Mapping Kibera:

New Strategies for Mapping and Improving the Slum

ARCH 442 Middle East & Africa Seminar | Final Independent Research Report| Glen Stellmacher | W 2011

Introduction

Kibera is one of the world's largest slums. Its area of 225 hectares is split in half by a railway, and bordered by a dam, a golf course and housing complexes. Located in Nairobi, Kenya, Kibera is, "the densest, most populous slum in the city" (Warah 149). Its population is estimated anywhere from 190,000 people by the Nairobi government to over 1 million people by international NGO's. There are many problems in Kibera, relating to sanitation, access to food and water, overcrowding, pollution, education, health care, and secure tenure, but for the most part these problems remain un-quantified.

In his essay, "On National Culture," Frantz Fanon wrote of the native intellectual, who, "standing face to face with his country at the present time...is terrified by the void, the degradation and the slavery he sees there" (219). This is the point we are at now with Kibera. People, natives or non-natives alike, are scared of the degradation that they see when looking at the slum. Fanon also wrote that, "the truths of a nation are its realities" (225). Kibera is possibly one of the harshest realities of human existence, with problems like open defecation areas, the forcible removal of students from their schools, and the daily struggle to find sustenance. It's estimated that 54% of Kenyans will be living in urban areas by 2025, which means that there needs to be a concerted effort to improve the future quality of life of residents in the slum (Trondsen). If there is a solution to the many problems of Kibera, one must first analyze the

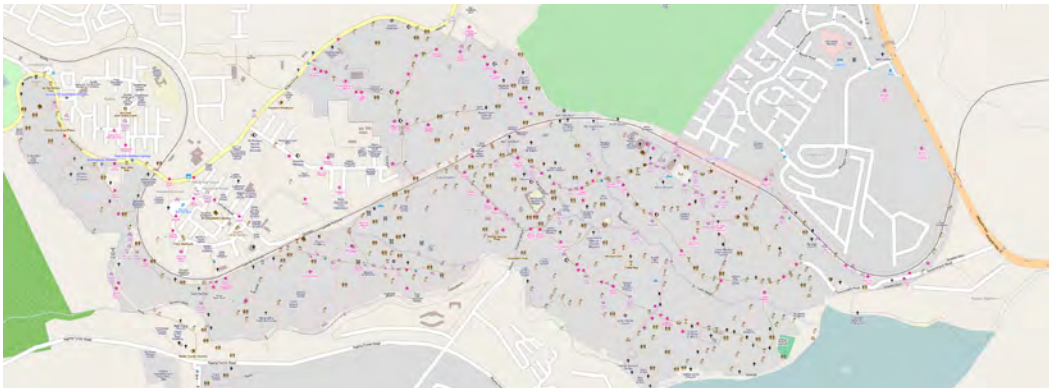
Photograph of an open defecation area within Kibera. <mapkibera.org/blog>

present realities. This paper will interpret these realities using the diagram of voronoi tesselation to quantify and unearth relationships that will further empower the people of Kibera and inform a new approach to slum improvement.

Map Kibera

This analysis of the present realities is the founding principle behind a new group dedicated to mapping Kibera. Map Kibera started in October of 2009 as a project between thirteen Kenyan youths ages 19-34 and a group of Kenyan organizations (Social Development Network, Kibera Community Development Agenda, and Carolina for Kibera), centered around the goal of addressing the "invisibility of up to 1 million of Nairobi's population" (Map Kibera). Kibera has largely been a blank spot of grey or green on most maps, graphically reiterating a general lack of understanding of the slum by foreign groups, as well as local residents.

Starting with GPS units, the youths spent three weeks marking points of interest in their neighborhoods, posting their coordinates on an open source map known as OpenStreetMap. These points of interest included water sources, toilets, health care facilities, food shops, barbers, schools, churches, and community centers, along with many other shared resources. Since the initial phase, the project has grown exponentially with numerous donations of computer equipment and volunteer time. Today, Map Kibera has started to carefully assemble a comprehensive set of maps for each



OpenStreetMap map of Kibera with infrastructure points pinpointed by the Map Kibera Project in 2009. <mapkibera.org>

of Kibera's 13 villages, with information on terrain, drainage, electricity supply, toilets, building materials, rent, population density, business distribution, schools, women, and marital status all being mapped by volunteers in the field.

