MAPPING AS A SOCIAL ENTERPRISE. IMPLEMENTING NEW TOOLS IN THE GAUTENG CITY-REGION.

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'There is no map without intent'.
- *Philippe Rekacewicz, Vision Cartographiqué*

'The failure…of the cityscape to register the presence of marginalised people who inhabit unacknowledged places effectively renders them unknown and hence unknowable, expunging them from history and memory'.
- *Martin Murray, Taming the Disorderly City*

1. Introduction

Regional planning must understand the daily lives and the socio-spatial patterns of movement by their residents, in order to create strategies for equitable urban development and sustainability grounded in specific local realities. On the regional scale in the Gauteng City-Region (GCR), these urban narratives are expressed in the paths and modes of transit people use to negotiate urban space in their everyday lives. This project represents an initial attempt to collect information on the ways in which urban inequality is shaped and transformed by this everyday mobility, by utilizing the method of volunteered geographic information (VGI). Including people in data collection through VGI, and understanding greater specificities of their lives can reframe the way socio-spatial inequality is understood in large urban regions such as the GCR. The central thesis of the project is therefore that mobility is not just characteristic but also generative—transportation provides access to resources and opportunities, which reproduces and reinforces patterns of urban development, and inequality, unless directly contested through spatial planning initiatives.

Previous research by the Gauteng City-Region Observatory (GCRO) has examined socio-spatial inequality by mapping statistical data, such as start and end destinations or commuter patterns, sourced from surveys, for example with the expansive Quality of Life Survey. While mobility mapping based on such resources can reveal the frequency of travel habits towards key points in the regional configuration, crucial aspects such as multimodal transportation, transfer points, total travel time, and cost cannot be precisely modelled. This kind of information is relevant to planning and development because the ways in which data are collected and mapped have the potential to contest or to reproduce social-spatial inequality.

While census data, for example, incorporates population enumeration, frequently in conjunction with a national population or housing census (UN 2008), recent examples conducted, for example, by the Gauteng City-Region Observatory have included qualitative statements such as 'life quality' and 'happiness' (CoJ 2011). This trend emphasises awareness of the risk of seemingly objective statistical data collection, and by association of quantitative mapping, quantifying the human experience of statistical phenomena. The collection of qualitative, ethnographic data based on the methods of the social sciences has been a significant part of mapping urbanization since Guelke (1976), Robinson et al. (1995), and many others described the 'quantitative revolution in geography' (Haklay and Jones, 2011:137). As noted by Harley (1989) 'even 'scientific' maps are a product not only of the 'rules of the order of geometry and reason' but also of the 'norms and values of the order of social tradition' (Marin, 1988:173).' Socially-based mapping includes the representation of not only physical data or experiential data like the Johannesburg census surveys, but the complex construction of relationships between places and people, following for example Castell's *space of flows* (Castells, 1989). Following this line of reasoning, addressing inequality, for planning purposes, could thus be visualized as co-presence in space rather than residential, area-based studies that remain the primary basis for analysis in urban studies (Rokem and Vaughan, 2017:2). This is a potentially high-impact shift in perception, particularly because the long-term shaping of

urban areas continues to be shaped by segregation and encounter reflected in the lived realities of their populations (Merrifield, 2013; Wacquant, 2016).

In order to address the research gap between statistical data collection and lived realities, a smartphone application called *myJoziMoves* and web-based data visualisation tool were developed to investigate the complex landscape of urban mobility in contemporary Gauteng. Grounded in the understanding that mapping comprises much more than an objective reproduction of quantitative data, this 2016 project reflects on relationships between mobility and inequality in the Gauteng city-region. For two months, a total of 368 participants utilised the smartphone application, gathering over 684 383 total data sets (GPS location packages) corresponding with qualitative survey data integrated into the application. The combined paths of the 368 participants not only tell the story of their everyday urban experiences, but also shed light on mobility patterns outside the recorded and regulated transportation modes across the city-region, and potentially beyond its borders (see figure 2). According to a survey conducted by the OECD (2011), an interdependent urban area can be determined by the commuter field drawn to an economic centre (in this case the Johannesburg CBD). However, this system is not capable of fully accounting for the polycentric urban configurations so common in the urbanised landscape that function on a territorial scale (cf. Diener et. al, 2005; Brenner et. al, 2014; Schmid, 2012). The smartphone application, if able to successfully overcome some of the limitations that occurred during the study, could have broad implications for tracking previously unidentified mobility patterns across transportation modes and municipal, metropolitan, and regional borders.

