*, Vol. XLII, No. 3, North American Congress on Latin America, May/June 2009.

CONCLUSION

Isla Urbana and Sistema Biobolsa had the foresight to intuit a meaningful partnership, and our team was able to craft the collection of practical, relevant tools outlined above to make this idea a reality. Together our clients can create a synergistic foundation to support periurban communities, going beyond simply improving quality of life and environment to validating these communities' existence in an ever globalizing marketplace. Witnessing our clients' work firsthand inspired us to consider a deeper understanding of how these communities fit into a larger paradigm, and how this leads back to the profound importance of self-sufficiency and autonomy.

Today's global economic system promotes freedom as emancipation from the realm of necessity. Necessity, however, is known by a different term in the developed world: subsistence. For small-scale subsistence farmers in periurban Mexico, however, this very system is threatening their existence. As transnational corporations are encouraged by governments and cross-border agreements to monopolize the global food trade, many farmers are abandoning their livelihoods and moving to the cities. They often move to periurban settlements in order to maintain a familiar vocation while tapping into cities' opportunities. But the choice between self-reliance through their own labor, and the acquisition of capital by selling their labor on a day-by-day basis, offers no promise of advancement or true freedom. Just as food is treated as a speculative commodity instead of as a human right, workers are transitioned from vocational subsistence to low-wage menial jobs. Often those who perform such exploitative itinerant labor are women and children, at a fraction of the pay of male migrant workers, let alone that of traditional vocational farm collectives. The outcomes are nutritional impoverishment and public health epidemics.

Periurban communities are often built on environmentally unstable land. Inadvertently, they become agents of environmental degradation in two ways: by overusing agricultural lands, and extracting land set aside by the city. As cities lose open land, the environment is degraded through erosion, unmonitored waste, loss of tree canopy and biodiversity, and unplanned growth. Finally, technology, whether mechanized farm equipment, genetic engineering, or complex shifts in trade liberalization and privatization, works to supplant the natural regeneration cycle of birth-life-death-rebirth, but predictably omitting one crucial piece: the small-scale farmers with whom the cycle originated.

These farmers are furthermore disregarded in their own communities. In one of the communities we visited, there had been a government subsidy in place to help install Isla Urbana's technologies; but when a new regime came to power, they immediately got rid of the subsidy without any explanation and gave it to a sub-standard enterprise that installed a far inferior system. So, the farmers' futures were again at the whim of people in power.

Hearing this story, and visiting the farmers who would be affected, made all-too visceral the situation these farmers were in. To this end, it made us realize how truly important and empowering it is for farmers and periurban households to have access to our clients' technologies—systems that provide real liberty and economic independence.

Indeed, the work of Isla Urbana and Sistema Biobolsa is crucial because it re-inserts farmers back into the paradigm, empowering them to have a voice in the conversation as they assert themselves on the edges of cities, rather than in traditional remote villages. They can confront both a socially and environmentally unsustainable agricultural paradigm as well as a labor-based cycle of poverty. A partnership between these two visionary enterprises would have the potential to expand their work greatly, and increase the farmers' voices accordingly. In order to actualize this expansion, governments need to start restructuring the local and national food economies and return to a perspective that supports the livelihoods of peasant farmers; our tools provide detailed arguments for the clients to use when petitioning those in power to support their part of this effort. We believe our clients' work—helping farms and other underserved households use resources efficiently and become self-sufficient in the process—will help revive a disappearing and vital livelihood, bringing small-scale farmers true freedom in working off the land.

APPENDICES

APPENDIX A: DATA MANAGEMENT PROGRAM

Both Isla Urbana and Sistema Biobolsa are very busy enterprises. In speaking with them, we heard one request to help optimize their day-to-day operations and maximize their workflow. Currently, both organizations are spending much of their time on administrative work, which limits their opportunity to execute the fieldwork needed to strengthen and expand their businesses.

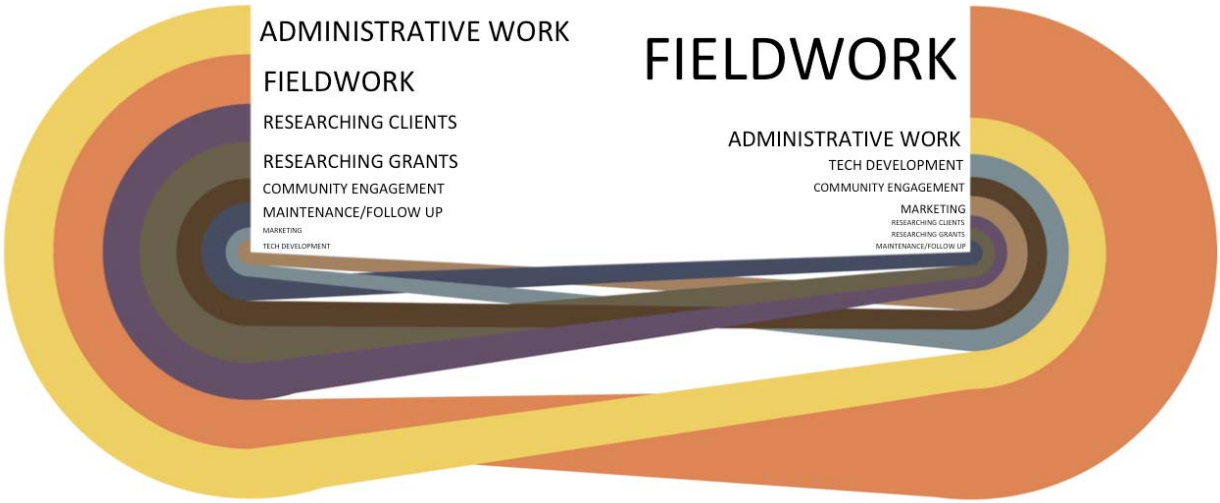


***Figure 12**. Graphic showing (left) how we understand the average workweek in the IU & SB offices, and (right) how we hope our tools can change workflow for them.*

Both enterprises carry out installation site visits and follow-up/maintenance site visits, requiring step-by-step documentation that needs to be downloaded to their computers. Currently, they use paper questionnaires, which are inefficient and can be misplaced or damaged during transport from field to office. One of our supplementary proposals is for Isla Urbana and Sistema Biobolsa to utilize a web-based software that will allow them to monitor some of their administrative and fieldwork inputs and outputs.

Our research shows that CommTrack system would be an ideal candidate for our clients' needs. Within the CommTrack dashboard there are many tools, categorized under *Messaging*, *Project Reports*, and *Data.* The messaging tool consists of numerous customizable outlets to clients, employees, and anyone else who is within the organizations' networks. SMS messaging, data collection, and report subscriptions support the overall messaging flexibility. In addition, there are *Project Reports* that can be used to monitor the internal and external activity of each organization. This option allows leadership to monitor, organize, and facilitate both administrative and fieldwork tasks from their desktop, tablet, and mobile devices. Customizable forms, activity logs, and completion/submission trends are all functions of the project reports feature.

Since Isla Urbana and Sistema Biobolsa are both client-based organizations, they thrive on the interactions that they have with their clients. CommTrack can enhance these interactions by minimizing the time spent on completing fieldwork paperwork and recalling the outcome of previous site visits, and increase the number of memorable interactions that will lead to client retention and new clients.

The messaging tool allows for:

- *SMS messages.*
  - Composing individual SMS messages
  - Broadcasting messages to customizable groups
  - Monitoring messaging history through the Message Log
- *Data Collection*
  - Creating reminders and reminder calendars which can be based on follow-up and maintenance schedules
  - Retrieving previous messages using an internal keyword search

The Project Report tool allows for efficient monitoring options such as:

- *Worker Activity/Daily Form Activity*.
  - Provides a summary of form and case activity by individual user or group
  - Tracks the number of form submissions per day
- *Form completion time*.
  - Monitors the time spent on filling out each form—may help determine what questions to include and or how much time to allot for this portion of the fieldwork
- *Case activity*.
  - Monitors follow-up rate on active cases
- *Worker Activity Times*.
  - Generates graphical representation of when forms are submitted

The data tool allows the organizations to export forms and cases. This tool also provides an app library with innovative applications that are available for download. For example, when touring the software, we observed an app called "Outgrower Farmer Monitoring, Dimagi." This particular mobile app was responsible for registering farmers and recording their yields over time.

These tools can help both companies manage their data in a central location which can then be exported to other systems such as existing spreadsheets, annual reports, etc. The SMS messaging program will also ensure a constant line of communication with clients; the Project Report tool will help leadership manage optimal operations; and the Data tool will make sure clients know about new apps that are compatible with the CommTrack software.

APPENDIX B: CORPORATE GOVERNANCE

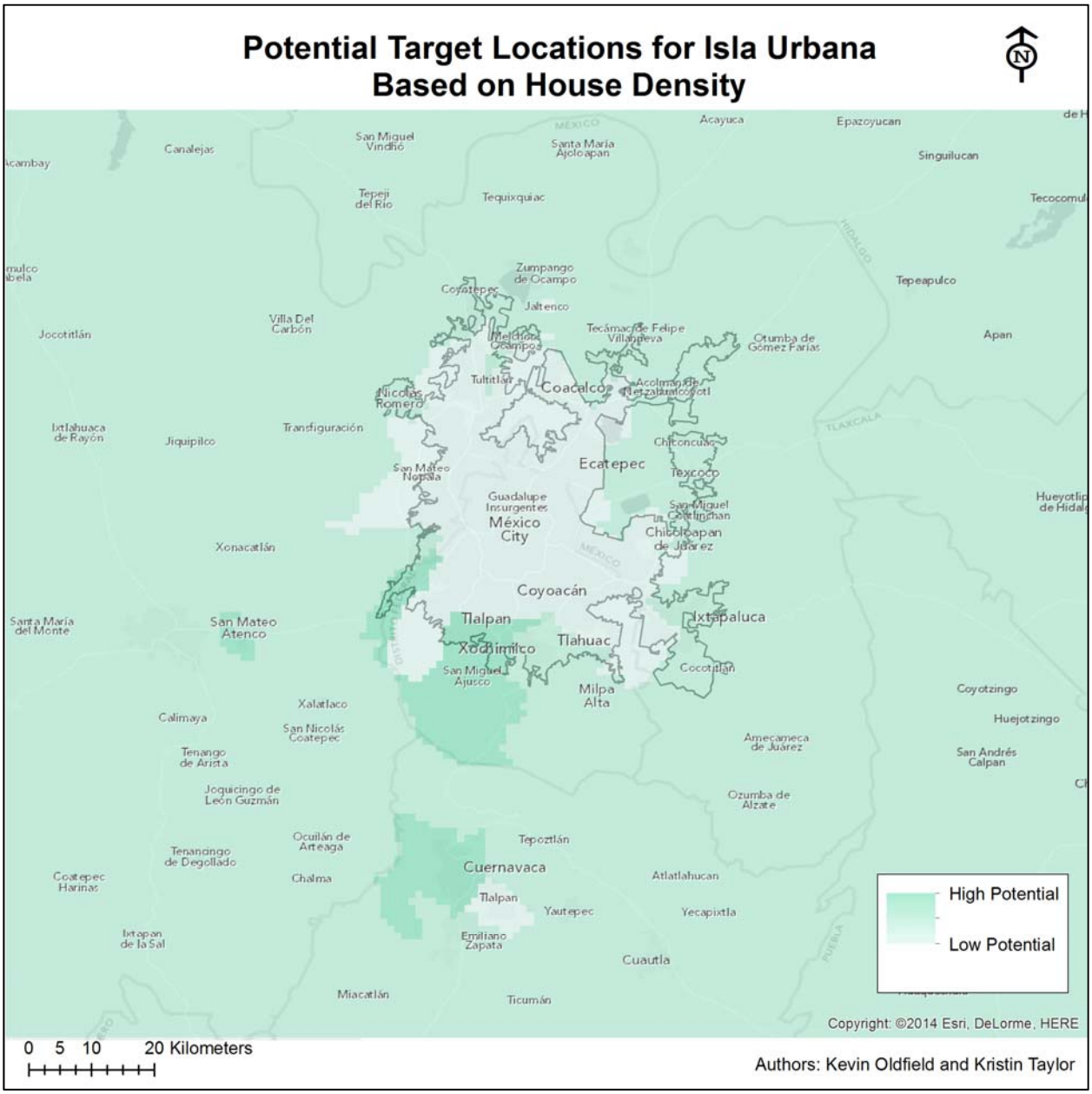
If Isla Urbana and Sistema Biobolsa are going to enter into a formal joint project or joint venture of some kind, it is imperative that they are first clear about how a new, dual structure would work, and many of the administrative details that have doomed other joint projects. For instance, how are profits shared? How much information do they need to share? How is the work divided up? Will they transfer workers to try to be more efficient? What training will they need? What is the incentive system? Who will be talking to financial institutions? What happens if one of the original partners leaves? Are their vendors agreeable to this situation? Will they need a new, joint questionnaire for new clients?