Projects of this scale and level of refinement are extremely unusual in the mapping of slums. Traditionally, NGO's, the UN and national governments have taken the initiative to map slums, however, the Kenyan government's lack of recognition of Kibera has led to a unique situation where residents of the slum itself had to define their own boundaries and infrastructure. Kenyan social scientist Joyce Nyairo notes that there must be an effort to, "concentrate on unearthing the life that is lived in the gaps between official practice/discourse" (74). This is exactly what the Map Kibera Project is doing, mapping the real life that is unrecognized by the Nairobi government. By removing the maps from, "a set of privileged positions or from accustomed frameworks of use..there is greater latitude to get whatever exists in the market [ie. maps] into more expansive circulation" (Simone, 109). Other slum mapping projects around the world, and especially within India, have involved community interaction and fieldwork, however, the data is almost always processed through the umbrella of an NGO (EGM Slum Mapping 9). The use of open source technology is the perfect response to Kibera, as it is derived from the necessity to analyze reality, along with providing a source of community empowerment. In some sense, the Map Kibera project is a metaphor of the slum itself.

Members of the MapKibera Project working in the field. <mapkibera.org>

However marginalized by the Kenyan government, Map Kibera is certainly recognized as incredibly important by many international organizations. At an Expert Group Meeting on Slum Identification and Mapping (EGM) in the Netherlands, the International Institute for Geo-Information Science and Earth Observation (ITC), along with UN-HABITAT, and the Center for International Earth Science Information Network (CIESIN), concluded that, "field surveys by technical teams through community based approaches are important. Field surveys can be done rapidly with the right local resources and they contribute to the local information base in a very effective manner" (6). The meeting also concluded that satellite images are in no way a replacement for micro level planning (9) and that a process like Map Kibera's, "contributes to community empowerment by enabling them to be fuller partners in settlement upgrading and in the subsequent management of their community" (10). It is clear to see that the Map Kibera Project is incredibly important to the people of Kibera while also being a huge step towards discourse, recognition, and improvement; however, it is not the complete answer.

The Generation of New Analysis Techniques

The EGM also called for multiple methodologies, a, "high level of image processing" and a, "combination of approaches...to produce the best results" (6). This "combination of approaches" and "high level of image processing" is a key next step in inter-

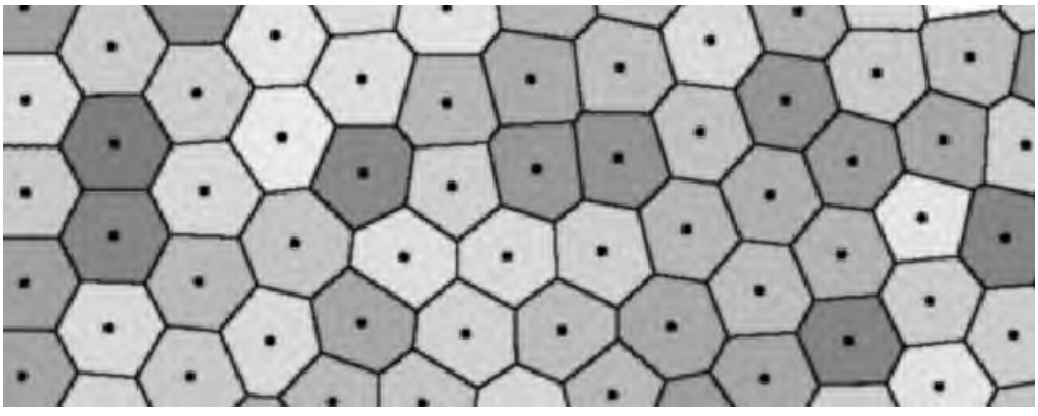
The extraction of knowledge from satellite and VHR imaging to form a graphic. *From CISEIN, UN-HABITAT, ITC, Expert Group Meeting on Slum Mapping report.

preting the data and information gathered by Map Kibera. As noted by the EGM and Map Kibera, the final goal is not slum mapping, but slum improvement. The question is, how can we take these comprehensive maps made by Map Kibera (MKB) and use this high level of image processing to form a framework for slum improvement?