The findings indicate that mapping a city's *inequality footprint*, utilizing data from both official institutes and gathered from the everyday experiential movements of an urban area's residents, can be a key tool in identifying the priorities that cities and regions can set for planning future development. The term inequality footprint is defined in this project as the extent to which low-income economic groups are concentrated as homogeneous enclaves and spatially isolated from centralities in the urban fabric. This report asserts that lack of mobility is one of the most defining characteristics of contemporary poverty (cf. Geertz, 1988; Rokem and Vaughan, 2017). Unless spatial patterns and social densities are significantly shifted, transportation will remain a key issue for the development of the GCR. Access to opportunities remains highly unequal, precluded by location and transportation, and the difference in daily routines is evident. As such, this participatory data-collection method aims to provide visual framework for more inclusive urban planning. The approach acts as a means to evaluate mapped lines of power in comparison with how people actually move through and negotiate their urban environment. Finally, the project provides insight into the power structures that shape the city: the intents of planning versus the everyday patterns of its residents (see 4.2: Policy Implications). It could therefore contribute significantly to future development plans for the Gauteng city-region and be applied to the analysis of other urban configurations. Moreover, utilizing both officially collected data as well as crowdsourced data represents a new paradigm in mapping and its crucial ability to convey both tangible and experiential phenomena.

1.1. The map as an instrument of power

Mapping is a means of recording geographical observations, delineating a fixed moment in time with an air of permanence and authority; cartography can even be considered one of the most basic mediums of visual communication. As noted by Haklay and Jones (2011: 139): Communication is and always has been central to all human endeavours. Since the meteoric rise of telecommunication from the 1950s onwards, communication has become faster, easier

and crucially cheaper for many. With this, the media of communication has also changed significantly, particularly with the development and widespread deployment of digital communication and the emergence of worldwide diffusion of the Internet in the last two decades. Within this framework, maps are most often understood as a form of visual communication used to encode geographic meaning and relationships.

As such, mapping lies at the crux of urban development: It can potentially disseminate information to a very wide audience in a concise, precise, and legible manner. From local communities to planning officials and academics, as well as the broader global population, a map strongly influences the perception of a place. 'Data' can impart a false sense of objectivism, and is always dependent on its sample size. The information obtained can even reflect an underlying, partisan bias in the kind of questions posited to the respondents of a survey (cf. Higgins and Green, 2011). Even a topographical map is subject to the constant change of its surrounding environment: a contemporary digital city map is a reliable source of the geographical information required to move between points, but cannot reveal the subtleties of atmosphere and human encounter traveling in between. As noted by Edney (1993:307), 'there is a world of geographic facts 'out there'…which are to be 'discovered' by the explorer and surveyor.' It is also a powerful tool of control in the urban realm; spatially delineating information, such as dividing territory through the allocation of administrative boundaries, can drastically change the character of a city and thus the relationship between residents and government. It is for this reason that urban planning was a key mechanism to enforce the political structure of apartheid South Africa.

Conversely, insomuch as the map can act as an instrument of power, it can also serve to highlight injustice and reveal patterns of marginalization that lend a voice to the invisible and serve as a basis for contestation of the urban encounter. Greater Johannesburg has a storied history of grassroots organization and contestation of spatial politics (cf. Hart 2014). In our times of Massey's time-space compression and geometries of power (Bird et al., 1990:59-69), urban configurations are influenced by factors far beyond the built environment, particularly with the advent of digital technologies. The reliability and precision of geographical data has altered significantly even over the course of the previous decade with the omnipresence of software such as Google Maps. As noted by Crampton (2009), such software has only been available since the summer of 2005 and has significantly changed the way populations worldwide interact with cloud data, one another, and the cities through which they move. Indeed, *crowdsourcing* geospatial information, or what he refers to as *spatial media*, remains on the forefront of developments in cartography (ibid: 91). As such, *mobile methods* tracking Castell's space of flows are becoming more and more widespread in evaluating urban regions (cf. Aitken and Michel, 1995; Harris et al., 1995; Shappard, 1995; Elwood and Ghose, 2011: 107-115).