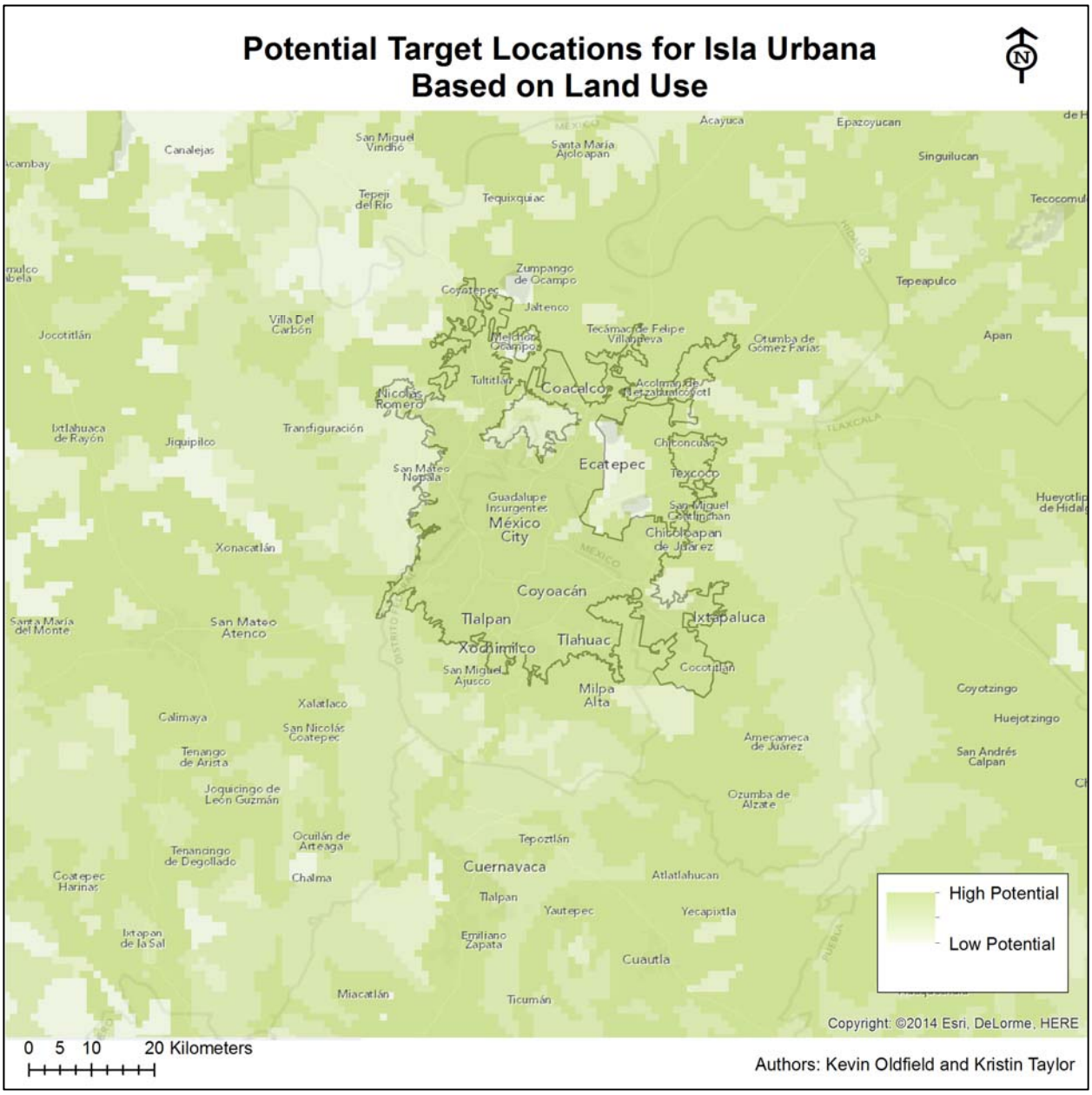
Here are some resources that these enterprises should review before launching a joint venture:

Gamestorming by James Macanufo, David Gray, and Sunni Brown
Centre for Social Innovation's Constellation Governance Model
Ashoka, Full Economic Citizenship
Acumen
Nesta
Business for Social Responsibility