In an effort to further the discussion on slum analysis and improvement, a new form of conceptualization was used to process and interpret data from MKB with digital tools to help form a framework for improvement. A metaphorical analysis of the slum typology as a natural evolution of structure led to examples of structural evolution in nature. Examples from dragonfly wings, fly eyes, and leaf structure were seen as good examples of a natural formation of structure and evolution. This led to the search for a way to geometrically define these natural processes of evolution, which concluded in the discovery of the Voronoi tessellation.

The Voronoi tessellation is used to describe the relationship of an area to a point. When a series of points is input into the equation, the output is a series of polygonal shapes. Each of these polygons, defined by a center point, is the area consisting of all points closer to the center point, in comparison to any other point on the map. The line segments defining the edges of each of these polygons are therefore equidistant between two points on the map. Using the Voronoi tessellation diagram as an analysis tool in mapping has been used before, and with incredible success.

Perhaps the earliest use of the Voronoi diagram was in 1854 when Dr. John Snow



Example of a Voronoi tesselation, or diagram. Each line of each polygon is equidistant between two points. < http://mrl.nyu.edu/~ajsecord/npar2002/html/stipples-img16.png>

needed to graphically represent areas surrounding different water pumps in London, determining the single point source of the infamous cholera outbreak of that year. Steven Johnson, a preeminent scholar on the mapping of the outbreak by Snow, noted the power of this mapping technique, "to solve problems if we listen to reason, listen to the wisdom of maps, [and] if we listen to locals who understand what's going on" (9:08). Contemporary uses of voronoi mapping have been used in conjunction with GIS (Beni Et. All; Lee & Breitkreutz). Using the Voronoi diagram in Kibera, a new set of maps can be created, in combination with the expert local knowledge of the residents of Kibera to form a structure for improvement.

To use the Voronoi diagram, a set of points is needed in which to define the polygons. Using the preliminary 13-week infrastructure mapping by Map Kibera as points created a new way of graphically representing the slum. Each polygonal region, defines an area served by a single infrastructure point. Smaller, lighter colored, polygons are regions within the slum that have better infrastructure access than the larger polygons. Using the definition of the Voronoi diagram, one can also see that new infrastructure must be placed on a line, and will have the greatest impact if placed on a vertex of three converging lines. These new diagrams are able to quickly convey the scope of infrastructure distributed throughout the slum and provide a reference point of where to provide new infrastructure.

What is not included in these diagrams are relationships to roads, arterials, train

Examples of Voronoi tesselations generated from infrastructure points on the OpenStreetMap. (Left): Voronoi generated from water point sources. (Right): Voronoi generated from toilet point sources.

tracks, terrain, other environmental factors or any analysis relating to other conditions. As a result, a second phase of Voronoi tesselations were formed, using more precise data of the Kianda village mapping phase. These new maps provided another layer of insight into the usage of the Voronoi diagram as a mapping tool. Voronoi tesselations were generated for water sources, toilets/baths, and businesses. These tesselations were then overlaid with maps generated by the Map Kibera Project of population density, rent per room and terrain. Conclusions from this second exercise clearly showed that businesses were largely distributed across areas of topographical significance, such as the high points along Kianda's northern edge, along with a depression that cuts through the south east of Kianda. These areas are also home to primary traffic routes. Areas with better access to water sources are generally also areas of greater population density. When overlaying any Voronoi with the rent map, one can see areas where low rent and high access to infrastructure are located, which are likely desirable places to live.

