Toward Open Source Kenya: Creating and Sharing a GIS Database of Nairobi

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Abstract:

In order to make good decisions about the future direction of cities we need data to contextualize and make recommendations that are based on past results and potential models for the future. Yet access to information including GIS is challenging, particularly as data is often seen as a commodity or source of power by those who control it, a dynamic more severe in contexts like Kenya. By generating GIS data for our own transportation model and then sharing it with those interested in doing research on Nairobi, we experienced firsthand some of the power dynamics associated with accessing and generating information in the developing country context. The project had several important lessons: 1) Simply developing data does not make it open, how "open access" is provided to the data is just as important as making it freely available 2) Developing data can show commitment to a particular place or project that can help generate support for stronger partnerships and project goals; and 3) Openly sharing data about place might help push those with access to information to share information as well. Overall this research project illustrated that sharing data can help support a more open access eco-system locally by establishing a culture of data sharing, but only if those interested in using it have the technical ability to both access and use data sets provided.

Key Words: GIS, PPGIS, Nairobi, Kenya, Data Sharing, Developing Countries, Spatial Data, Community and GIS, Empowerment, Power Dynamics

Background and Introduction

In this paper, we share our experience of the challenges involved in trying to acquire a Geographic Information Systems (GIS) database in Nairobi, Kenya and how key actors who possess data create barriers to information access. Our response to these challenges was ultimately to generate our own dataset and disseminate it to anyone interested in using it. This case study thus illustrates the critical value of sharing data as a way of cultivating and encouraging a broader ethos of sharing (Craig 2005) and also building better local partnerships. This case study also clearly reveals how "locally, contingent and complex social forces" are involved in the creation of GIS (Harvey and Chrisman 1998, 1683) and reveals some of these particular forces and dynamics in an African city. Finally, this case study demonstrates how the production and dissemination of datasets creates what Harvey and Chrisman call "boundary objects" or new forms of power relations between those who control and use the dataset versus those who have limited access to the possibilities it offers (1998).

The process of both trying to acquire a GIS dataset and then build a new one vividly illustrates the power dynamics associated with access to information for urban planning and development work. To achieve our goals we worked with outside researchers (academia), local researchers and think tanks, consultants and international development agencies interested in governmental contracts, technology firms, civil society and the Kenyan governmental itself. Each group had its own agenda for control and dissemination of information about Nairobi. Our project started with the development of a GIS database for our own transportation modeling and planning analysis because we were unable to obtain a dataset from the government or private sources. However,

we realized that the data we created could be useful and powerful to share with others working in Nairobi and we hoped it would encourage an ethics of sharing among some of the actors (Craig 2005). Our own internal shift in understanding the power of the data reflects the arguments associated with production of this type of knowledge by Harvey and Chrisman (1998) among others (Harvey 1998; Elwood 2002; Sieber 2007; Elwood 2008). Ultimately, we hoped that by providing free and open access to data for Nairobi, we had an opportunity to contribute to a small but growing movement around opening access to data, including GIS data, in Kenya.

Our narrative of data creation and dissemination shows our own shift in understanding of the potential power of the GIS database. Initially, we saw it as a tool for modeling and research, but as we deepened our action research agenda in Nairobi, we realized that the construction of the spatial data and our willingness to share it widely showed our commitment to an action research agenda with our partners in Nairobi. Once we viewed the GIS data in this way, the logical next question was how to disseminate it in a manner that would provide more actors trying to improve urban planning in Nairobi with the tools they needed to do so. Here too, we experienced obstacles to the data's effective use, including the fact that simply making data available does not necessarily mean that stakeholders have the capacity to use it. However the work ultimately had many positive results including a more open relationship with our partners and the beginning of an increased community of data sharing amongst the actors we were able to reach.

Geographic Information is Political

It is no surprise that geographic data is highly political. There is a great deal of literature that explains why maps are powerful tools that can serve specific interests and represent different ways of conceiving, articulating, and structuring the human world (Harley 1988; Wood 1992; Havery 1998; Elwood 2002). Because they represent "privileged and formalized knowledge," maps are both the products and creators of power (Kitchin et al 2009, 9), and the mapmaker has a great deal of power in depicting data and information. Varying representations of the same data in maps can reveal and convey very different information (Wood 2010; Monmonier 1996). Ultimately the ability to effectively use this information can be both empowering and disempowering for communities (Elwood 2002).

The power relations involved with Geographic Information Systems are complex because GIS, like many other technologies, appear to have the ability to both marginalize and empower different populations depending on who uses GIS and for what purposes within existing socio-political and economic dynamics (Harris & Weiner 1998; Lupton 1997; Elwood, 2002). GIS that empowers communities have been labeled as "Public Participation GIS" (PPGIS) (Sieber 2006). PPGIS was originally defined as ''a variety of approaches to make GIS and other spatial decision-making tools available and accessible to all those with a stake in official decisions'' (Schroeder 1996, 28). Recent PPGIS literature addresses how "geospatial collaboration" can empower or mobilize communities around a specific policy issues, emphasizing justice for marginalized populations. (Craig, et al 2002; Elwood 2002a, 2002b; Elwood and Ghose 2003, 2004, Baily and Grossardt 2010).

In PPGIS projects, GIS is often used by community groups to gain legitimacy in decision-making processes because most information used in policymaking, including crime, land use planning, conservation, and service provision, contain a geographical or spatial component (Sieber 2006). It can be argued that when these groups effectively engage spatial data and analysis in their efforts, they have more power in political and civic decision-making processes (Elwood and Leitner 2003; Bailey and Grossardt 2010). Non-governmental organizations (NGOs) and community groups are increasingly using PPGIS to improve local decisions and enable local-level analyses to be shared and thus influence national-level policies (Alcorn 2000; Rambaldi 2004).[1] Community-based organizations are using GIS to increase their effectiveness in neighborhood-level organizing, planning, and problem solving (Sawicki 1996; Kellogg 1999, Elwood 2002, Ghose 2007).

Empowerment derived from Participatory GIS is dependent on the process but also the geographic decision making tools or GIS systems developed to allow for that collaborative process. Whether the tools give access to information/data or provide the ability to analyze geographic knowledge many would argue the systems developed for participatory GIS have their own science. (Jankowski and Nyerges 2001; Elwood 2008; Baily and Grossardt 2010) Research looking at these tools is referred to as Participatory Geographic Information Science or P-GIS. P-GIS focuses on the methodologies used to incorporate stakeholder values. (Jankowski and Nyerges 2001). P-GIS literature looks at how GIS might improve knowledge transmission from participants to experts (e.g.,Hopfer and MacEachrean, 2007). It also looks at how the use of GIS might affect organizational culture through it adoption and systemic use (Cai et. Al. 2006). Other P-GIS research looks at how groups can experiment with new uses of GIS that allow for

collaboration. (Nyerges et al 2002; Voss et al. 2004; Jankowski et al. 2006). P-GIS illustrate how Geographic Information Systems themselves affect participatory results and community empowerment. Our work creating and sharing a GIS database for Nairobi falls into both areas of research because we created both a tool and process for decision making using that tool.