APPENDIX C: ADDITIONAL MAPS

ISLA URBANA

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Based on Land Use
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Epazoyucan
Canalejas
San Miguel
Vindhó
Santa María
Ajoloapan
Singuilucan
Tepeji
del Río
Tequixquiac
Tecocomul
Zumpango
de Ocampo
Tepeapulco
Coyotepec
Jaltenco
Villa Del
Carbón
Jocotitlán
Melchor
Ocampo
Tecámac de Felipe
Villanueva
Otumba de
Gómez Farías
Apan
Tultitlán
Coacalco
Acolman de
Nezahualcóyotl
Nicolás
Romero
Ixtlahuaca
de Rayón
Transfiguración
Jiquipilco
Chiconcuac
Ecatepec
Texcoco
San Mateo
Nopala
Guadalupe
Insurgentes
México
City
San Miguel
Coatlinchan
Chiconcuac
de Juárez
Hueyotlip
de Hidal
Xonacatlán
Coyoacán
Santa María
del Monte
San Mateo
Atenco
Tlalpan
Ixtapaluca
Tlahuac
Xochimilco
San Miguel
Ajusco
Cocotitlán
Milpa
Alta
Coyotzingo
Xalatlaco
Calimaya
San Nicolás
Coatepec
Huejotzingo
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de Juárez
Tenango
de Arista
San Andrés
Calpan
Joquicingo de
León Guzmán
Ozumba de
Alzate
Ocuilán de
Arteaga
Tepoztlán
Tenancingo
de Degollado
Cuernavaca
Chalma
Atlatlahucan
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Yautepec
Yecapixtla
Ixtapan
de la Sal
Emiliano
Zapata
Cuautla
Miacatlán
Ticumán
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Low Potential
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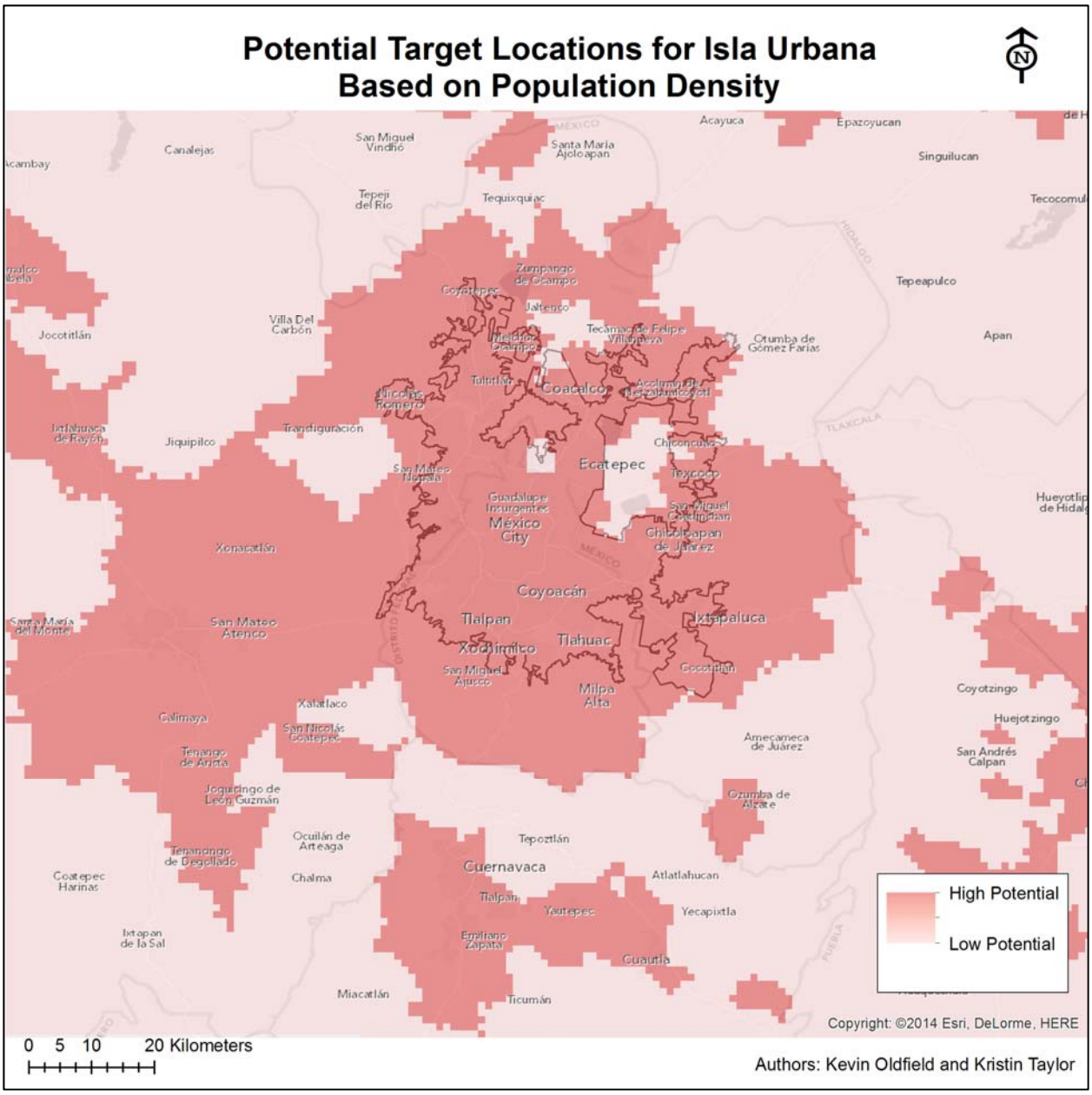
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Based on Population Density
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Tequixquiac
Tecocomul
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Coacalco
Nicolás Romero
Tlalnepantla de Baz
Tultepec
Ixtlahuaca de Rayón
Jiquipilco
Tranfiguración
Chiconcuac
Ecatepec
Texcoco
San Mateo Nopala
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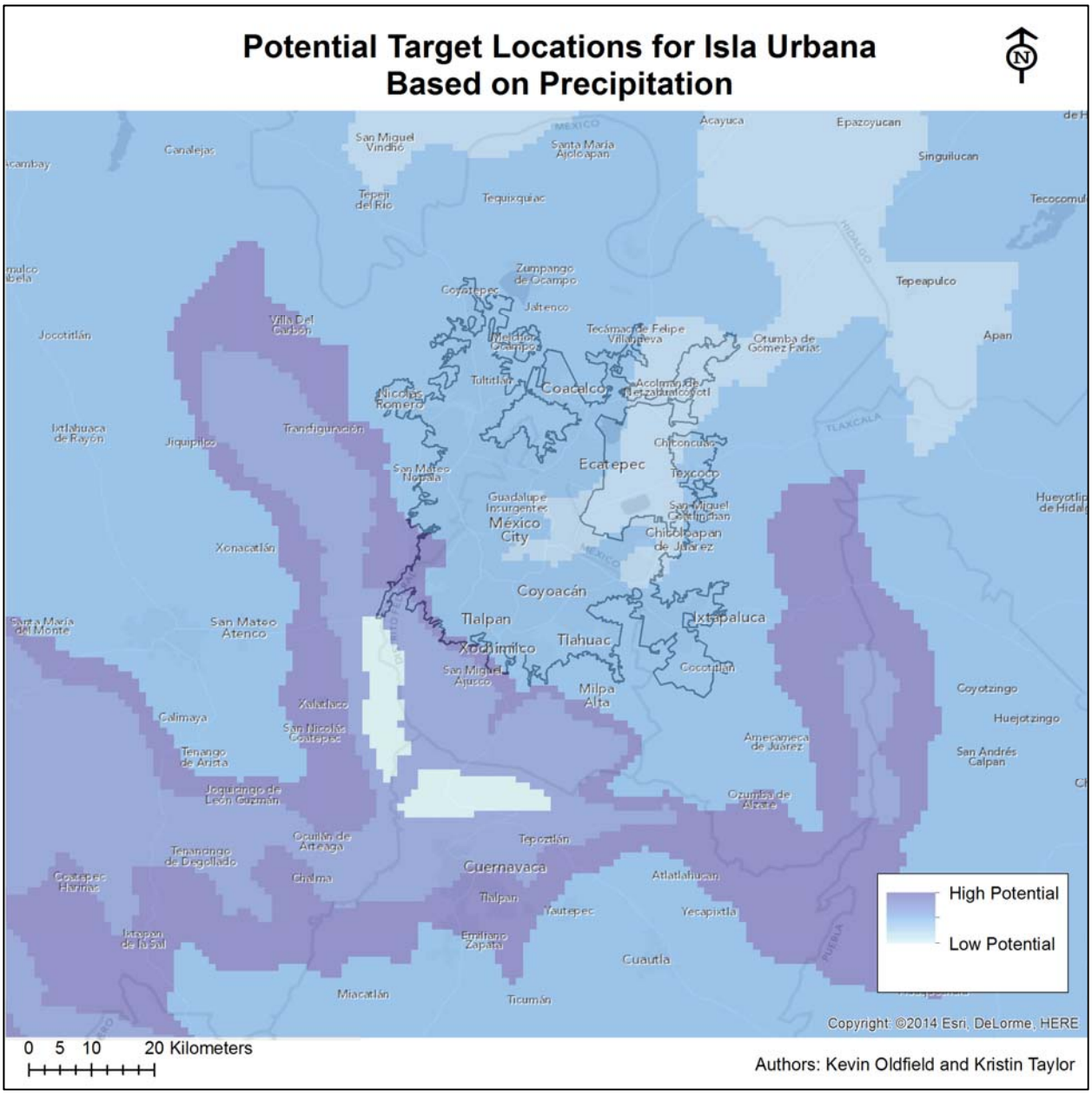
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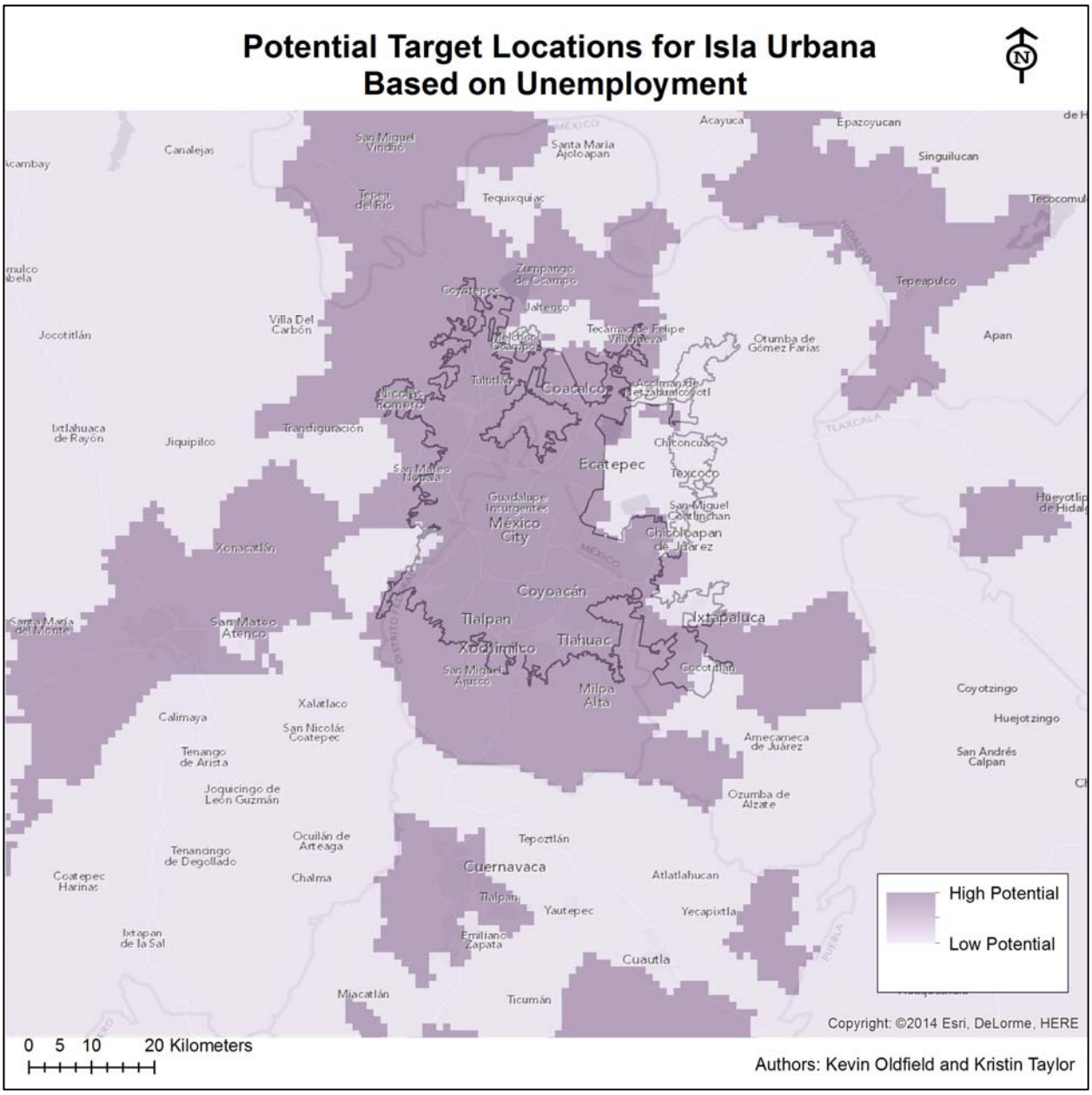
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Tepeapulco
Jocotitlán
Villa Del Carbón
Apan
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México City
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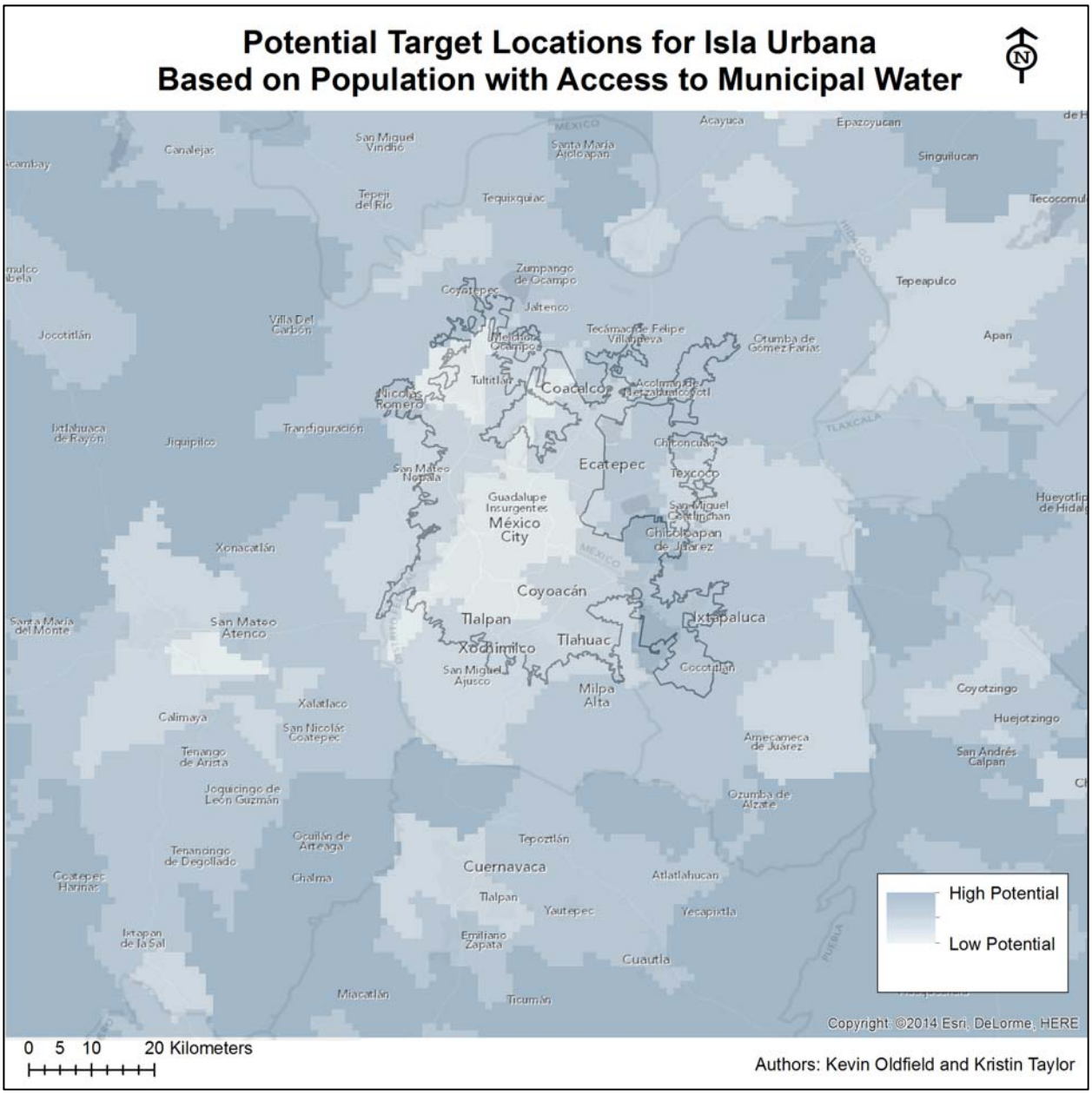
Potential Target Locations for Isla Urbana
Based on Population with Access to Municipal Water
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Epazoyucan
Singuilucan
Canalejas
San Miguel Vindhó
Santa María Ajoloapan
Tepeji del Río
Tequixquiac
Tecocomul
Zumpango de Ocampo
Coyotepec
Jaltenco
Tepeapulco
Villa Del Carbón
Jocotitlán
Melchor Ocampo
Tecámac de Felipe Villanueva
Otumba de Gómez Farías
Apan
Tultitlán
Coacalco
Acolman de Nezahualcóyotl
Nicolás Romero
Ixtlahuaca de Rayón
Jiquipilco
Tlaxcala
Chiconcuac
Ecatepec
Texcoco
San Mateo Nopala
Guadalupe Insurgentes
México City
San Miguel Coatlinchan
Chiconcuac de Juárez
Hueyotlipan de Hidalgo
Xonacatlán
Coyoacán
Santa María del Monte
San Mateo Atenco
Tlalpan
Ixtapaluca
Tlahuac
Xochimilco
Cocotitlán
San Miguel Ajusco
Milpa Alta
Coyotzingo
Xalatlaco
Calimaya
Huejotzingo
San Nicolás Coatepec
Amecameca de Juárez
San Andrés Calpan
Tenango de Arista
Joquicingo de León Guzmán
Ozumba de Alzate
Ocuilán de Arteaga
Tepoztlán
Tenancingo de Degollado
Cuernavaca
Coatepec Harinas
Chalma
Atlatlahucan
Tlalpan
Yautepec
Yecapixtla
Ixtapan de la Sal
Emiliano Zapata
Cuautla
Puebla
Miacatlán
Ticumán
High Potential
Low Potential
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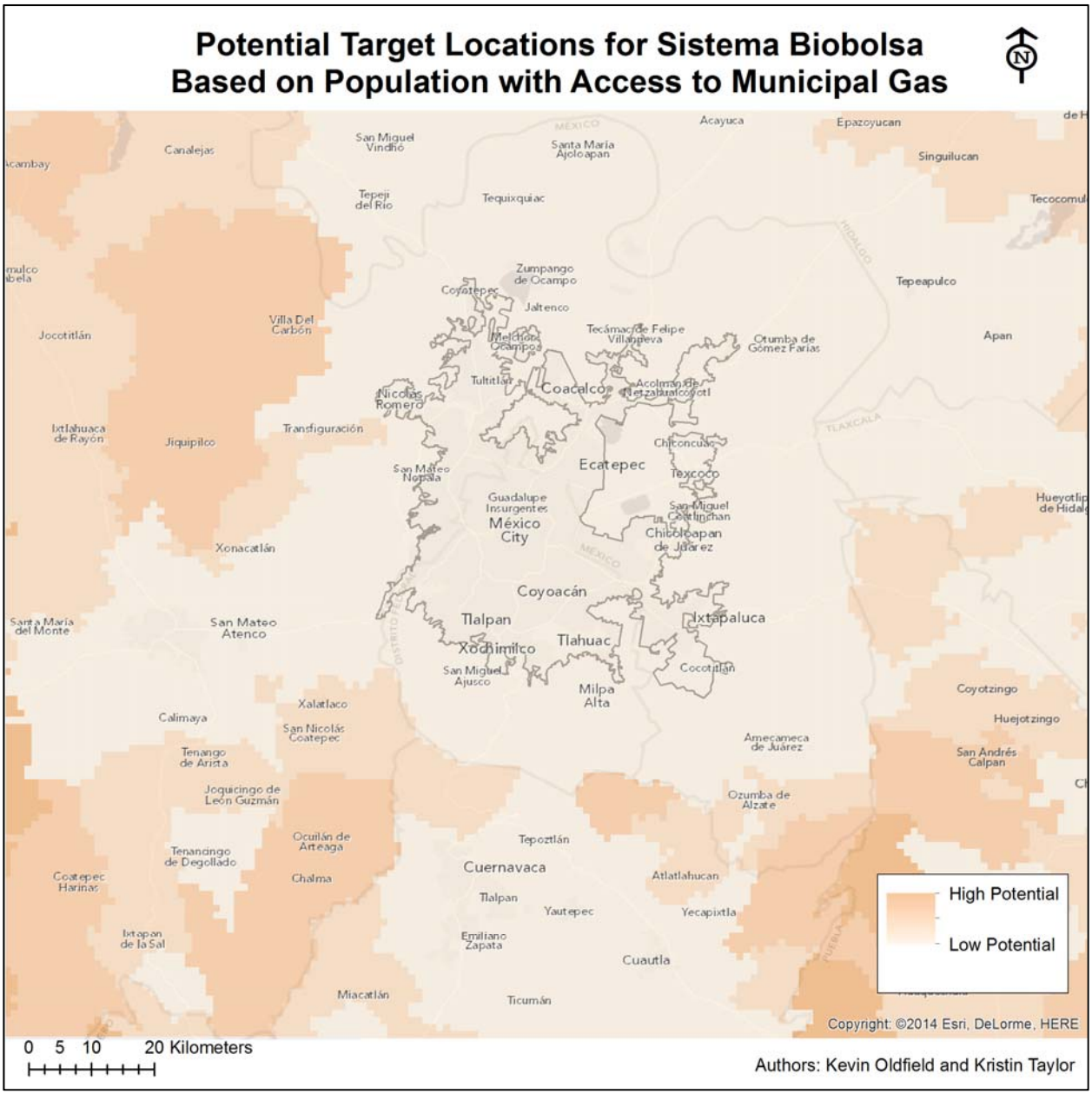
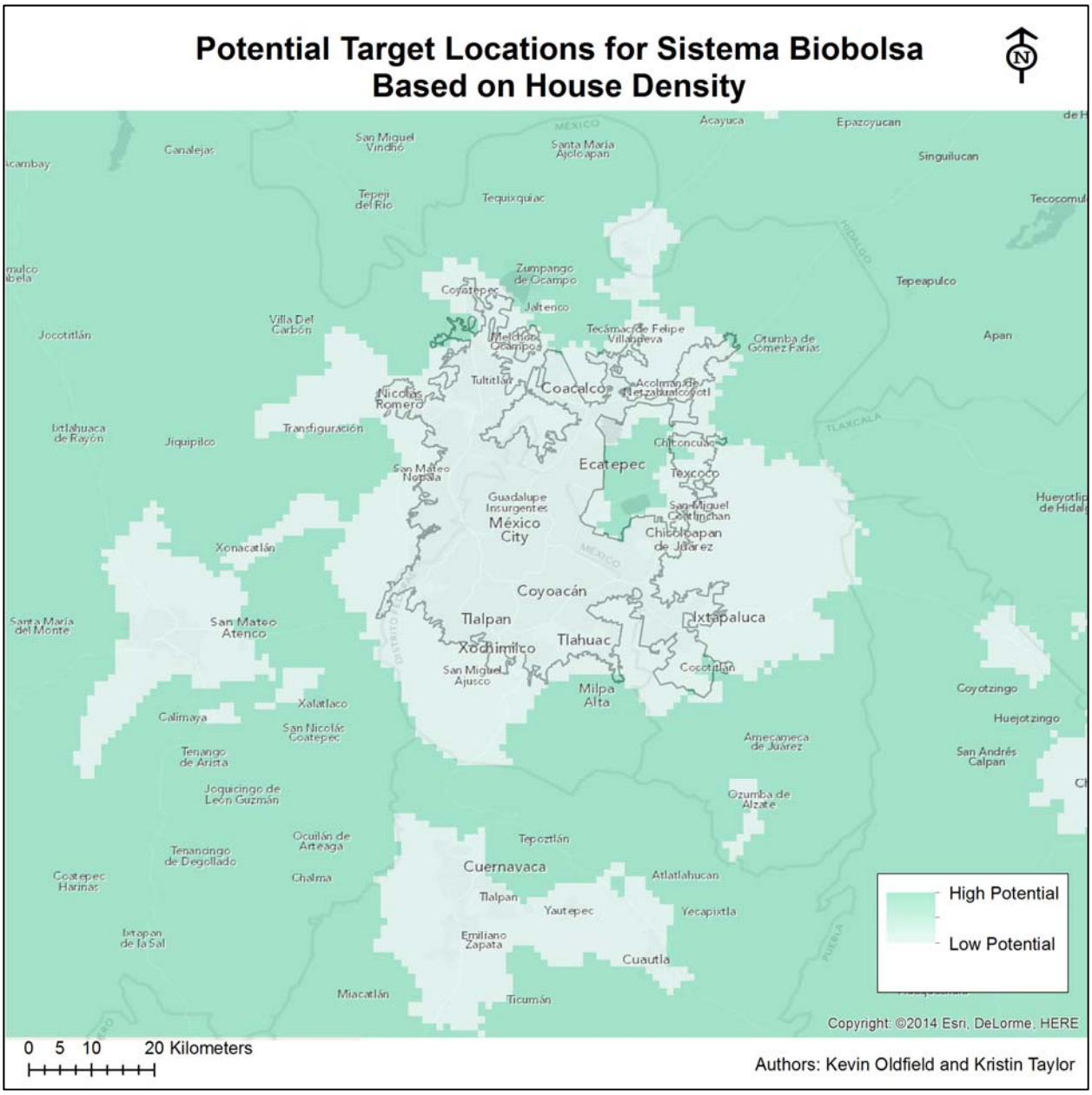
SISTEMA BIOBOLSA