Perhaps another way to read the set of Voronoi diagrams is overlaid on top of each other, which produces a complicated web of polygons that might help to understand other aspects of Kibera. Many have written optimistically about the slum, noting that it's a,"site of immense opportunity and enterprise," (Warah 149) where resi-

Voronoi tesselations generated from infrastructure points in Kianda. (Left): RAW Voronoi generated from water point sources. (Center): Raw Voronoi overlaid with Kianda structures. (Right): Water source Voronoi overlaid with rent map of Kibera. Areas in green have lower rent and better acces to water.

dents, “maximize opportunity and livelihood,” (Simone 118) and where, “restaurants and business thrive” (Warah 148). Using the overlaid Voronoi diagrams of Kibera as a whole, one can see that Kibera is an immensely interconnected city, where food, water, toilets, leisure, and health care are all sporadically located throughout. This is in stark contrast with an American conception of a city, where hospitals serve many square kilometers, water and toilets are available in every home and business and supermarkets provide food for a large areas. The extreme interconnectedness of Kibera can now be defined by the Voronoi diagrams. These intertwined regions can also help to understand the level of community interaction in Kibera, where a person’s visit to each of their region’s different infrastructure points creates multiple opportunities for social contact and could possibly leave them more invested in a greater area of the city. The sense of investment in the community is key and leads to projects like Map Kibera. Compare this to an American city, where social opportunities are slim, and places like supermarkets seem large and out of scale for social interactions to flourish.

Slum Improvement

When beginning to conceptualize slum improvement projects, designers and community leaders must keep this sense of investment in the community and interconnectedness intact. Many projects throughout history have failed to understand their

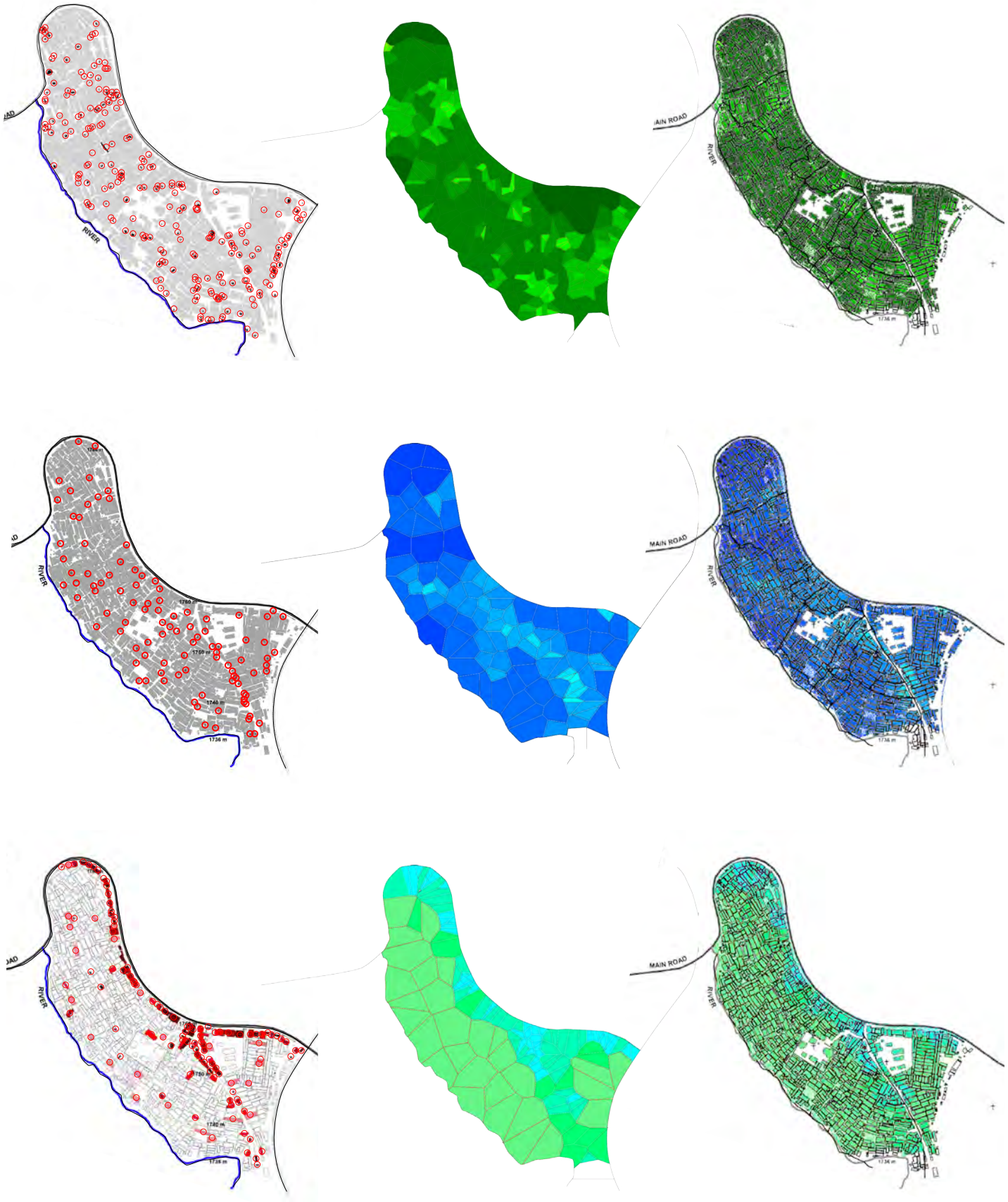
(Left): The overlaying of all five Voronoi tesselations for Kibera. (Right): Michel Ecochard’s response in Casablanca. <bertrandterlindeninarchitecture.wordpress.com>