How GIS data is accessed and produced influences its role in policy and planning processes. Often, when community groups have GIS data, they derive or obtain it from a variety of sources, including government offices, intermediary institutions, and other community groups, depending on the context (Elwood and Leitner 2003; Sieber 2007). As we experienced and will explain later, many organizations face difficulty in obtaining GIS data (Elwood and Leitner 2003). Further, when data is obtained, it was often originally produced for another purpose and thus may not be appropriate for a community group's specific needs, or data may require significant modification (Ghose and Huxhold 2002; Elwood and Leitner 2003; Warren 2004; Elwood 2008). How data is organized (e.g., classification or aggregation) may also be project-specific, which can present problems when sharing data between organizations. Finally, data format may also influence and organization's ability to share and obtain appropriate spatial data (Sieber 2007). Sieber (2007) found that the ability of community groups to access appropriate and useable data heavily influences community groups' activities, and occasionally "shifts or precludes activism."

Whether data was created through a participatory process or not, access to GIS data remains a key issue when working on urban planning and development projects. "Access" is defined by context, connectivity, capabilities, and content (Laituri 2003), and when one of these components is missing, potential users do not have access. Harvey and Chrisman usefully draw attention to

"boundary objects" or new forms of power relations between those who control and use the dataset versus those who have limited access the possibilities it offers (1998). Indeed, the tools to maximize the power and potential of GIS are expensive, limiting those who can ultimately benefit from them; Harris (1995) notes that the establishment of a GIS database and all its requirements including hardware, software, and trained personnel, can be an impediment to its widespread proliferation. Consequently, as we would discover in our case, GIS technology is often limited to state agencies or large private corporations, and these agencies and corporations have discretion over the access to that data (Harris 1995). This creates a problem for downward accountability to citizens, particularly in peripheral areas, where technology remains inaccessible and limits communities' ability to use it for planning and development (Obermeyer 1998; Rambaldi et al. 2006).

The dissemination and creation of GIS databases has been contentious because of the role it plays in empowering some and disenfranchising others (Schuurman, 2000). Given these power dynamics there have been efforts throughout the world to increase the availability of spatial data for more community-based initiatives and more inclusive and transparent planning through collaborative GIS and geographic data sharing agreements (see Balram 2006; Onsrud 1995, for example). These collaborative data-sharing entities or Spatial Data Infrastructures (SDI's) allow for sharing and access of data across different organizational and governmental entities (Groot and McLaughlin 2000; Elwood 2008). SDI's are typically developed through governmental mandates to encourage collaboration or data sharing between governmental entities. (Harvey and Tulloch 2006) However there are bottom-up SDI's that have been developed to help those holding data about a particular place share their information. The prevalence of bottom-up or

privately developed SDI's has increased in the last few years as many private organizations realize the benefits of creating a shared resource where the government has not been able to create that resource. (Rajabifard et al 2006).

Access to GIS data helps grassroots organizations be involved in planning process, but research has shown that having data access alone does not necessary guarantee a role in the policy process. (Craglia and Masser 2003; Onsrud and Craglia 2003; Tulloch and Shapiro 2003) Social and cultural institutions also influence the level of access to and participation in PPGIS (Aiken and Michel 1995; de Man 2003), and social networks and cultural practices and expectations shape these institutions (Kyem 2004). Institutional conditions and factors shape how effective any PPGIS exercise will be at influencing societal outcomes and public processes (Kyem 2004). And, local political context, which includes various actors and institutions, shapes the process of participation and PPGIS production (Ghose and Elwood 2003). Some research shows even with the development of SDI's communities still rely on their social and political networks for accessing and updating information (Harvey and Tulloch 2006).

Even with these efforts significant challenges to making free and reliable spatial data available and useful in urban planning and development and policy-making processes exist. This is particularly true in developing countries, where the development of SDI's has been difficult because of technological barriers, funding issues, and governmental and political capacity to build these structures (Nkambwe 2001). In addition, accessing official GIS data in these countries can be difficult, if not impossible, as governments often tightly guard data, if it exists at

all (Bishop et al 2000). This is not surprising because geographic data, especially as it relates to land and claims over property, are often highly political.

The inter-related problems of accessing GIS technology and establishing sophisticated spatial data infrastructure are often more prominent in low-income countries for a variety of reasons (Bishop et al 2000; Burke 1995; Makanga and Smit 2010). For example, developing countries tend to lack standard guidelines and laws for land registration, planning, and land management, making it difficult for them to establish standardized SDIs (Bishop et al 2000). Land records are sometimes deliberately left in disarray (Klopp 2000). This stems from the colonial inheritance of multiple legal systems and flawed and exclusive planning systems that continue to serve the more powerful and hence are difficult to reform (Njoh 1998; Myers 2003).[2] In addition, typically, those who possess GIS skills, data, and technology (a smaller pool of people in the developing world context) are often those who work for more powerful entities; the less-skilled are disadvantaged are thus often easier to control (Klopp and Sang 2011; Sieber 2006).

Another barrier to spreading GIS and developing open SDIs worldwide is the commoditization of spatial data. Raw electronic spatial data appropriate for GIS is often legally restricted with copyrights and licenses. Copyrights grant exclusive rights to publish, and licenses govern access, cost, and use of data (Sieber 2007). When protected by copyrights and/or licenses, data access is often restricted, often to data sellers (Day 2004 in Sieber 2007). Thus, through mass production and marketing, spatial data becomes subject to market forces and hence available only to those who can afford it. This can often lead to global as well as local inequities in access. Although the data may be promoted as something that is "general purpose," because it is a

commodity that can be bought and sold, it is often produced to serve a particular constituency (McHaffie 1995; Sieber 2007). Often this constituency has the resources to pay for GIS services, excluding many who do not have access, and the interests and agendas of the buyer influence the product. The marketing of GIS data in this manner also assumes that GIS data produced for one purpose may be appropriate for an often entirely different purpose (Sieber 2007).

The commodification of data is also problematic in developing countries, where the cost of developing the data is often high or prohibitive. Once developed, the data becomes a commodity for the government or entity who created it and maintains control over it storage and dissemination (Openshaw and Goddard 1987; Thakur and Sharma 2009). This relates to GIS and Society arguments, as access to spatial data can be limited by those in power simply because they have the money to purchase or pay for the development of GIS systems. To deal with this, PPGIS advocates posit that the development of data by local communities can help alter the relative power that the traditional producers of GIS data hold, while at the same time challenging state priorities and creating new space for local groups to influence neighborhood change (Elwood 2001, 2003). Finally, the movement towards free and open source software for GIS and towards open access GIS data is helping to counter the complete commoditization of this valuable data (Makanga and Smit 2010, 25).

Despite the many barriers, there has been a push to promote the development of GIS and SDIs in Africa. Although this is changing, GIS data development has typically been performed by NGO's, academics, or outside contractors. After these organizations leave their project site, local institutions often struggle to use and maintain the files generated by the external entity

(Crampton 2009; Dunn et al. 1999, 328). According to Weiner (1999), this lack of capacity after an NGO or other external body stops work is widespread. In fact, in most developing countries the "establishment of a spatial technology infrastructure is dependent on external funding or temporary support received through aid projects often introduced with a view to demonstrate the use and need of technology" (Thakur and Sharma 2009, 133). Thus, when the financial support ends, so ends the licensing of software and the motivation to maintain the initial efforts also disappears. Thus, sustainability of these efforts around GIS and SDIs is a key issue, although it is interesting to note that regardless of the barriers, over the last two decades Africa is moving towards "the rapid adoption and proliferation of GIS with potential to influence and shape the way in which society views, values and uses spatial information" (Koti and Weiner 2006).