Potential Target Locations for Sistema Biobolsa
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Santa María Ajoloapan
Acayuca
Epazoyucan
Singuilucan
Tepeji del Río
Tequixquiac
Tecocomul
Zumpango de Ocampo
Coyotepec
Jaltenco
Tepeapulco
Villa Del Carbón
Jocotitlán
Melchor Ocampo
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Apan
Tultitlán
Coacalco
Acolman de Nezahualcóyotl
Nicolás Romero
Ixtlahuaca de Rayón
Jiquipilco
Transfiguración
Chiconcuac
Ecatepec
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Guadalupe Insurgentes
México City
San Miguel Coatlinchan
Chiconcuac de Juárez
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Tlalpan
Ixtapaluca
Tlahuac
Xochimilco
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Calimaya
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Huejotzingo
Amecameca de Juárez
Tenango de Arista
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Tepoztlán
Ocuilán de Arteaga
Tenancingo de Degollado
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Coatepec Harinas
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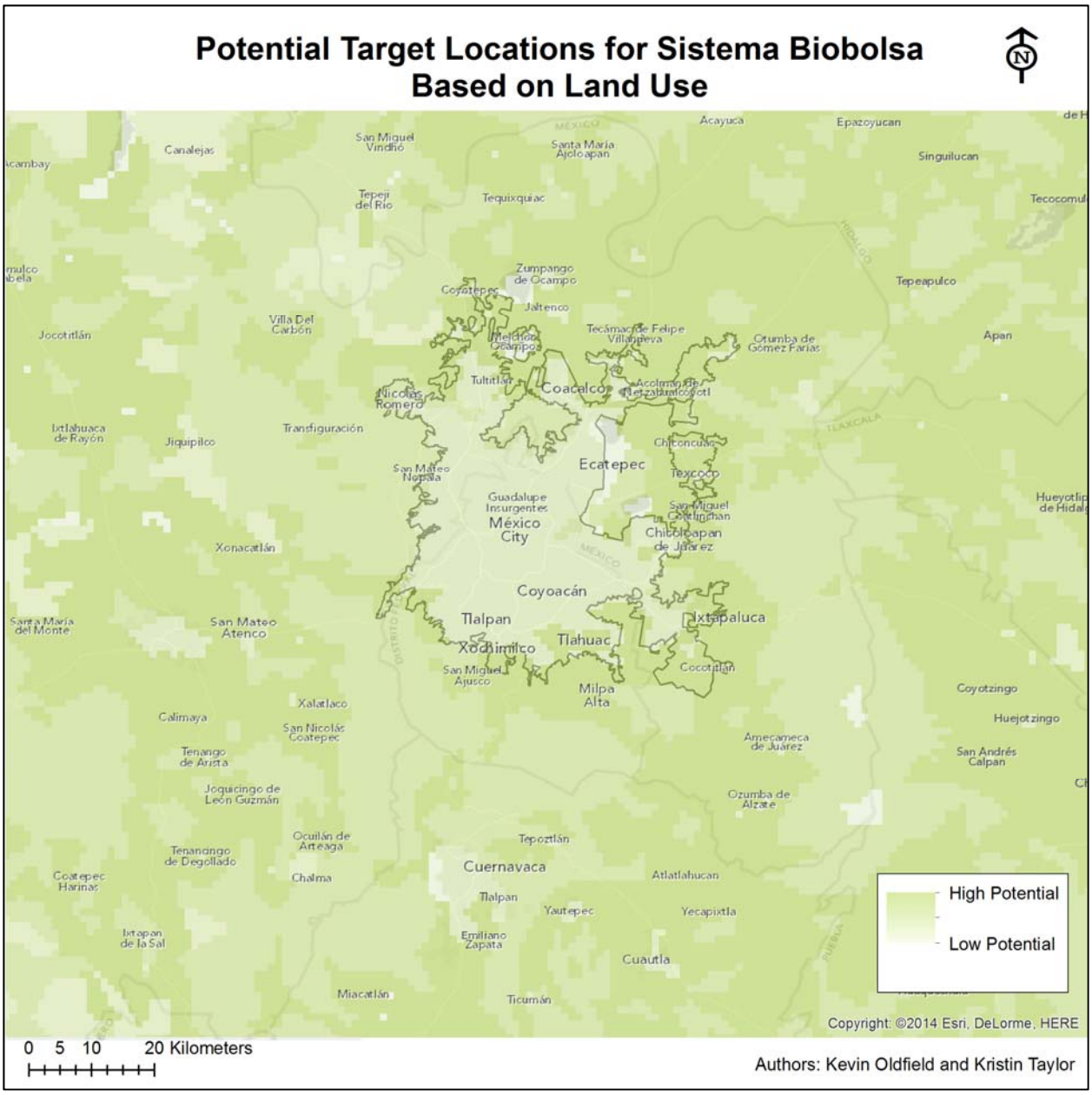
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Vindhó
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Ajoloapan
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del Río
Tequixquiac
Zumpango
de Ocampo
Coyotepec
Jaltenco
Tepeapulco
Villa Del
Carbón
Jocotitlán
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Ocampo
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Villanueva
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Gómez Farías
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Coacalco
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de Rayón
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Nopala
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de Juárez
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Coyoacán
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del Monte
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Atenco
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de Juárez