context and relationships, and have failed because of it. Michel Ecochard's 1946 response to housing in Casablanca, for example, ignored, "variables of society, geography, culture, climate, and construction materials" (Rainbow 180). So called, "urban renewal" projects also fail, "for the reason that slums do have social structures, however misunderstood they may be" (Woods). Kibera residents also fear that "redevelopment" will, "leave them homeless," and lead to land speculation (Warah 149). New slum improvements must take a different approach from the past to succeed.

Architect Rem Koolhaas, argues that situations and habitats like Kibera are not poorly planned, they are a, "rational response to a dysfunctional scenario" (652). If designers and leaders can be inspired by this "rational response" and by the spaces formed in the slum, which, as Edward Said point out, "acquire emotional and even rational sense by a kind of poetic process," we as designers can intervene with a greater knowledge of the culture and climate in Kibera (Nyairo 73). This will lead to ideas based on real conclusions and infused with poetic process, which are the qualities of great architecture.

This brings the discussion back, full circle, to the mission statement of Map Kibera: "Without basic knowledge of the geography and resources of Kibera it is impossible to have an informed discussion on how to improve the lives of residents." Hopefully this new type of analysis using Voronoi tesselation can be used as a tool to further inform designers and interventionists on issues relating to relationships within Kibera, so that clear, informed action can be taken to improve the lives of residents.

Structures in Kibera. <http://affordablehousinginstitute.org>



(Top): The extraction and integration of knowledge through the processing of the Kianda map for toilets/baths (Left), to the RAW Voronoi diagram (Middle), to the Voronoi overlay of the structures of Kianda (Right).
(Middle): The same processing of the Kianda map for water sources.
(Top): The same processing of the Kianda map for businesses.