Geographic Information in Kenya

Even though Kenya, one of East Africa's largest countries, is recognized for having a thriving Information Communication and Technology (ICT) sector, it faces the typical problems and dynamics around GIS and SDI more generally. A shortage of spatial data and information, especially openly accessible data exists, and while the government has an official e-government strategy (Republic of Kenya 2004), it does not have an official policy or strategy around spatial information and infrastructures. Where spatial information required for urban and development planning (physical and climactic features; population and demographic characteristics; economic activities; transport and communication; infrastructural utilities; social services; land ownership, tenure, lease, size; etc.) does exist in Kenya, it is often outdated or suffers from limited scale and inconsistent jurisdiction and spatial area unit, and is often stored under poor conditions with

limited access for those who might need it (Omwenga 2001). This lack of freely available and up-to-date spatial information in Kenya has severely limited the ability of jurisdictions (cities, municipalities, towns, and urban councils) to prepare development plans (Omwenga 2001).

Reinforcing observations made by Harris (1995), access to GIS and geo-spatial databases in Kenya "the central government, large municipalities, local and international research institutions, and donor funded and individual projects" primarily have access to GIS data (Koti and Weiner 2006, 1). The Kenyan government claims it would like to increase the use and development of spatial data. However, currently, it does not always make GIS data easily available for its own planning professionals at lower levels of government. The Survey of Kenya is taking a lead role in this initiative and the latest Kenyan census used GIS. It was also able to insert the Kenyan SDI into the National Development Plan for 2002-2008, thereby mandating resources at the Ministry of Lands and Settlement, towards the development of a national GIS system.

Overall, despite the active technology community, growing numbers of local GIS experts and new teaching programs[3], Kenya's development of GIS and national spatial data infrastructure is still heavily dependent on donor projects and funding. For example, the Kenya National Spatial Data Infrastructure (KNSDI) was launched in order to "facilitate the capture, storage, conveyance, and display of geographical information" (Murage, et al 2008).[4] KNSDI held five workshops between 2001 and 2006 aimed at creating awareness around spatial data and its importance, and also to create a central spatial data clearinghouse (Murage, et al 2008), which has in fact happened making Kenya one of the few African countries to have one in operation (Makanga and Smit 2010, 24). Beginning in October 2006, Japan International Cooperation

Agency (JICA) provided further technical assistance to the KNSDI program. The aim of JICA's involvement was to: 1) formulate standards for KNSDI; 2) enhance the Government of Kenya's competence in map digitization; and 3) develop resources for GIS dissemination in Kenya (Murage et al 2008). NSDI standards, digitization manuals, and guidelines for facilitating data sharing were successfully completed. However, the broader objective of promoting the use of GIS in Kenya remains to be achieved.[5] It should be noted that the development of this spatial data infrastructure was largely contracted to JICA, which left Kenya with many of the problems associated with the development of SDI's in a developing country context: limited capacity once the agency that the develops the infrastructure leaves or is no longer involved (Massar 2005).

More recently in July 2011, the Kenyan Government launched the Kenya Open Data Initiative. The initiative makes government development, demographic, statistical, and expenditure data available in digital format on a website.[6] That data is intended to provide a "platform for innovation" that will produce more efficient outcomes in terms of service delivery, job creation, and citizen feedback systems; enable data-driven and better-informed decision making processes; and improve transparency and accountability in all government operations (opendata.go.ke). The website features over 160 datasets, including the 2009 census. Although the data isn't specifically "spatial," raw data is available for download and much of it can be depicted spatially.

Despite this initiative, major hurdles exist in terms of accessing GIS and other forms of data for Kenya. Government agencies do not wish to release existing data for sharing (Wahitu 2012) and sometimes, in any case, do not have good data to share (Omoto 2012) or do not have it in a very

user-friendly format. More recently, attention has been drawn to the need for a legislative framework to facilitate greater openness, give life to the right to information which is part of Kenya's young 2010 Constitution, and formalize the relationship between "government agencies and those in charge of the information" (Kenei 2012, 9). Furthermore, a growing recognition exists that a broader network of actors or eco-system is needed that includes civil society (Kenei 2012, 10). Indeed, this might help create an environment that enables more "white knights" or "people with the vision and motivation to convince an entire organization to adopt GIS technology and share it" (Craig 2005, 5). Currently, given the reluctance of the government to share data and also the actual lack of critical data including GIS data, more technology firms, researchers and civil society groups are taking up the challenge. In July 2011, for example, a technology firm Upande Ltd, Wildlife Clubs of Kenya, Jacaranda Designs Ltd and the International Livestock Research Institute (ILRI) in alliance with a global NGO, the World Resources Institute launched Virtual Kenya, a platform for aggregating spatial data on Kenya. The aim is to increase data sharing and spatial analysis for decision-making and development planning.[7]

Although conditions are clearly improving, finding usable spatial data for the Nairobi area remains difficult. This may in part be due to the fact that there is no longer an allocation for the KNSDI in Kenya's National Development plan, thereby making it hard to continue to dedicate resources that would allow for the dissemination of this information and efforts instead fall on groups like Virtual Kenya. While low-quality, downloadable maps and other information are available on the KNSDI website, raw data is not available. While the data available on Kenya's Open Data Initiative website holds great potential in providing open access to information, the

web site has just been established and much of the data is not inherently geographic or is provided at a regional scale, which makes it hard to use for local planning projects. At the same time KNSDI does not have the online infrastructure to purchase or download data. It is possible to obtain spatial data through the Survey of Kenya, yet this is still limiting because of the cost and the strict licensing agreements involved with obtaining this information.

From a Transport Model to a GIS Map for Nairobi

In fall 2006, with funding from the Volvo Research and Educational Foundations (VREF)[8] we engaged partners at the UC Berkeley Center for Future Urban Transport and the Kenya Institute of Public Policy and Research Analysis (KIPPRA) to help us examine Nairobi's transport system. We started with a preliminary transportation and land-use model of the metropolis and using it to develop a macroscopic traffic simulation model. The traffic simulation model would then be used for scenario analysis and to help identify a course of action to improve the efficiency of Nairobi's notoriously problematic transport system that suffers from high levels of oil dependency, poor mass transit, high levels of traffic crashes, poor air quality and severe congestion (Aligula et al 2005; Republic of Kenya 2010; Klopp 2011). Specifically, teams from our center and UCB aimed to use the traffic simulation model to assess current traffic conditions in the Nairobi metropolitan area (NMA), including average vehicular densities and travel times.