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de Arista
San Andrés
Calpan
Joquicingo de
León Guzmán
Ozumba de
Alzate
Ocuilán de
Arteaga
Tepoztlán
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de Degollado
Cuernavaca
Coatepec
Harinas
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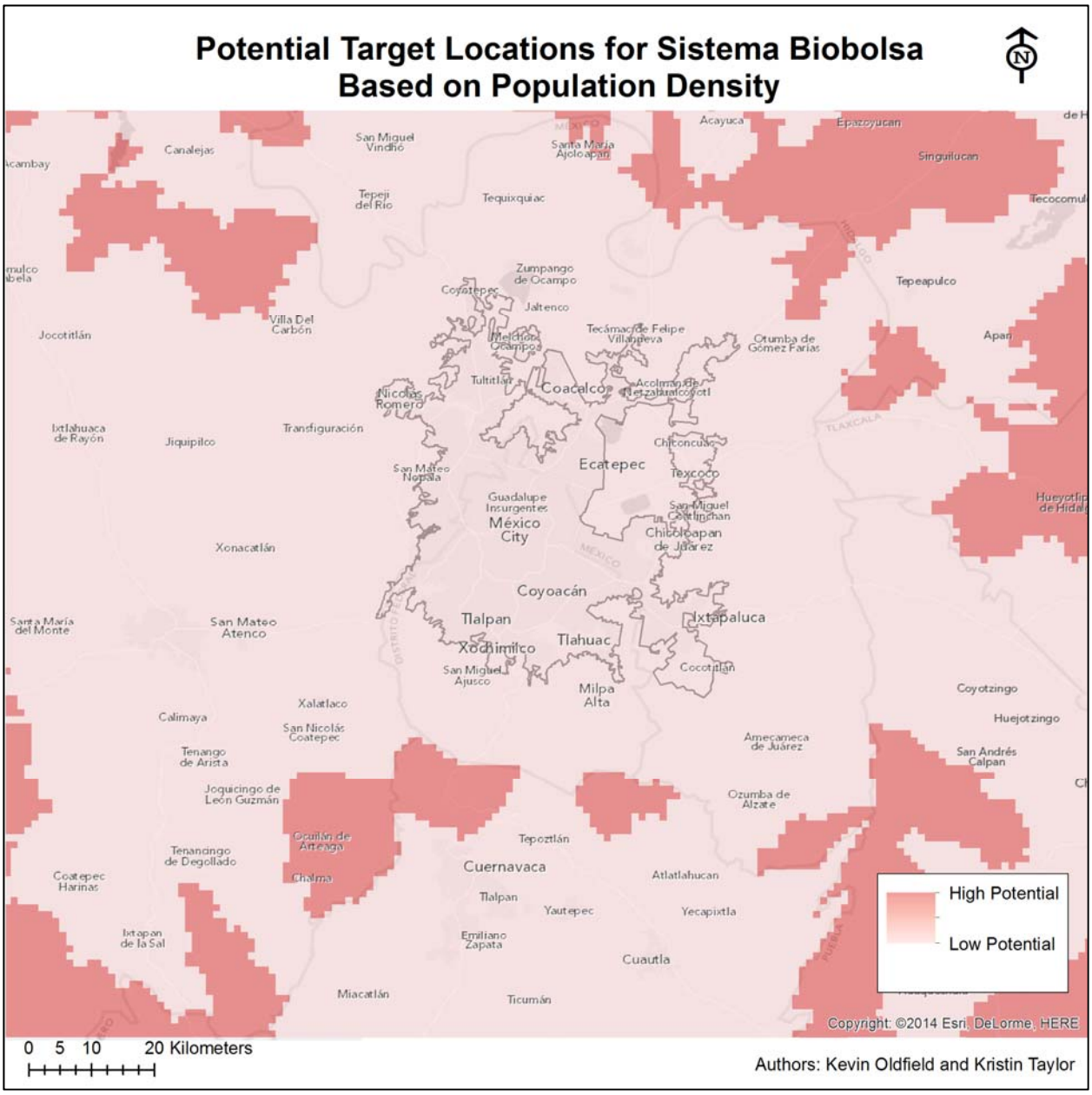
Potential Target Locations for Sistema Biobolsa
Based on Population Density
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San Miguel Vindhó
Santa María Ajoloapan
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Tequixquiac
Singuilucan
Zumpango de Ocampo
Coyotepec
Jaltenco
Tepeapulco
Villa Del Carbón
Jocotitlán
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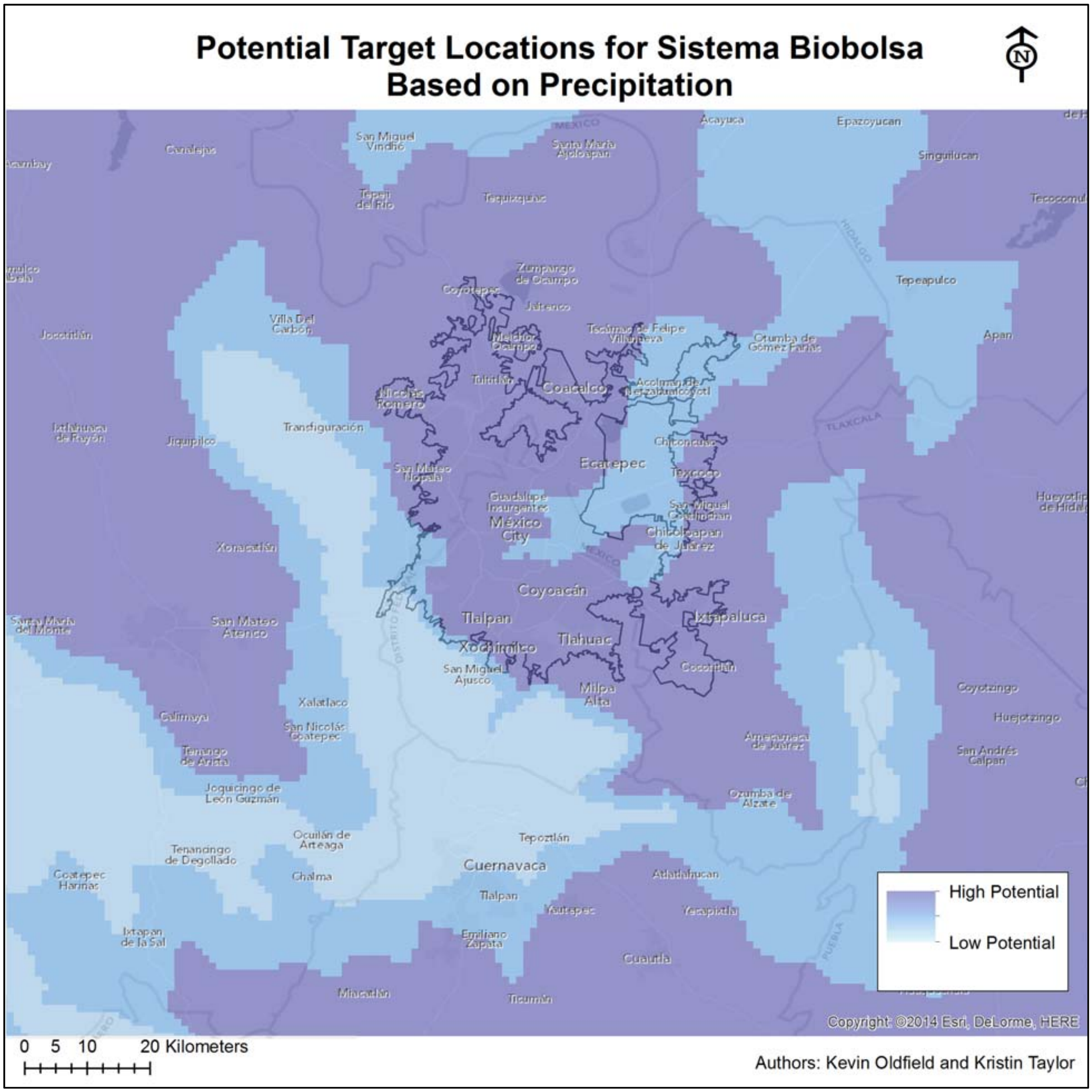
Potential Target Locations for Sistema Biobolsa
Based on Precipitation
N
High Potential
Low Potential
0 5 10 20 Kilometers
Authors: Kevin Oldfield and Kristin Taylor
Copyright: ©2014 Esri, DeLorme, HERE
México City
Coyoacán
Tlalpan
Xochimilco
Tlahuac
Ecatepec
Ixtapaluca
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Transfiguración
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Apan
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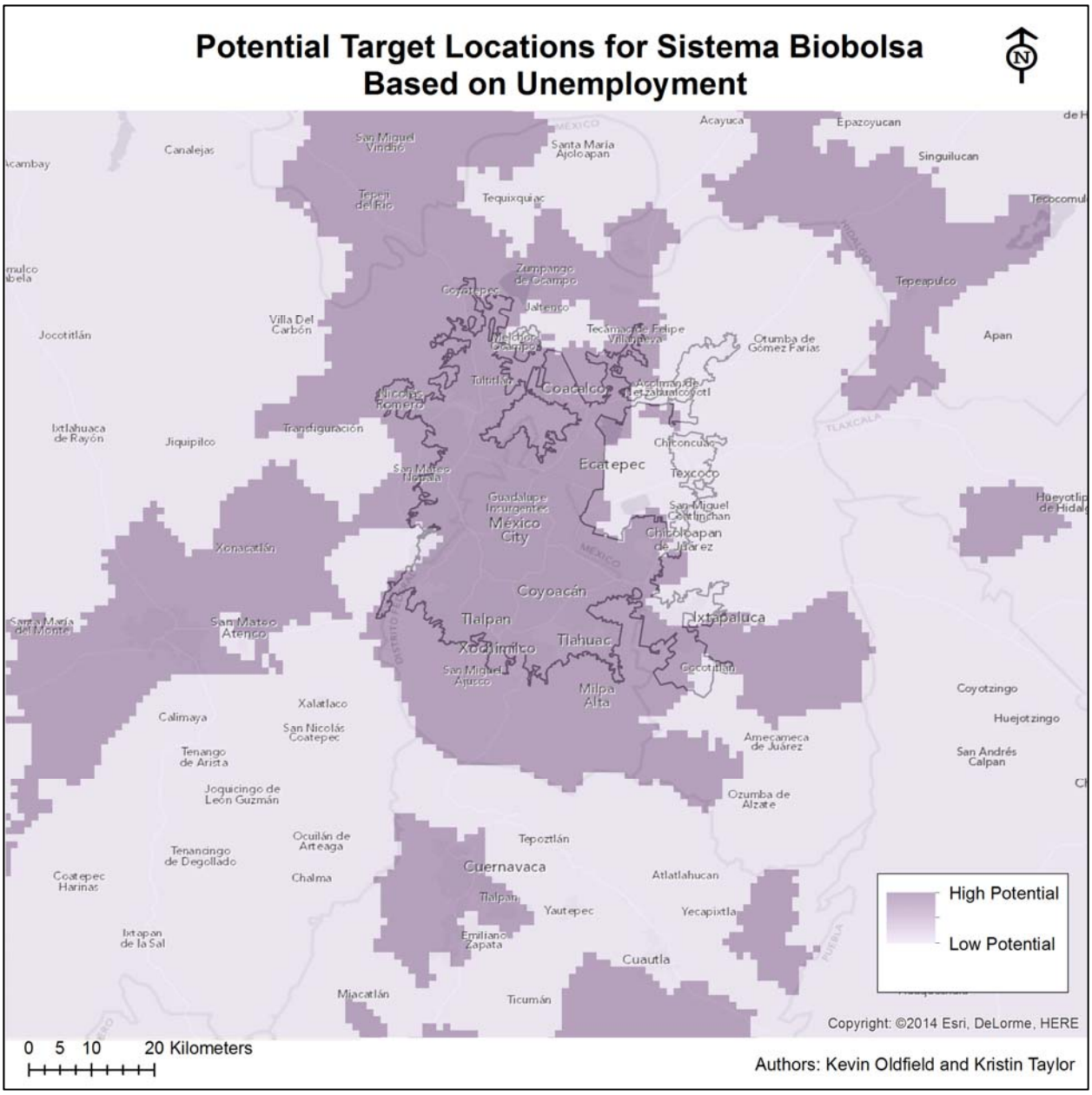
Potential Target Locations for Sistema Biobolsa
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Tepeji del Río
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Tepeapulco
Coyotepec
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Villa Del Carbón
Jocotitlán
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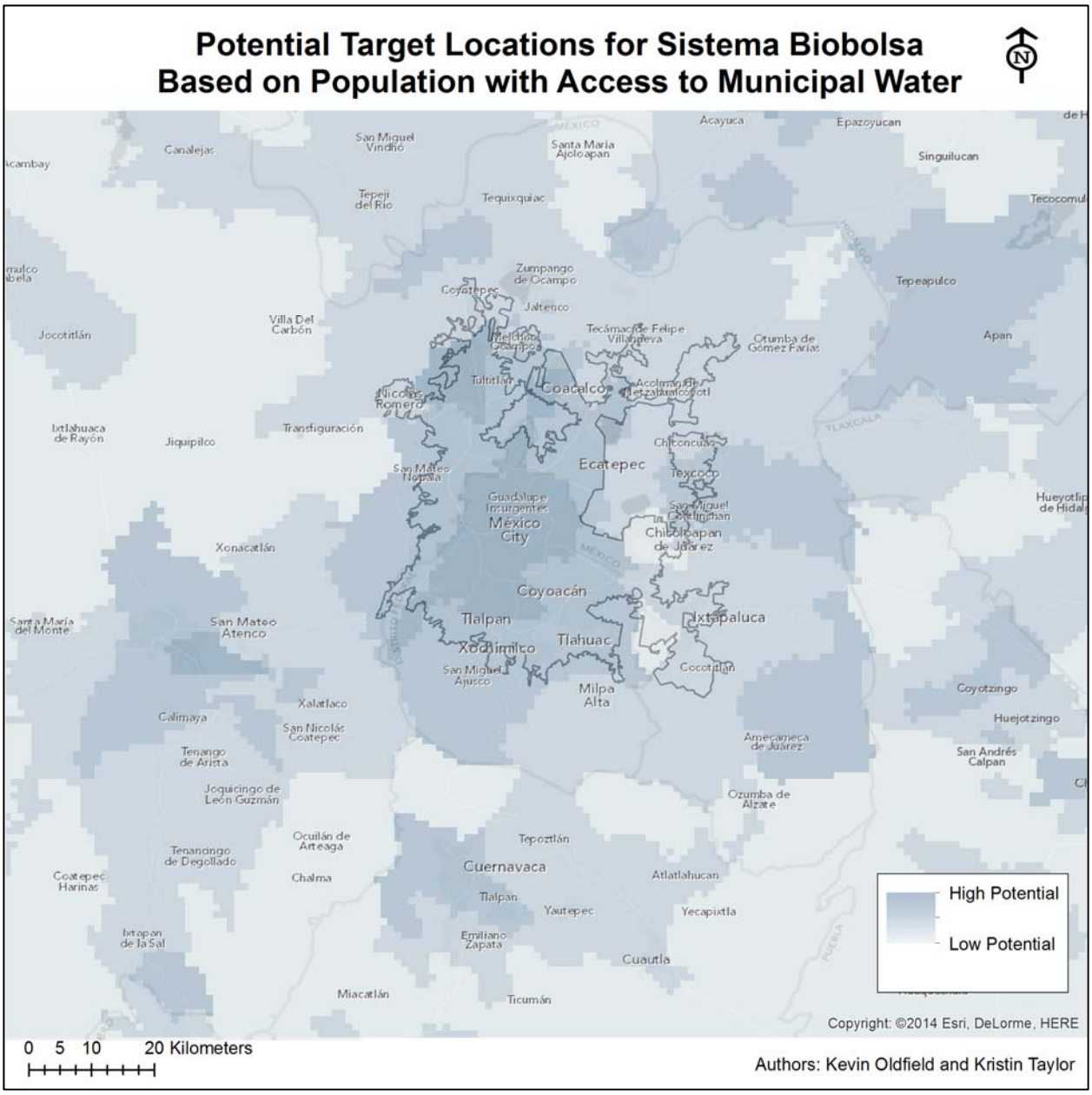
Potential Target Locations for Sistema Biobolsa
Based on Population with Access to Municipal Water
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Santa María Ajoloapan
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Ticumán
High Potential
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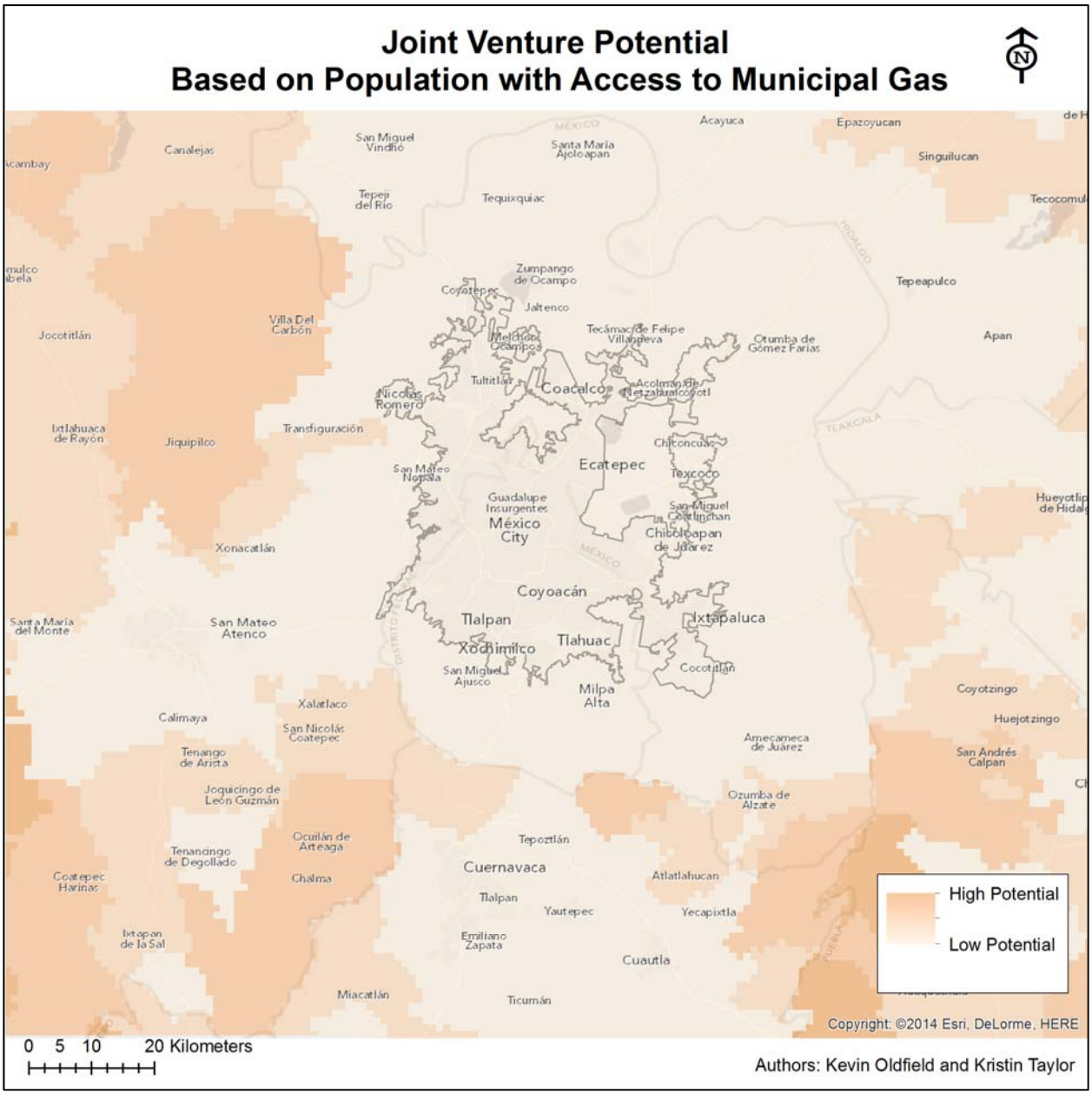
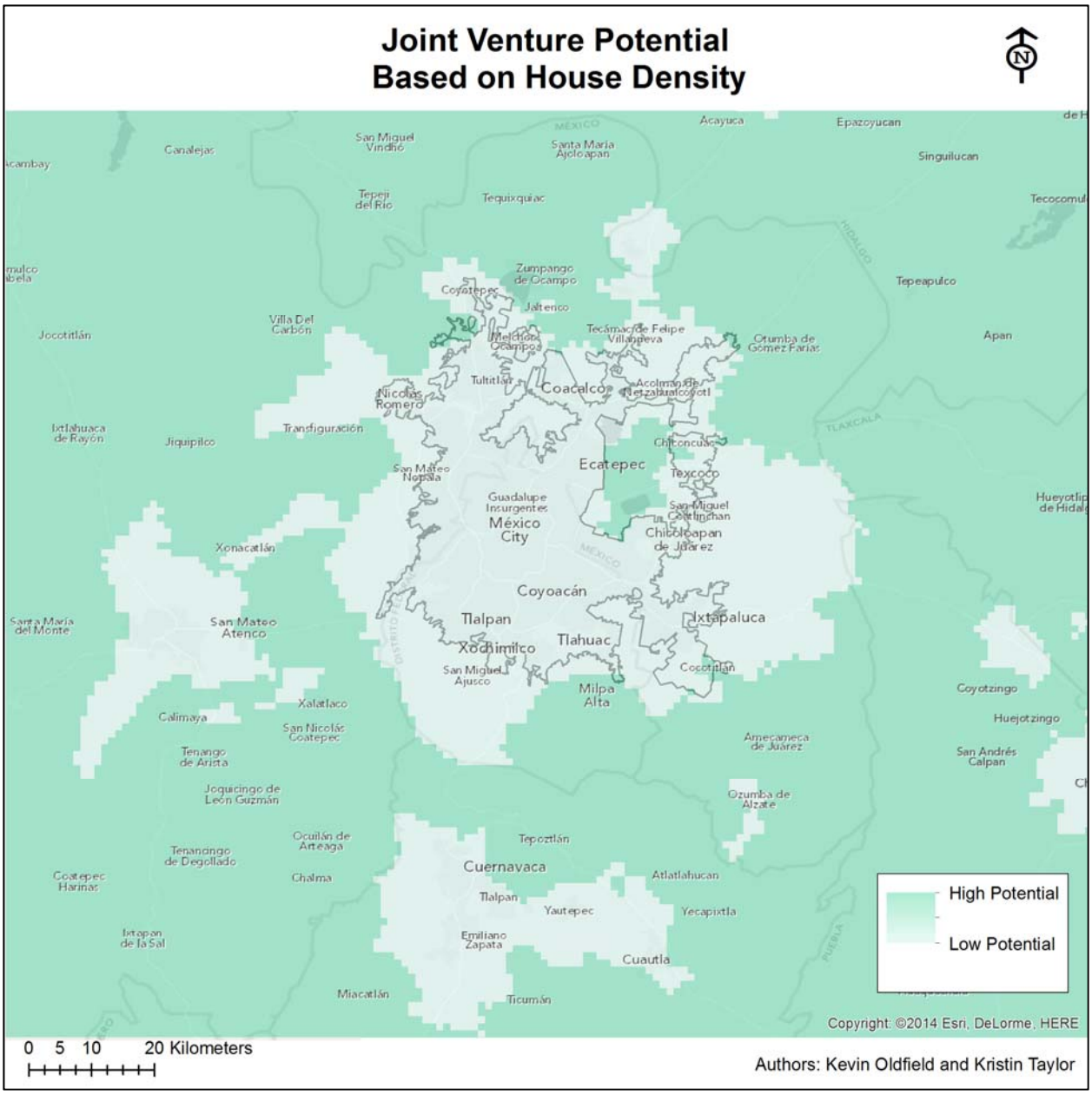
JOINT INSTALLATIONS