*All maps were generated from data from the current maps of the Kianda village found on < http://mapkiberaproject.yolasite.com/kianda.php>

Rent Distribution

Water Voronoi

(Top): The composite graphic of rent per room, overlaid with the water Voronoi diagram. Areas of green indicate areas where low rent and easy access to water are present. Darker areas indicate where rent is higher and water access is less convenient.
(Bottom): Map of comparative rents within Kianda on the left, where yellow is low rent, and dark red is high rent. On the right is the Voronoi diagram for water sources.
*All maps were generated from data from the current maps of the Kianda village found on < http://mapkiberaproject.yolasite.com/kianda.php>

Population Density

Water Voronoi

(Top): The composite graphic of population density, overlaid with the water Voronoi diagram. Areas of light green indicate areas where population is dense and access to water is good. Areas of darker green indicate a decrease in density, along with average water access. Dissregard areas of blue, as they indicate no density in the shelter. (Bottom): Map of population density within Kianda on the left, where yellow is a high density of people, and dark red is minimal population per shelter. On the right is the Voronoi diagram for water sources.

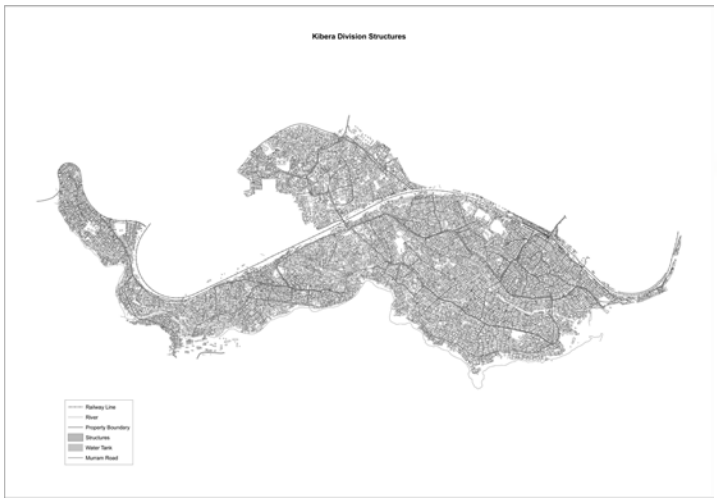
*All maps were generated from data from the current maps of the Kianda village found on < http://mapkiberaproject.yolasite.com/kianda.php>

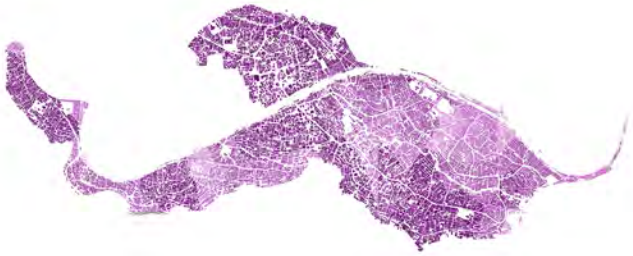
(Top): Overlaying infrastructure points for schools, water sources, health care, toilets, and leisure activities, with the OpenStreetMap of Kibera.
(Middle): An image of Kibera's 13 villages. < http://mapkiberaproject.yolasite.com/maps-and-statistics.php>
(Bottom): An image of Kibera's structures produced by Map Kibera. <www.mapkibera.org>






(Top, Left): Blank map of Kibera.
(Top, Right): RAW Voronoi diagram of Kibera's medical infrastructure.
(Middle, Left): RAW Voronoi diagram of Kibera's schools.
(Middle, Right): RAW Voronoi diagram of Kibera's toilets.
(Bottom, Left): RAW Voronoi diagram of Kibera's leisure activities, such as bars, hair salons.
(Bottom, Right): RAW Voronoi diagram of Kibera's water sources.
*All of these maps were generated from data from the current OpenStreetMap of Kibera on <MapKibera.org>