The UCB team wanted to be able to provide an assessment of future traffic conditions under different scenarios: if nothing is done versus undertaking certain congestion mitigation strategies such as restricting motor vehicle access to the central business district or bus-only lanes. This assessment would then be shared with KIPPRA, who would incorporate existing data on buses

and other shared-use vehicles, such as matatus (small 14 seaters), at different times of the day. Our research team would be responsible for finding the best fit between possible transportation system strategies and implementation issues as well as engaging a network of policymakers in discussions around the different scenarios. This involves recognition of the need for a multi-level approach and discussions at all levels on policy, institutional and governance reforms, and management and oversight of the transportation system. Ultimately, this work was meant to provide leverage for much of our policy work that focuses on encouraging sustainable policy and planning approaches in the Nairobi metropolitan area.

Acquiring GIS data for Nairobi for the purpose of the transportation study proved to be a delicate matter. Our research team had identified an existing set of GIS data that was developed by JICA and owned/controlled by the government. However, when we approached the Survey of Kenya for JICA's GIS files developed in 2006, we were told the cost would be $50,000 USD and the files came with strict restrictions on sharing that data with our partnering institutions, including those in Kenya. These terms meant that it would be impossible to use this data for our purposes. Specifically, we needed to be able to share the data with at least three to four partners, which means we would be required to pay the full costs of the dataset three to four times, putting the cost of the dataset at $200,000. Even with that cost, if we included another partner or shared the data again it would continue to cost $50,000 each time. Therefore, we needed an alternative solution; the cost of accessing the data was simply too high. Overall, we found that obtaining information and maps from government offices, both local and central, to be a disorganized process in Kenya even after the development of the KNSDI.

JICA was contacted about the possibility of obtaining data for the project, but was not interested in sharing the data for our research purposes. While it is hard to speculate whether JICA was interested in the work we were doing or not, ultimately they cited contractual issues with the government as precluding them from sharing the data set. It should be noted that JICA is in competition with other development agencies and promotes its own transportation and consulting firms within Nairobi and across the developing world.[9] In many ways this would account for why they would align themselves with governmental practices of control over the data set: this position also provides control to JICA which then has the capacity to realize the full potential of the analytics provided by the data.

While JICA retained control of the GIS dataset the Survey of Kenya allowed us to use scanned geo-registered version of their official maps, also produced by JICA, to create digital maps for our transportation model. These maps represented on-the-ground conditions in 2003 and were published in 2005. A team of trained graduate and undergraduate students at our center's university used these maps to trace/digitize land features into GIS files. These Columbia University students were funded directly by our center through a grant from the Volvo Research and Educational Foundations.

Our research partners worked closely to identify the attributes that would be needed for the land use and road network GIS data files.[10] The scope of work originally only included the development of the road network file, but once the team realized that there was some ability to glean density and land use information from the base maps, the development of these attributes were included in the GIS database development. As we created the land-use file we realized that

the amount of buildings on a site might help to measure the building density of an area, and density information could then help us approximate the number of trips generated by a particular place. We determined density figures by counting the number of buildings per acre on each land parcel. We also developed general land use categories, because the detailing on the JICA maps helped to provide some clues into land uses.

INSERT FIGURE #1 and #2 HERE

The creation of the land use shapefile involved the digitization of the original Survey of Kenya base maps. Polygons representing the various land uses denoted on the original Survey of Kenya maps were drawn and assigned a land use category. Land use categories included commercial, industrial, institutional, mixed commercial-institutional, mixed commercial-residential, no-structures, recreational, residential, residential-"slum", open space, transportation, water, unknown. The definitions for these categories were created for the digitization process and were obtained from reading the land uses marked on the Survey of Kenya maps. For example "residential-slum" was delineated and marked on Survey of Kenya maps as a land use type, and where this was written on the map we generated a polygon and categorized that polygon as "residential-slum". Where land uses were not marked on the on Survey of Kenya maps an "unknown" category was given to the land divisions. The maps did not include official parcel boundaries, but JICA did create delineations of land masses using a dotted line and these borders were used to create the polygons for the land use map. Depending on the amount of information provided by the original map, a more specific description and/or official name were added to the polygon in the attribute table. This further information could easily be translated into points-of-

interest data. The number of buildings contained within the land use polygon was then counted, either individually or by determining an average building per acre. Because lot lines and parcel boundaries were not always clearly indicated on the original map, we created polygons using these boundaries as only a loose guide.

INSERT FIGURE # 3 HERE

The creation of the roads network GIS file involved much of the same process as the development of the land use files. Street centerlines were digitized by tracing the original Survey of Kenya maps and measuring width to add to the attributes table. Street centerlines are network-based GIS files that are the standard for use with transportation models and can have a number of attribute fields including speed limit, traffic signals, average traffic flow. The data we developed only had information about width and road category because we had limited information on traffic rates. The road categories were taken directly from the Survey of Kenya JICA map categorization included: main road, bitumen (minor road), earth (dirt road), other tracks, footpaths, and main tracks. Depending on the amount of information provided by the original map, an official name was added to the attribute table. We then measured the width of the road in meters on the original map and also added an attribute table. Lastly, we identified several road obstacles and added them to the attribute table. This was needed because several roads were completely impassible even though they appeared to be through streets. All of the map and attribute information was gleaned from the Survey of Kenya paper maps to provide consistency in the way the data was produced through-out the maps. [11]

INSERT FIGURE #4 and 5 HERE

Once the data set was complete the UCB team set out to study traffic conditions in Nairobi by developing a CORSIM module that uses street networks and intersection to observe "the evolution of congestion" based on different demand scenarios (Gonzales et al 2009, 10). CORSIM simulates behavior of individual vehicles through predicting the impacts on traffic patterns from implementing changes to the road network or through an increase or decrease of traffic volumes. The module makes it possible to identify a relationship between existing road conditions and the impacts of increased travel demand (Gonzales et al 2009). The study revealed that Nairobi has a predictable macroscopic fundamental diagram (MFD). That is, the relationship between the accumulation of vehicles on a street network and the ability of the network to serve the number of vehicular trips is predictable (Gonzales et al 2011). Further, this relationship is reproducible, as it is consistent at different levels of demand. More broadly, the UCB study showed, perhaps unsurprisingly, that as population in Nairobi increases, so too does vehicular traffic, which increases the demand on the road network. The goal of the project was to help quantitatively and visually support claims that showed the increased travel demand would create increased gridlock on Nairobi roadways. The model produced evidence to support this claim, which the research team hoped would help influence much needed changes to Nairobi's transport system.

Sharing the Nairobi GIS Database

After sharing the GIS database with our Kenyan partners including KIPPRA and the University of Nairobi we realized that the map not only had value to our work in Nairobi, but that it might also have value to others doing work in the area. This realization was heightened when Google asked if we would share the data to enhance their Points of Interest (POI) data for their Google Map of Nairobi. For KIPPRA, the data was largely used to understand possible associations between land use patterns and Nairobi traffic survey data that they had collected (Salon and Aligua 2011). According to KIPPRA, the data was also useful in enabling "a better visualization of the land-use patterns on the ground." Towards this end, the maps have been used for drafting policy reports (Personal Communication with Eric Aligula, KIPPRA March 2011). The data was also useful in a transportation modeling study conducted by a member of the young professionals program of the infrastructure and economic services division at KIPPRA. Interestingly, we did not find out that the data was used for this purpose until a year later, when we discovered that the individual had simply "found" our land use data on a disc in KIPPRA's offices (Personal Communication with James Gachanja July 2011). After we discovered this, we knew that formalizing that data-sharing process had been a valuable endeavor, and that the GIS data could have great value if more widely and systematically disseminated.