Joint Venture Potential
Based on House Density
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Tequixquiac
Tecocomul
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Tepeapulco
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Melchor Ocampo
Tecámac de Felipe Villanueva
Otumba de Gómez Farías
Apan
Tultitlán
Coacalco
Acolman de Nezahualcóyotl
Nicolás Romero
Ixtlahuaca de Rayón
Transfiguración
Jiquipilco
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San Miguel Coatlinchan
Chiconcuac de Juárez
Hueyotlipan de Hidalgo
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Coyoacán
Santa María del Monte
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Joquicingo de León Guzmán
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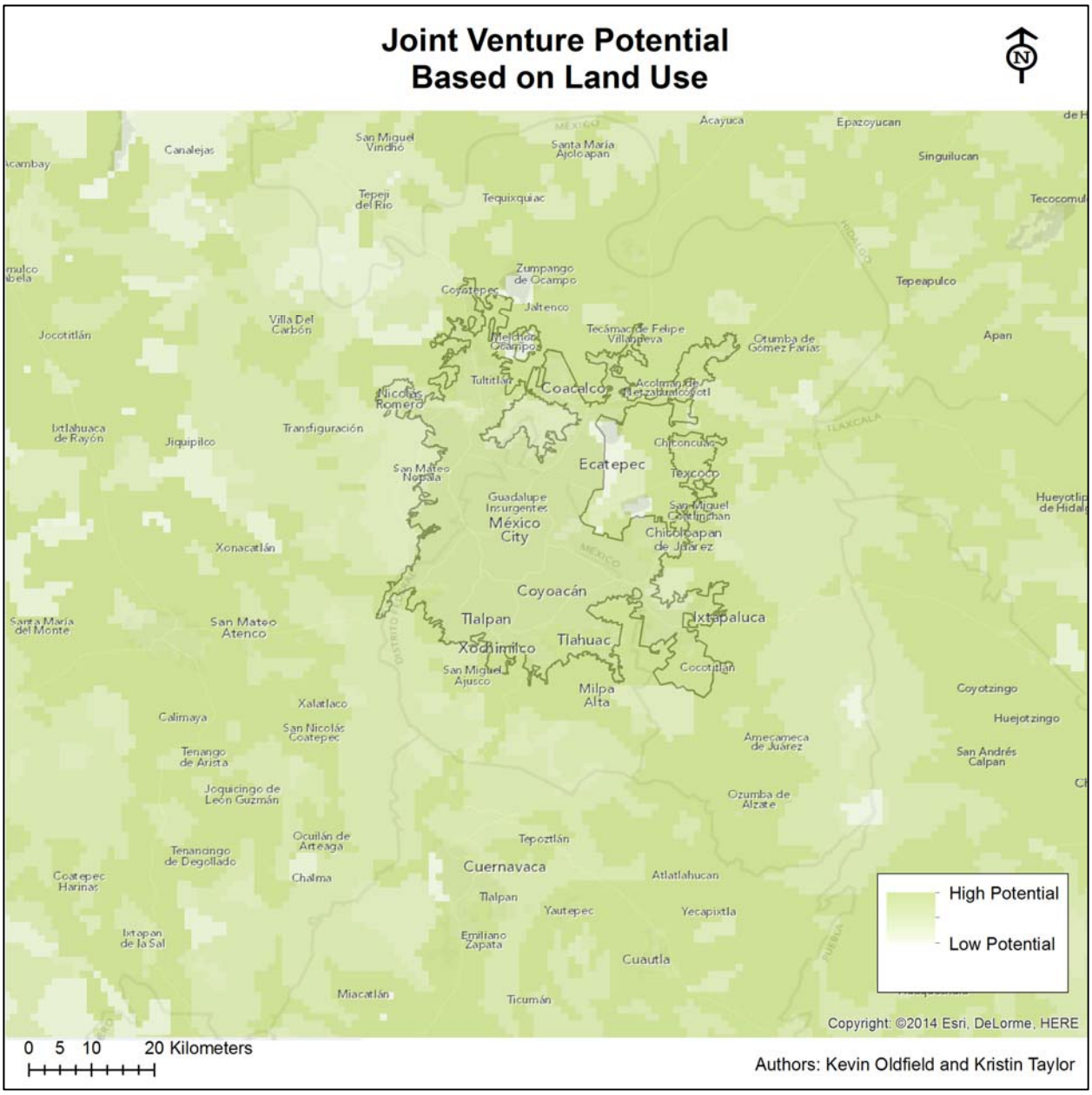
Joint Venture Potential
Based on Land Use
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Tequixquiac
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San Nicolás Coatepec
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Tenango de Arista
Amecameca de Juárez
San Andrés Calpan
Joquicingo de León Guzmán
Ozumba de Alzate
Ocuilán de Arteaga
Tepoztlán
Tenancingo de Degollado
Cuernavaca
Coatepec Harinas
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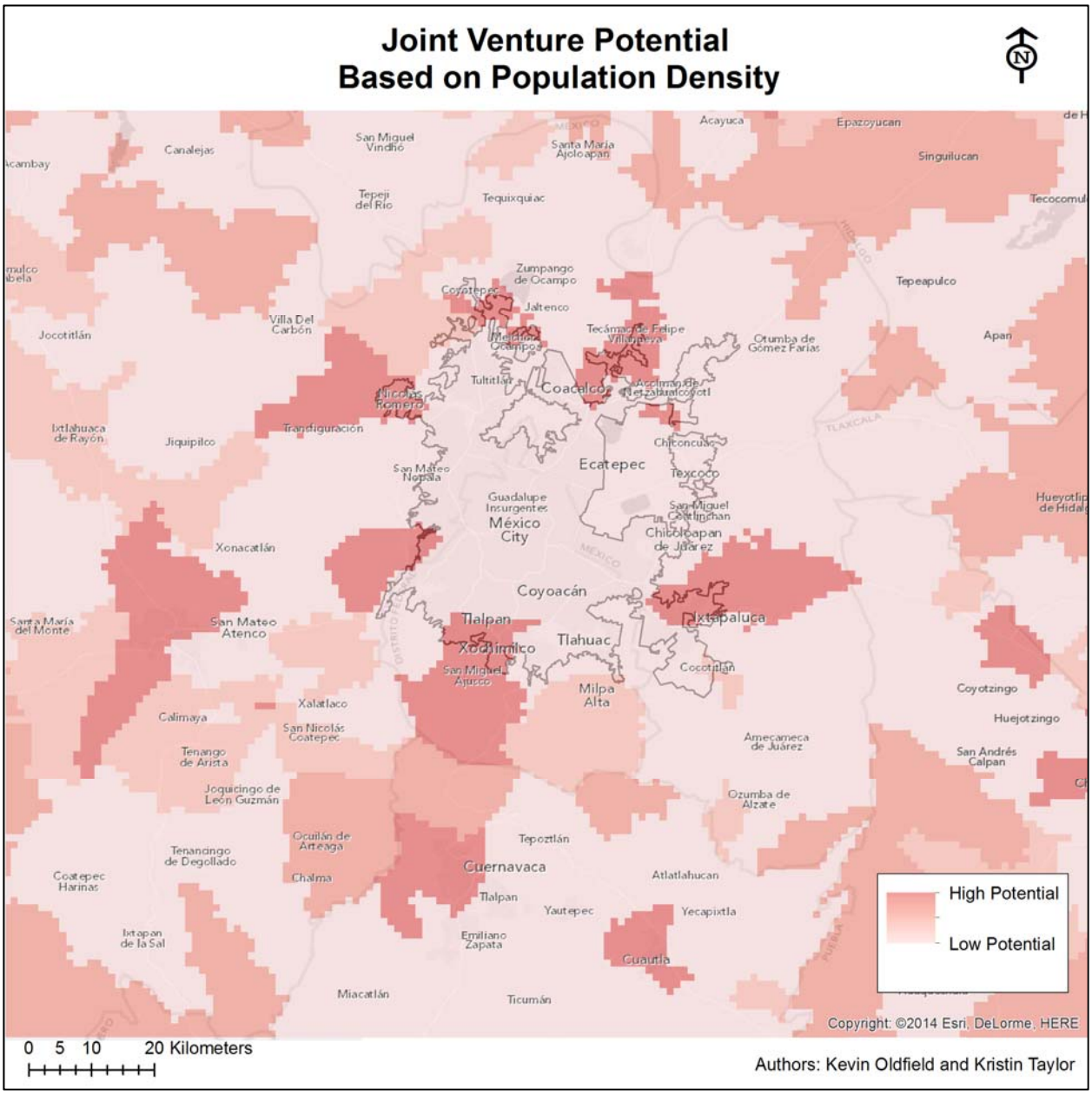
Joint Venture Potential
Based on Population Density
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Epazoyucan
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Tequixquiac
Tecocomul
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Jaltenco
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Villa Del Carbón
Jocotitlán
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Otumba de Gómez Farías
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Nicolás Romero
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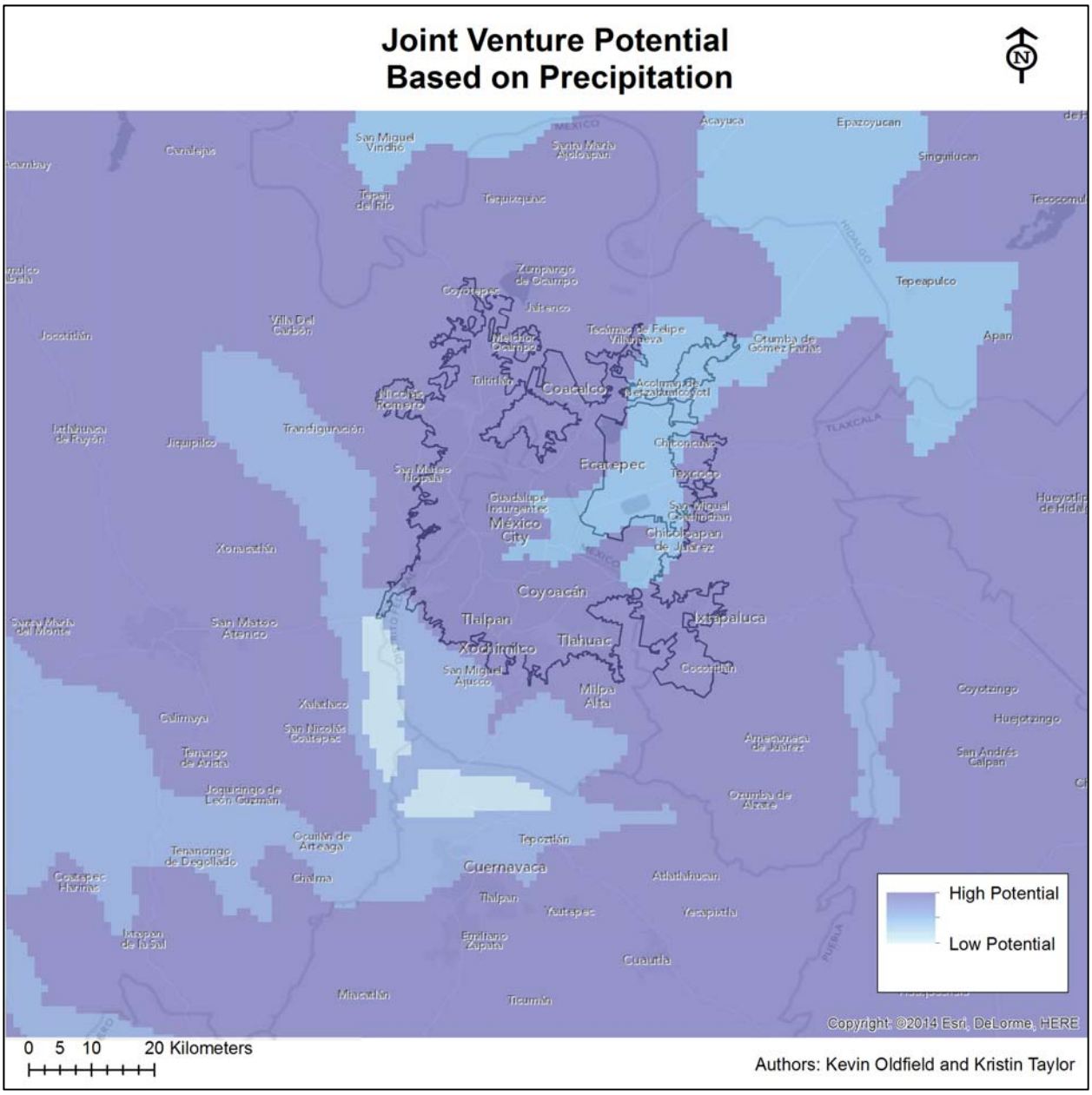
Joint Venture Potential
Based on Precipitation
N
High Potential
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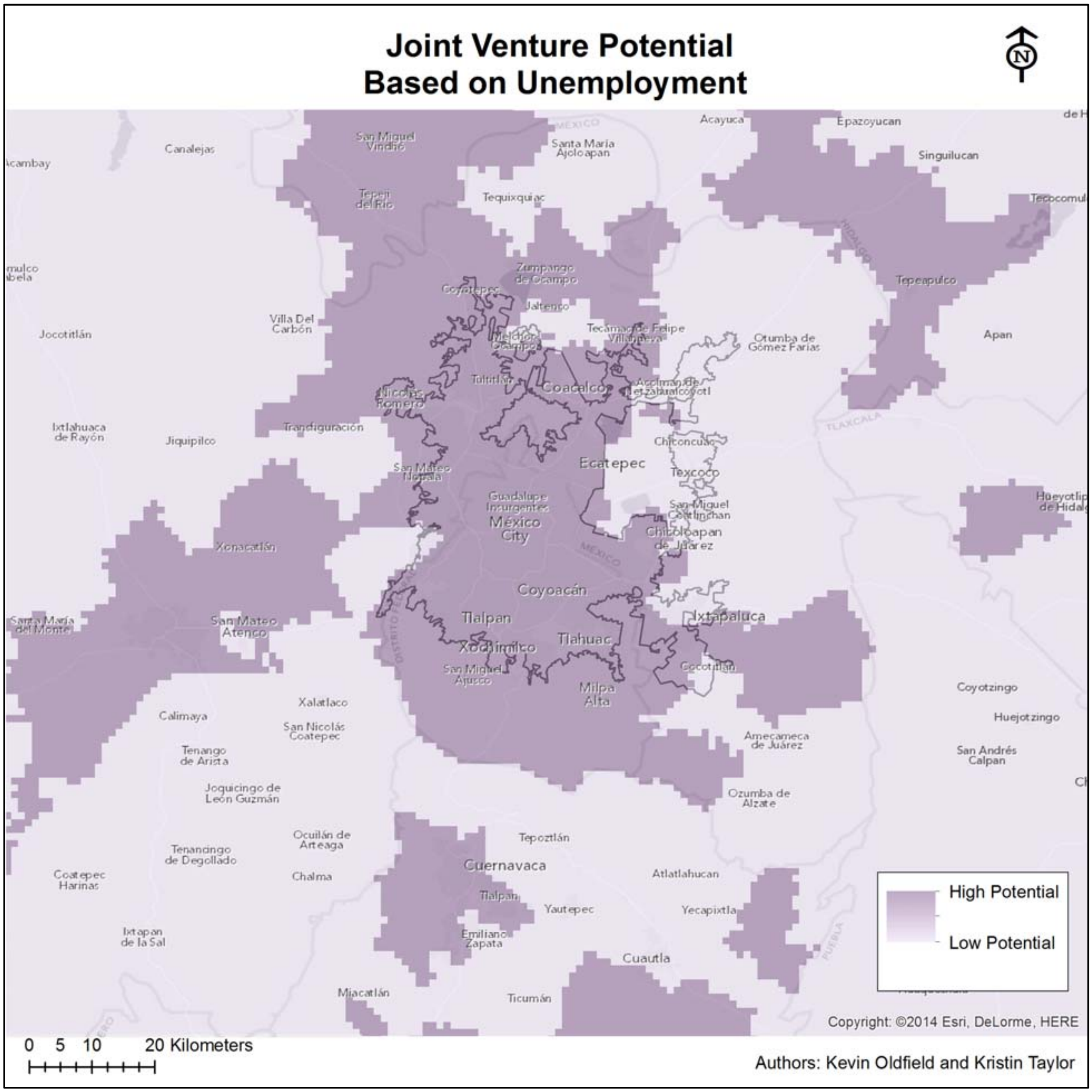
Joint Venture Potential
Based on Unemployment
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San Nicolás Coatepec
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Tenango de Arista
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Joquicingo de León Guzmán
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Ocuilán de Arteaga
Tepoztlán
Tenancingo de Degollado
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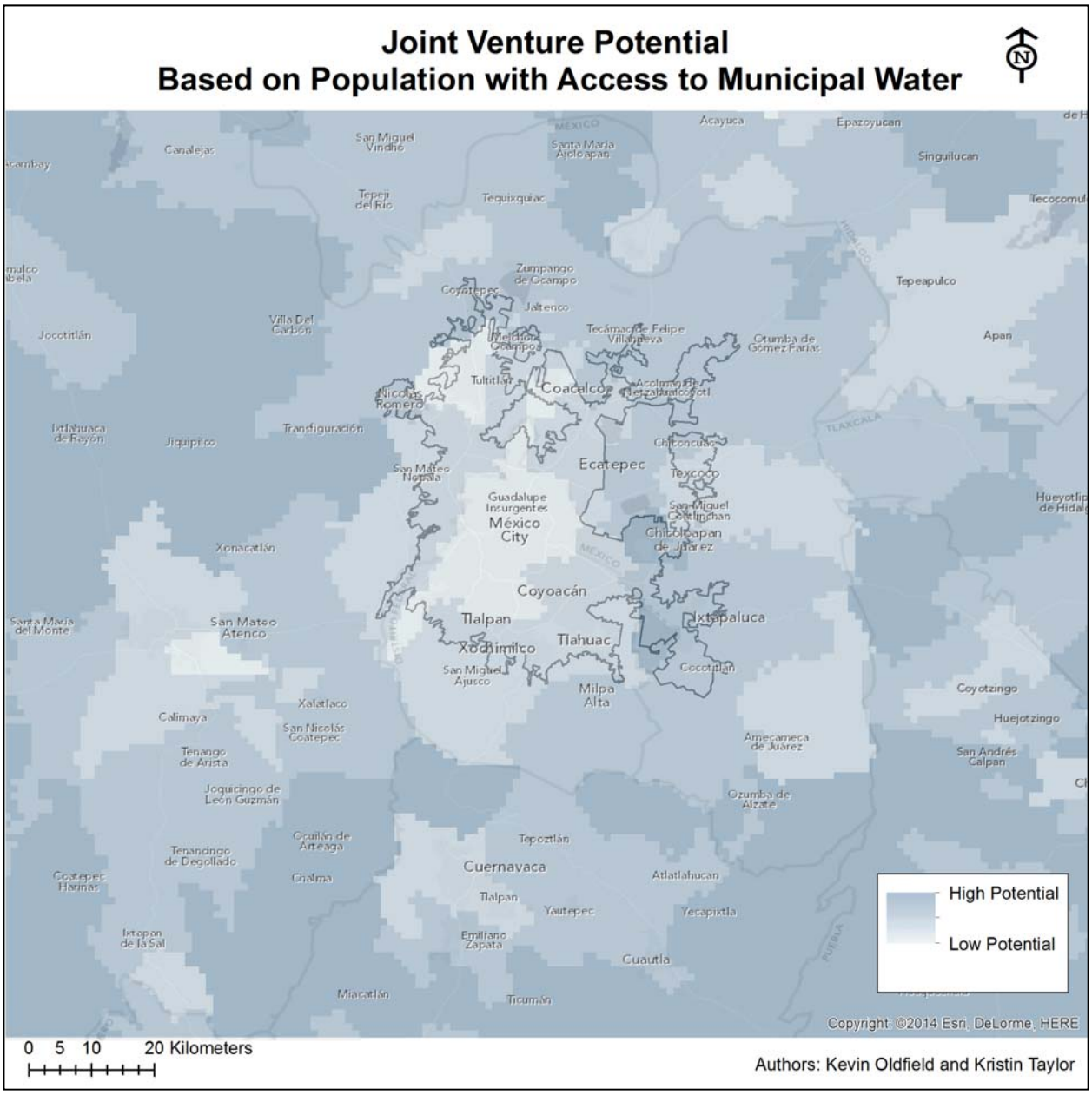
Joint Venture Potential
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Jaltenco
Tepeapulco
Villa Del Carbón
Jocotitlán
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Otumba de Gómez Farías
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Tultitlán