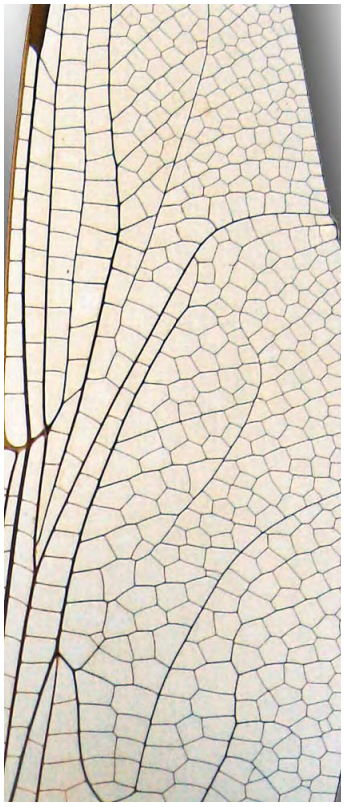


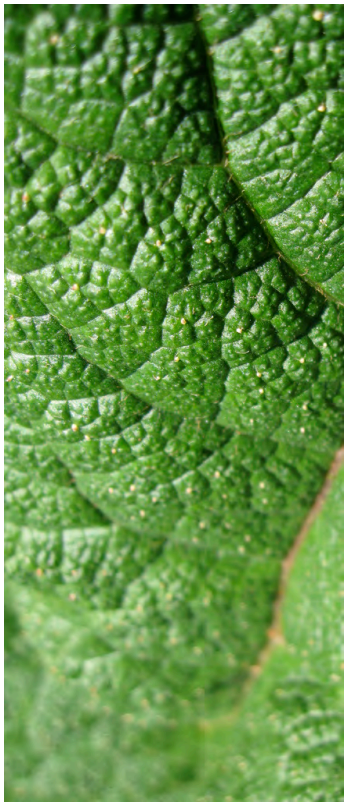


(Top, Left): Map of Kibera's structures. <MapKibera.org>
(Top, Right): Voronoi diagram of Kibera's medical infrastructure overlaid with structures.
(Middle, Left): Voronoi diagram of Kibera's schools overlaid with structures.
(Middle, Right): Voronoi diagram of Kibera's toilets overlaid with structures.
(Bottom, Left): Voronoi diagram of Kibera's leisure activities overlaid with structures.
(Bottom, Right): Voronoi diagram of Kibera's water sources overlaid with structures.
*All of these maps were generated from data from the current OpenStreetMap of Kibera on <MapKibera.org>

(Top, Left): Voronoi of Kibera's schools.
(Top, Right): Voronoi of Kibera's schools + leisure activities.
(Middle, Left): Voronoi of Kibera's schools + leisure activities + toilets.
(Middle, Right): Voronoi of Kibera's schools + leisure activities + toilets + water sources.
(Bottom, Left): Voronoi of Kibera's schools + leisure activities + toilets + water sources + medical infrastructure.
(Bottom, Right): Voronoi of Kibera's schools + leisure activities + toilets + water sources + medical infrastructure.
*All of these maps were generated from data from the current OpenStreetMap of Kibera on <MapKibera.org>

(Top): Example of poor sanitation conditions in Kibera. <http://www.flickr.com> (Middle): A boy mans a cooking gas stand in Kibera. < http://ipsnews.net/pictures/20080820_Kibera_HighRes.jpg> (Bottom): Volunteers of the Map Kibera Project organize themselves at a meeting. < http://www.flickr.com/photos/tags/mapkibera/>





(Top, Left): A water vendor in Kibera. <http://cleanwaterforall.files.wordpress.com/2010/11/kibera-low-res.jpg > (Top, Right): Rooftops in Kibera. <http://www.flickr.com/photos/tags/map-kibera/> (Left, Middle): A small shop in Kibera. <http://lh3.ggpht.com/_Z3rPXBhTJGo/S9tGlw-YwykI/AAAAAAAAJ60/IFylP3Bdjos/IMG_1820.JPG> (Right, Middle): A woman receives medical attention at a health clinic in Kibera. <www.flickr.com> (Bottom, Left): Cracking in sandy ground, revealing a natural Voronoi diagram. <www.flickr.com> (Bottom, Middle): A dragonfly wing, revealing a natural Voronoi diagram. <www.flickr.com> (Bottom, Right): A close up view of structural formation of a leaf, revealing a natural Voronoi diagram. <www.flickr.com>

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