Although we cannot say this definitively, we suspect that sharing the GIS data with KIPPRA gave them a reason to more freely share some of their data with us, namely, Nairobi traffic survey data. Data exchanges with KIPPRA went more smoothly after the Nairobi GIS data files were shared with them. Until that point, our research center had largely depended on KIPPRA

for much of the data used for transportation and policy analysis. Early on discussions between the two organizations about access to data were often strained, as motives behind the research and the terms of the partnership were not always well understood. We believe that KIPPRA saw the potential for using the data with their traffic survey data and was perhaps more willing to collaborate on data sharing. The initial sharing of the GIS map was based on the ideal that each organization brings its own data and shares it with others in an effort to collectively solve a common problem (Pinto and Onsrud 1995) and promotes an ethos of sharing (Craig 2005). This helped reinforce that message that we were seeking a more equal basis for collaboration in examining Nairobi's transport problems. While our transportation model for Nairobi did not start as a participatory GIS project, the boundaries shifted, and the data access we enabled provided for a more collaborative analysis and decision making process with our partners, akin to a Participatory GIS.

In order to disseminate the data beyond KIPPRA, we realized that a more efficient and formalized system to share the data would be necessary. To facilitate the data-sharing process, our research team created an online wiki space through an existing interface within our center's home university known as "wiki scholars." This wiki space would allow for download of the data files and public discussion on data quality and possible uses for it. Our decision to make the data available in a wiki space stems from the fact that the wiki scholar interface already existed within our university's information technology services. Many of the features we wanted for the dissemination of the data (discussions, commenting, etc), were already in the system. Thus, it made the most sense to take advantage of it and experiment with it. We have since learned that there is some precedent for making data available through online wiki spaces, although most of

the existing and well-established approaches, such as Freebase[12], are top-down, and few efforts exist at the grassroots level (Benson et al 2010). While in many ways the wiki space provides an easy way to allow people to download the data, ultimately we believe that because it was not initially directly linked to other data sharing initiatives in Kenya we did not reach many of the people we had hoped to engage. While this might not have been directly a result of the wiki format, it does show connections with existing data communities are important for the dissemination of this type of data. In some ways we created our own boundaries to data access by working within our own knowledge base and not initially reaching the broader Kenya open data community. [13]

While anyone who finds the website is free to download data, at the beginning when we posted the data, we required users to register to the wiki space so that we could track use. At this point, the Nairobi GIS data wiki has been functional for over two years and requests have largely come from other academic institutions, NGO's, or students interested in doing work in Nairobi. As of June 2013December 2012 it has 65 registered users, a substantial number in Kenya, and we are exploring ways to increase availability and use of the data. People who initially came to the site did so through a reference from our center or one of the partnering institutions, although it appears that more people are finding the data through Internet searches. In October 2011, we also partnered with Virtual Kenya, which posted our data on its platform, no doubt increasing its accessibility to a group with the skills and knowledge to use it. Indeed, James Gachanja, a junior professional officer at KIPPRA used the map to enter a Virtual Kenya competition that he subsequently won along with two other entrants. In his words, "the GIS land use database for Nairobi is a great initiative. It holds the key to solving many planning issues especially

monitoring development control and guiding urban development policy."[14] (Personal Communication James Gachanja December 14, 2012).

Most of the participants registered to download data from the wiki site have academic affiliations, and a large portion of these academics have been students interested in investigating or exploring issues in Nairobi. While we are excited about the number of people who have already downloaded the data it is clear that we are not reaching many of the people we would like, particularly community-based policy and planning groups in Nairobi. Our early perception was that those agencies doing community and urban development work in Nairobi would be eager to use this kind of data. However, that has not been the case, most likely because most fall outside of the "boundary object" for various reasons. In other words, simply building a GIS dataset does not necessarily mean that it will be used. There continues to be institutional and technological barriers that make access and use of the data for political process hard to achieve. (Harvey and Chrisman 1998) Had we made a better attempt to work with in those structures, perhaps by publicizing it existence to the various stakeholder the possibilities for it use might have grown. It is not enough to create a delivery tool for participatory data sharing without engaging the community in which it serves. Overall, more publicity and networking for the GIS data are required to continue to spread the use of the data.

Conclusions :

Our process of developing and ultimately disseminating a GIS database in Nairobi illustrates the inherent boundary relationships created when these types of systems are developed. (Harvey and

Chrisman 1998) The power dynamics are complex, because they involve foreign and local researchers, development agencies, technology firms, civil society, consultants interested in governmental contracts, and the Kenyan governmental itself. As one might expect each one of these groups has their own agenda for control and dissemination of information and GIS data. As we developed our research we had to negotiate and navigate within this political landscape to develop a dataset that would allow us to work with our partners aiming to make informed decisions about Nairobi. However the ability to perform the analysis was not the only result of our research, as the sharing of the data ultimately showed that we could begin to change our relationships with Nairobi partners (KIPPRA). Sharing the data with our direct partners helped to establish trust and we believed disseminating to the larger Nairobi community would help further establish our relationships with the Nairobi planning community. We also came to believe that opening the data to anyone interested in using it would help to further even access to knowledge and cultivate and sharing ethos. However in doing this we operated within our own institutional boundaries as we had yet to connect with groups who could access, use, and disseminate the information more broadly. Realizing this, we actively sought to enlarge the community within the boundaries created around the data (Harvey and Chrisman 1998).

GIS data access is a global problem but perhaps, made more acute in Kenya because of its authoritarian past. Making spatial data freely available threatens the relative power governments and other entities maintain by keeping data private or available for a high cost. When the government has power over a commodity, especially one that might reveal problems in government services or accountability, it is no surprise that the government would not be willing to share it freely.[15] Until access to spatial data is increased, either through the development of

SDIs or by governments and civil society simply making spatial data more freely available, stakeholders will continue to have unequal power relationships because of a lack of access (Elwood, 2008).

Our attempts to access GIS data shows the Government of Kenya needs to take better ownership and initiative in developing a functioning SDI; legislative measures are necessary to create an environment for public access to spatial information (Sieber 2007, Kenei 2012, Harvery and Tulloch 2006). Kenya has a strong and growing ICT community within the private sector and academic world that could be leveraged for these efforts. The KNSDI, launched largely through the initiative of external actors (e.g., JICA), has not been wholly successful. This is not surprising as projects proposed by external entities, including NGOs or private companies, often have mixed results because of a lack of leadership, capacity, and interest at the civil society and government level (Weiner 1999). The Kenya Open Data Initiative is another promising project on the part of the Kenyan Government but it needs continued pressures from a wider open data ecosystem and time will show how well the datasets are maintained and shared. The development of SDIs across Africa has been problematic because of the complexity of funding, political structure, and capacity. The question becomes how Kenya can overcome some of these problems to develop a successful plan for GIS and its society. In a small way, building and sharing data at any level thus becomes part of building a broader environment to enable change.