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Acolman de Nezahualcóyotl
Nicolás Romero
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Chiconcuac
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Guadalupe Insurgentes
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San Miguel Coatlinchan
Chiconcuac de Juárez
Hueyotlipan de Hidalgo
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Coyoacán
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San Andrés Calpan
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Joquicingo de León Guzmán
Ozumba de Alzate
Tepoztlán
Ocuilán de Arteaga
Tenancingo de Degollado
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Coatepec Harinas
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Tlalpan
Yautepec
Yecapixtla
Ixtapan de la Sal
Emiliano Zapata
Cuautla
Puebla
Miacatlán
Ticumán
High Potential
Low Potential
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0 5 10 20 Kilometers
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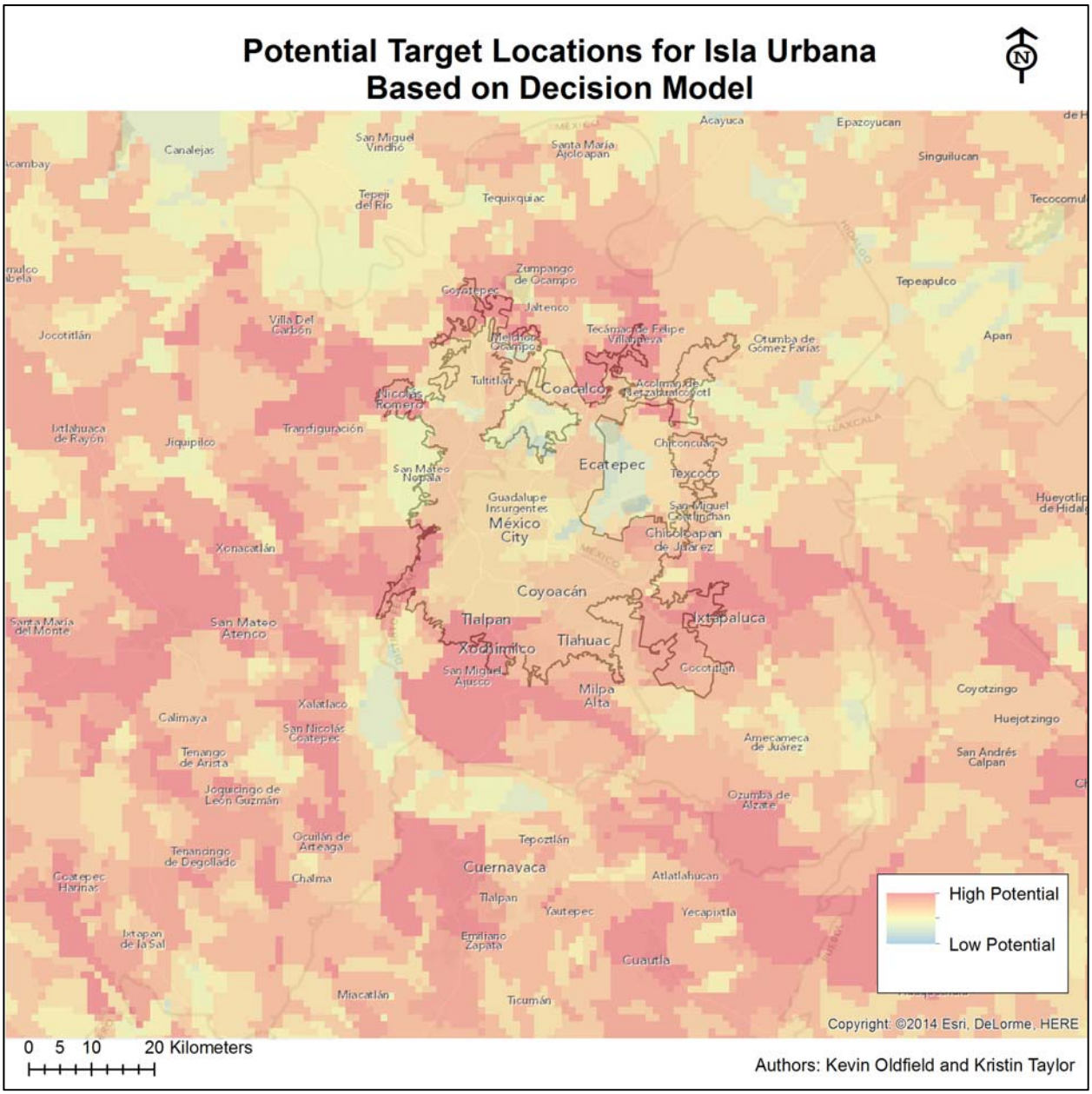
TARGET MAPS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Canalejas
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Tequixquiac
Tecocomul
Zumpango de Ocampo
Coyotepec
Jaltenco
Tepeapulco
Villa Del Carbón
Jocotitlán
Melchor Ocampo
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Apan
Tultitlán
Coacalco
Nicolás Romero
Ixtlahuaca de Rayón
Jiquipilco
Transfiguración
Chiconcuac
Ecatepec
Texcoco
San Mateo Nopala
Guadalupe Insurgentes
México City
San Miguel Coatlinchan
Chiconcuac de Juárez
Xonacatlán
Coyoacán
Santa María del Monte
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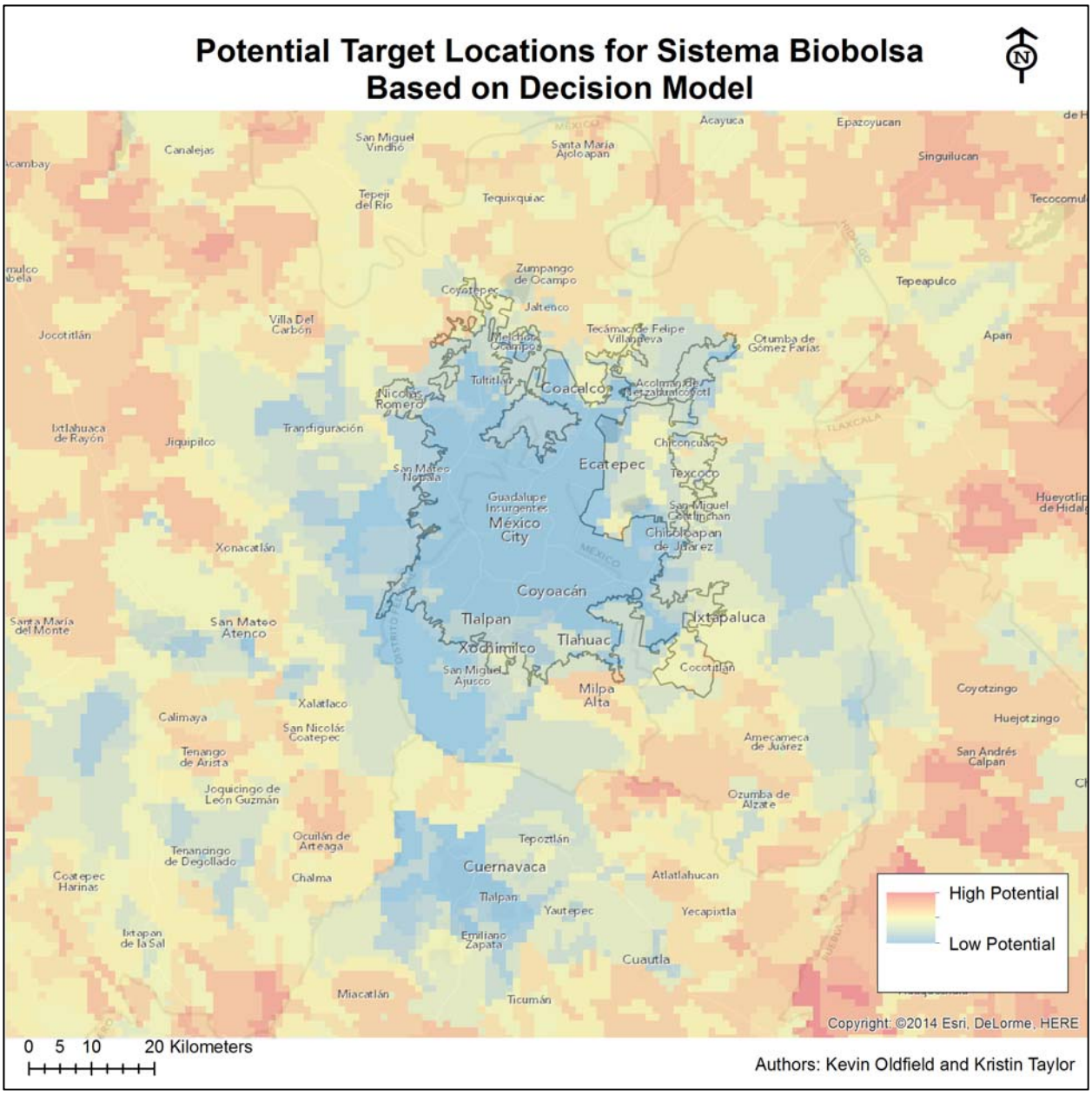
Potential Target Locations for Sistema Biobolsa
Based on Decision Model
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High Potential
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Authors: Kevin Oldfield and Kristin Taylor
Acayuca
Epazoyucan
Canalejas
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Santa María Ajoloapan
Singuilucan
Tepeji del Río
Tequixquiac
Zumpango de Ocampo
Coyotepec
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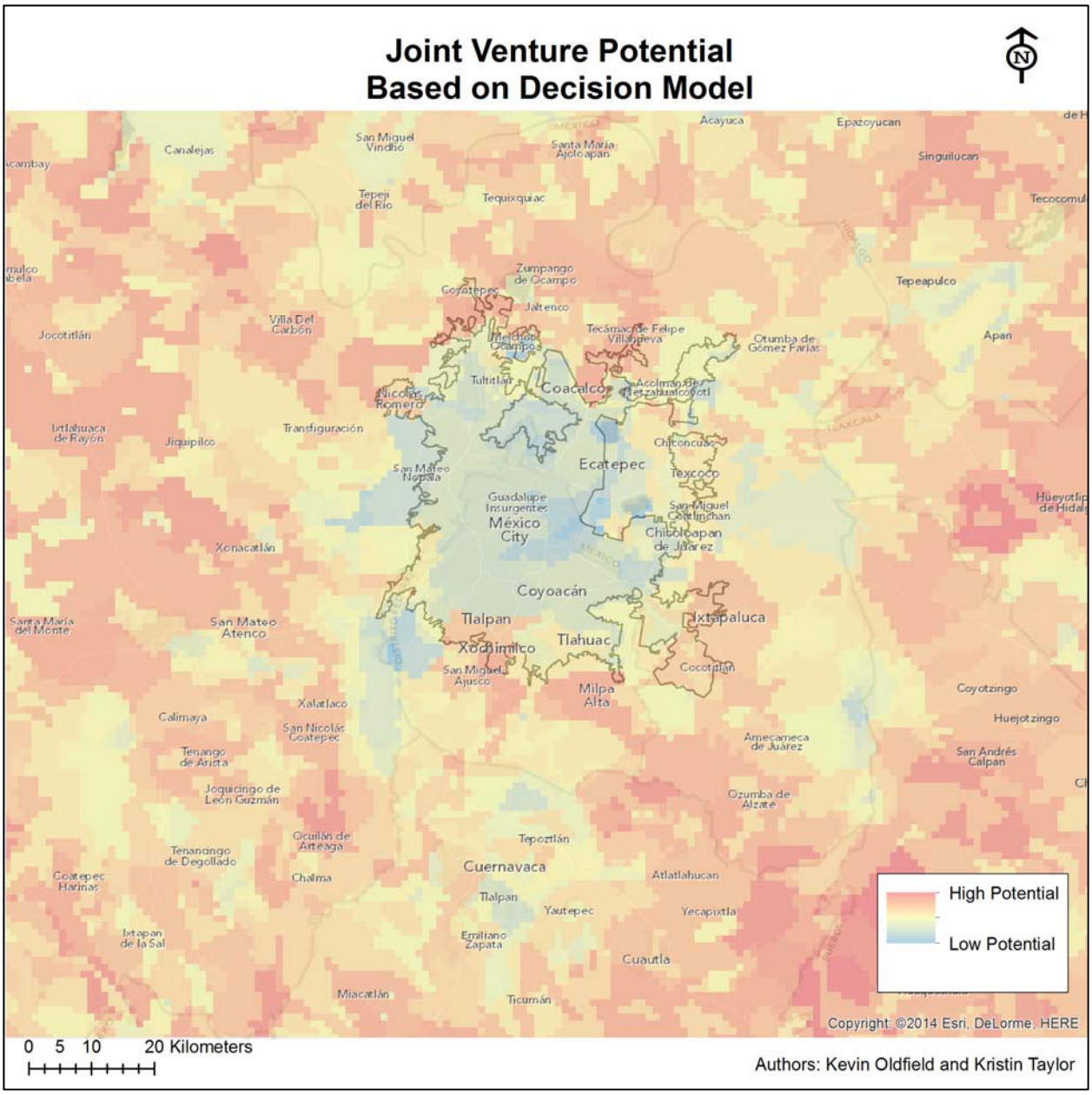
Joint Venture Potential
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Tequixquiac
Zumpango de Ocampo
Coyotepec
Jaltenco
Tepeapulco
Villa Del Carbón
Jocotitlán
Melchor Ocampo
Tecámac de Felipe Villanueva
Otumba de Gómez Farías
Apan
Tultitlán
Coacalco
Acolman de Nezahualcóyotl
Nicolás Romero
Ixtlahuaca de Rayón
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Transfiguración
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San Mateo Nopala
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APPENDIX D