Grassroots dissemination of data doesn't break down boundaries if the message about the availability of the data has not reached by the community that needs it. While we may have

helped to fill a small gap in the distribution of GIS data in Nairobi, a solution for the provision of this data for those interested in performing research and doing policy work still needs to be developed. Had we used a more participatory method in data collection we might have reached more local actors interested in the using and disseminating the data, reinforcing the PPGIS literature that finds participatory data collection helps expand the potential of many groups using and the data and telling others about it. (Baily and Grossardt, 2010) Similar to other developing countries, it is clear that the ability to obtain GIS data in Nairobi has a little to do with capacity; however it is likely it has more to do with power and control, as one can obtain the data for a price. Moving forward our research will continue to work towards providing open access to data developed in the course of action research. Ultimately and more importantly, Kenyans themselves need to address the issue of data accessibility at many levels, pushing the government to open up, creating new databases from below and building a vibrant and inclusive open data ecosystem. Moving towards open access in this way might just help improve policy decisions in and for Nairobi.

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Notes

[1] Rambaldi has developed an online PPGIS training course for NGOs and GIS activists at http://pgis-tk-en.cta.int/

[2] Early attempts to develop a GIS database in Botswana show that record keeping for land tenure in many developing countries can be complex and based on a cross-section between colonial allocation and indigenous systems, thus making it hard to develop databases that correctly convey ownership (Nkambwe 2001).

[3] For example, in 2006 the Department of Geospatial and Space Technology within the school of Engineering at the University of Nairobi started a MSc. GIS program.

[4] The policy of the KNSDI is to collect, integrate, and distribute geospatial information and services for use and sharing by all public, private, and civil society organizations in Kenya. The overall stated goal of the initiative is to encourage the use of geospatial information in local, regional and national levels of government to achieve gains in market development, sustainable development, and transparent and participatory governance (SoK 2008). KNSDI policy acknowledges the importance of establishing a national repository of spatial data to encourage access, sharing, and dissemination. Further, the policy acknowledges how important spatial information is for legislative and policy development, natural resource allocation, public safety, and regulatory activities.

[5] Some of the limiting factors to achieving this goal include high internet costs, the need for a clear communication strategy to reach more users and increase awareness of the NSDI, passing NSDI policy and related legislation to legalize and institutionalize GIS, a lack of adequate funding for NSDI for both hardware and software, and the wider recognition that spatial data is a resource and that should be accessed freely and disseminated (Murage, Gitimu, and Sato 2008).

[6] See opendata.go.ke

[7] See www.virtualkenya.org.

[8] VREF represents a collaboration of four foundations that fund research and education on transportation, the environment, and energy. The four foundations that contribute funds to VREF include the Volvo Foundation; the Volvo Educational Foundation; the Dr. Pehr G. Gyllenhammar Foundation; and the Hákan Frisinger Foundation for Transport Research. It supports eight research centers funded by VREF, or Centres of Excellence (CoEs), located throughout the world that focuses on the future of urban transport. VREF is governed by a Board that decides which research will be funded, establishes policy, and is responsible for long-term asset management; and The Scientific Council, which evaluates the scientific quality of research funding applications and the ongoing output of each of the CoEs. VREF funded this work as part of its Future Urban Transport Programme (FUT), which aims to "contribute to the development of sustainable transportation systems" through interdisciplinary academic research in collaboration with intended users research results, such as traffic and city planners, politicians, government agencies and interest groups (VREF 2013).

[9] As an anonymous reviewer for this articles points out "This intra-development coalition competition for geospatial data is not confined to the Kenyan case. It is a fundamental reality for all users of geospatial systems" (Goss 1995).

[10] It should be noted that transportation models usually need a combination of land use data, population information, and road network data. The road network data in a transportation model is clearly one of the most essential components, as it usually provides information on road capacity and limitations such as street direction or ability to turn. As mentioned, while census information for Nairobi was available for population information, land use and building density data could help to estimate the amount of trips generated by certain land uses. For example, a retail location will produce more trips then a residential location.

[11] While we recognized the importance of verifying data through on-the-ground observations, the Survey of Kenya maps were made earlier than our maps and we wanted the data we digitized to represent the world as it was surveyed by JICA at the time.

[12] See: http://www.freebase.com/

[13] In many way our addition of the data to a wiki space acted as an informal or bottom-up SDI for Nairobi where a governmental SDI did not yet exist.

[14] See the project "Map of Land Use Change From Residential to Commercial: City of Nairobi: 2008-2010 http://www.virtualkenya.org/maps/map-images/524-map-of-land-use-change-from-residential-to-commercial-city-of-nairobi-2008-2010

[15] We also discovered that people within government or with links to government sometimes use spatial data as a commodity to be sold informally. Thus, thus group would have little interest in making such information freely available.