RATINGS FOR IU & SB DATA

Rainfall					
Value		SB Count	SB Rating	IU Count	IU Rating
1	<50mm	0	0	0	0
2	50-100mm	0	0	0	0
3	100-200mm	0	0	0	0
4	200-300mm	1	0	0	0
5	300-400mm	5	0	0	0
6	400-500mm	43	1	0	0
7	500-600mm	121	2	10	1
8	600-800mm	311	4	103	2
9	800-1000mm	356	4	102	2
10	1000-1200mm	107	2	383	4
11	1200-1500mm	52	1	242	3
12	1500-1800mm	9	1	0	0
13	1800-2000mm	4	1	0	0
14	2000-2500mm	7	1	0	0
15	2500-3000mm	23	1	0	0
16	3000-3500mm	5	0	0	0
17	3500-4000mm	0	0	0	0
18	4000-4500mm	0	0	0	0
19	>4500mm	0	0	0	0

Population with Access to Municipal Water		
Percent Population	IU Rating	SB Rating
0-25%	4	n/a
26-50%	3	n/a
51-75%	2	n/a
76-100%	1	n/a

Land Use					
Value		SB Count	SB Rating	IU Count	IU Rating
10	Forest	144	2	84	2
20	Mixed	53	1	0	0
30	Grassland/Scrub	189	2	20	1
40	Agriculture	622	4	373	4
50	Wetland	2	0	0	0
60	Barren	1	0	0	0
70	Built-Up	32	1	363	4
80	Water	1	0	0	0

Population Density				
Value	SB Count	SB Rating	IU Count	IU Rating
100	395	4	1	0
200	170	2	1	0
300	196	2	1	0
400	112	2	89	1
500	18	1	0	1
600	13	1	0	1
700	26	1	0	1
800	6	1	0	1
900	2	1	0	1
1000	5	1	0	1
2000	88	1	549	4
3000	9	0	17	1
4000	2	0	85	1
5000	0	0	0	1
6000	0	0	0	1
7000	0	0	3	1
8000	1	0	16	1
9000	0	0	3	1
10000	0	0	0	1
20000	1	0	75	1

Unemployment		
Percent Population	IU Rating	SB Rating
5-6%	4	4
4%	3	3
2%	2	2
1%	1	1
0%	0	0

House Density				
Value	SB Count	SB Rating	IU Count	IU Rating
100	895	4	92	2
200	48	2	0	2
300	26	2	1	2
400	58	2	2	2
500	5	1	563	4
600	6	1	0	2
700	4	1	73	2
800	0	0	0	1
900	0	0	12	1
1000	0	0	0	1
2000	1	0	20	1
3000	0	0	3	1
4000	0	0	69	1
5000	1	0	5	1

Population with Access to Municipal Gas		
Percent Population	IU Rating	SB Rating
0-25%	n/a	4
26-50%	n/a	3
51-75%	n/a	2
76-100%	n/a	1

APPENDIX E

NEXT STEPS

Our Capstone Group held a client briefing with representatives from Isla Urbana and Sistema Biobolsa on May 10, 2014. They are very eager to continue this collaboration with Columbia University; we discussed some possibilities for projects, and the process of working together, in the future.

- *Process.* It was suggested that the clients could define more specifically projects that would be useful for them, and be more involved in specifics (see "mapping" below). This would reduce time spent figuring out what projects to undertake, leaving more time for productive work. It would also ensure that the work done was more specifically relevant to their needs.

- *Research Archive*. The clients thought the RA would be very useful, and wanted to make sure it is continually built upon and used in the future. One idea was to convert it from Excel to one of the many available databases that provide easier and more comprehensive search capabilities and online access with full-function capability. Other ideas are welcome going forward as well.

- *Mapping.* During the presentation it became clear that, once the clients realized the potential in mapping target areas, they had many ideas for more accurate ratings and desired factors. Therefore, they should communicate in advance the factors that they would like the mapping team to include in their map plotting. For instance, Isla Urbana can actually work well with areas of high rainfall, but this wasn't clear from prior usage statistics simply because they hadn't worked in the south of the country, where rainfall is much higher than in Mexico City. Sistema Biobolsa can work well in a wide variety of precipitation rates, except for the extremes. Counterintuitively, they also prefer to work where gas is already available, so that they can calculate savings. Both clients would prefer to use poverty statistics rather than unemployment rates, which are a poor proxy because of the "unofficial" economy, particularly in rural areas.

- *Pilot project.* The clients are interested in some kind of pilot project. We had explored Xochimilco during our visit, due to its high visibility and thus marketing potential, but decided to focus on other projects this year.

- *Data Management Program.* If the clients haven't settled on a good program for collecting and storing customer data by next year (see our suggestion for Comm Track in Appendix A), this would be a very useful product for them. Perhaps we could attract students with computer science expertise.

- *Intern program.* Professor Widder would like to secure funding for follow-up work to the project next year.

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