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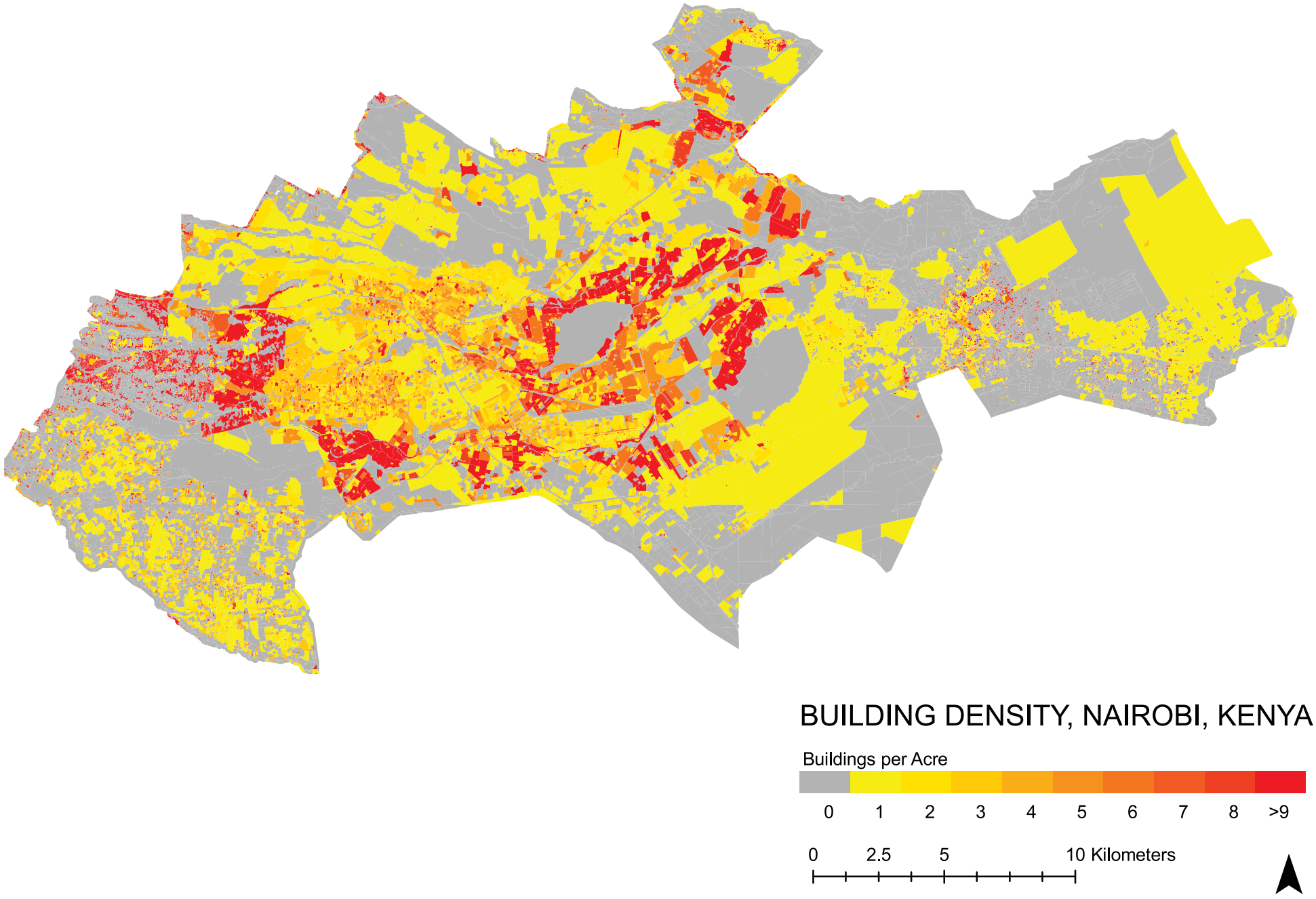
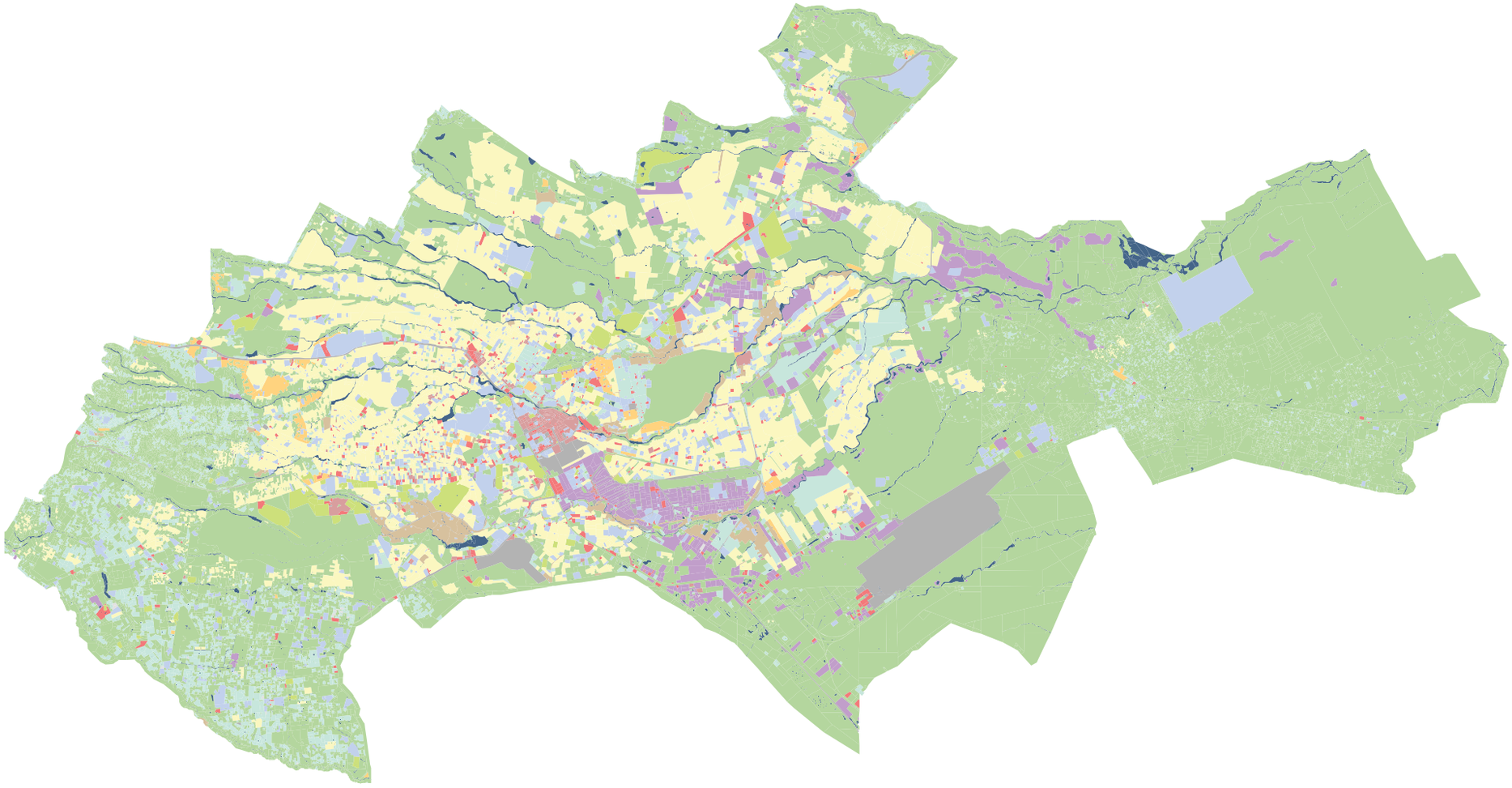
FIGURE CAPTIONS:

Figure 1 & 2 : GIS map of the buildings density (left) and street centerline map (right) file created through the digitization process described.

Figure 3: GIS map of the land use file created through the discussed digitization process described.

Figure 4 &5: Screenshot of the GIS database as it was being created in ArcGIS (left) and Google Earth image of the same area (right). The screenshot shows an area where obstructions can be seen on the map.

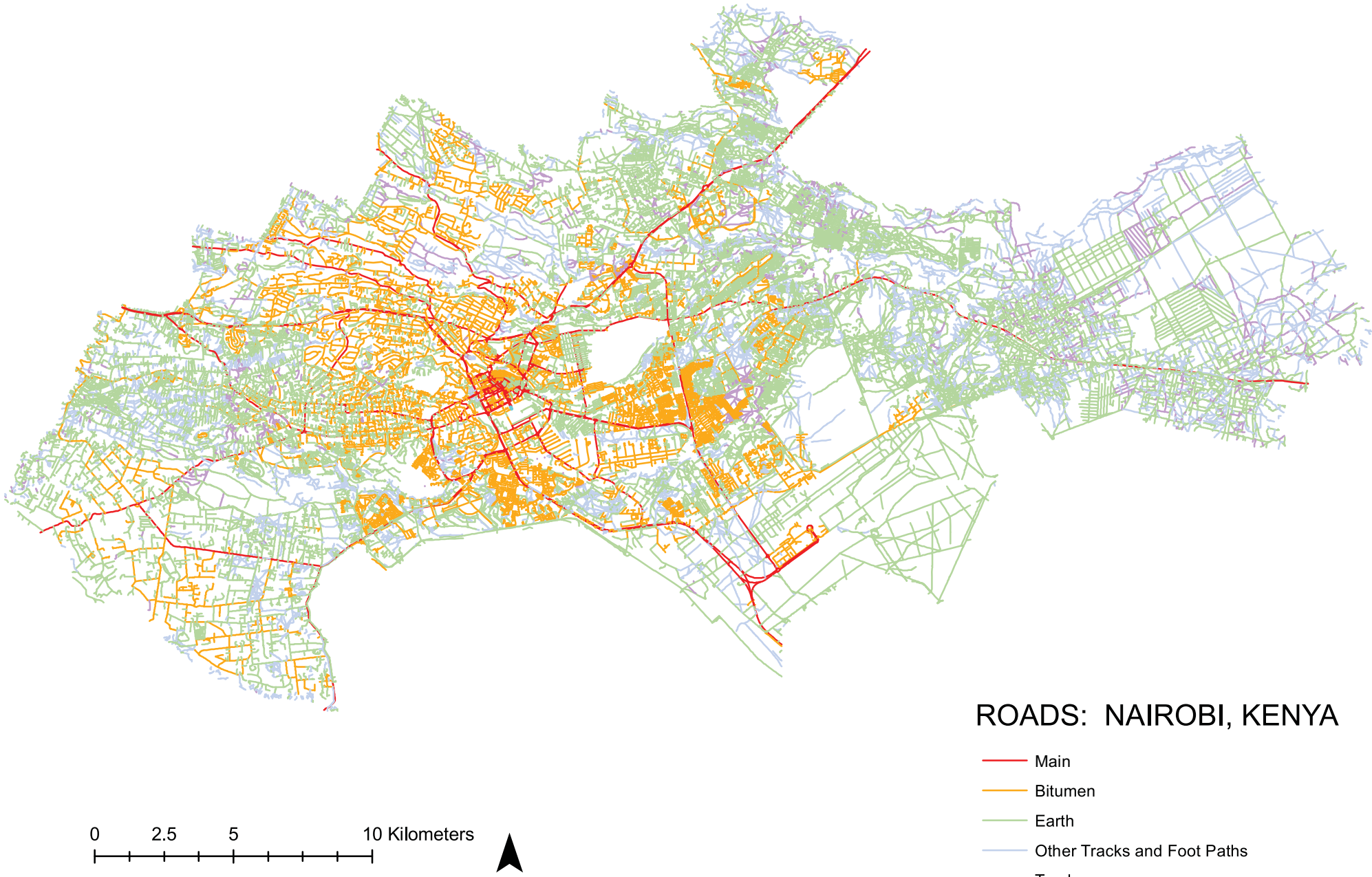

BUILDING DENSITY, NAIROBI, KENYA
Buildings per Acre
0
1
2
3
4
5
6
7
8
>9
0
2.5
5
10 Kilometers

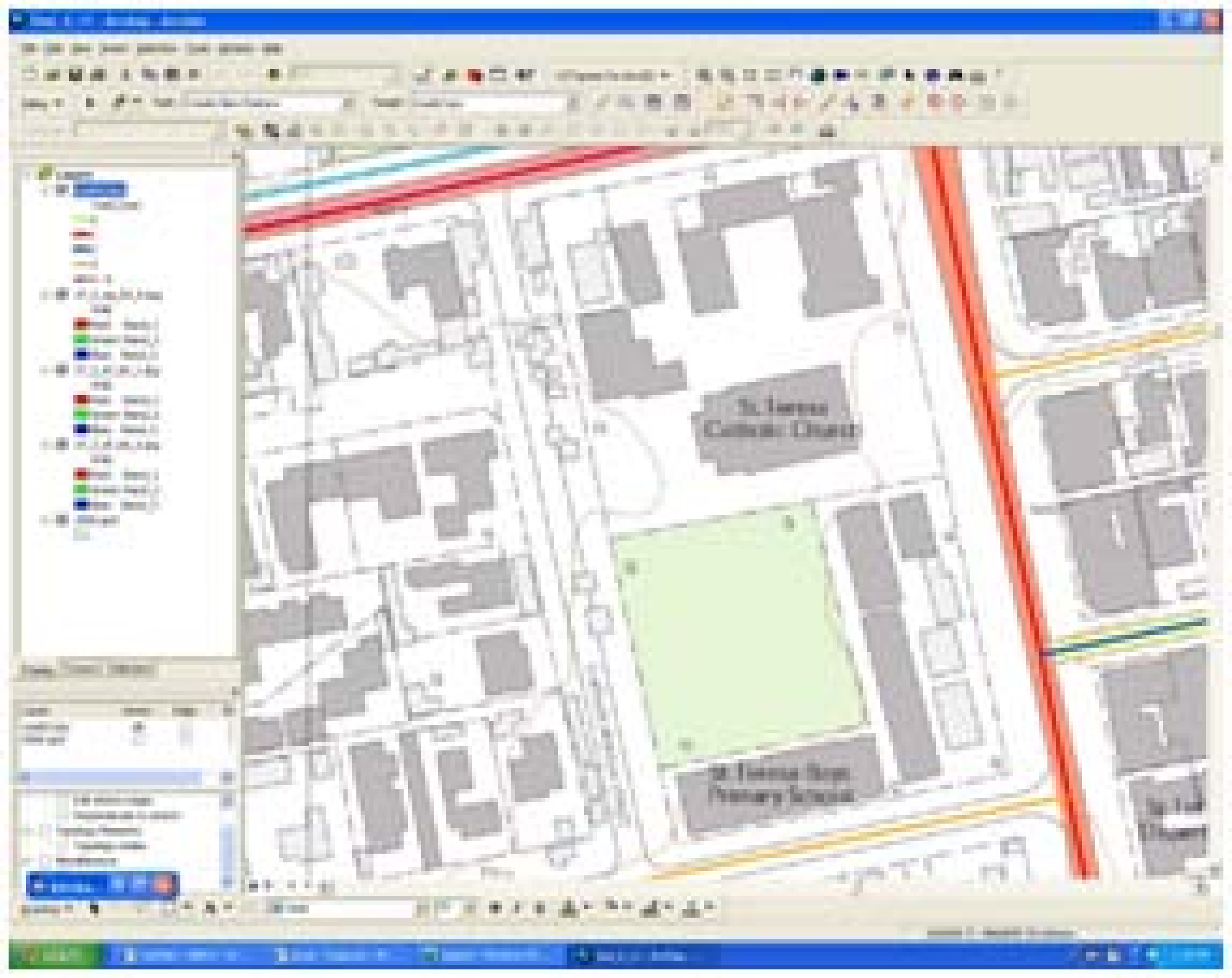


LANDUSE NAIROBI, KENYA

- Commercial
- Industrial
- Institutional
- Mixed Commercial & Insutrial
- Mixed Residential Commercial
- No Structures
- Open Space
- Recreational
- Res Slum
- Residential
- Road
- Transportation
- Unknown
- Water

0 2.5 5 10 Kilometers


ROADS: NAIROBI, KENYA
Main
Bitumen
Earth
Other Tracks and Foot Paths
Tracks
0
2.5
5
10 Kilometers


St Teresa
Catholic Church
St Teresa RC
Primary School