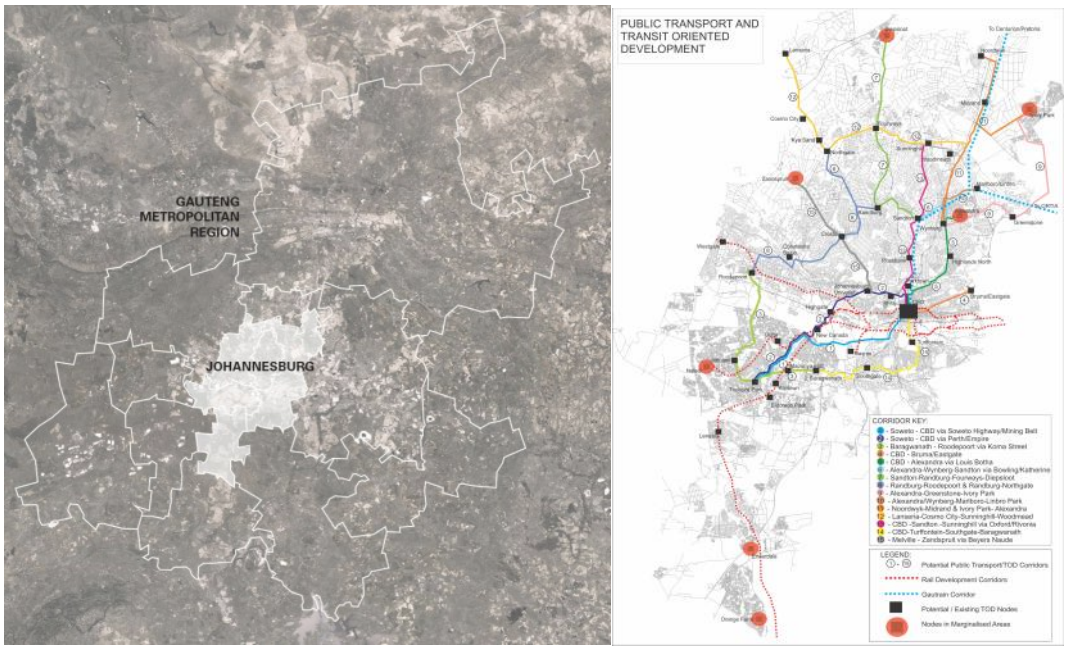
Mobile data also has the potential to modernise the way in which sociological data is collected and interpreted. The precision of geographic information, supplemented with user surveys as was conducted in this project, allows planning officials to receive a much fuller, more accurate picture of the everyday challenges faced by their constituents. Geertz (1983:99) explains how maps can function as a mechanism to uphold a social code, which is particularly relevant to his description of culture as both a product and process of appropriating the surrounding environment (Geertz 1988). Specifically, social codes are visualized through mapping, and are also upheld by these maps. Viewed from the perspective of low-income urban areas, his denotation implies that these areas and their residents lack influence on their present circumstances and are often excluded from determining their future. Incorporating the needs of the least privileged into planning is a crucial step in maintaining a balance between

economic, environmental, and social equity interests in pursuit of sustainable urban development. A further potential of the VGI data and mapping visualisation tool is the transdisciplinary link between ordinary residents of the city and planning officials, which would address such critiques of producing visual representations. Such engagements and exchange can not only foster more productive discussions about the urban, but also underline inclusive strategies for planning and upgrading that have the most effects on those who live in poverty. It is a particularly effective means of describing and communicating about socio-spatial inequality that can appeal to demographic groups across the GCR.

1.2 The importance of mobility

Recent academic as well as praxis-oriented debate has noted the particular importance of transit in shaping urban landscapes (Todes et al., 2014; GCRO, 2014; Harrison et al., 2008). As noted by Gotz and Wray (2014:1) 'a key factor in understanding a functional city-region is the daily flows of people between its constituent parts'. In fact, recent government initiatives in several metropolitan areas of the GCR have begun to encourage growth along corridors of infrastructure, such as lines of transportation. This strategy is intended to infuse areas with a higher density and connect peripheral areas to the rest of the city (Figure 1). Transit is frequently cited as a solution for ingrained apartheid patterns of development, particular in the City of Johannesburg in alignment with their transit-oriented design (TOD) development initiative. This strategy is intended to infuse areas with a higher density and connect peripheral areas to the rest of the city. However, according to Todes (2012), even though proposals by developers are now evaluated according to these strategic frameworks, the real estate market is still the primary driving force behind growth. As such, urban development projects continue to remain focussed in homogenous urban areas and address a single target group (Harrison 2017).

Figure 1. The Gauteng City-Region (GCR) in context. The City of Johannesburg, as well as the metropolitan districts of the City of Tshwane and Ekurhuleni Metropolitan Municipality, plans to emphasise public transportation through bus rapid-transit systems and incentivising zones for integrated development programs. However, to be successful across the breadth of the GCR, these programs will require high levels of coordination and detailed understanding of how people move on a regional scale. Current planning, as reflected in the images above, is not sufficiently coordinated on the regional scale.



TOD is largely based on the expansion of a Bus Rapid-Transit (BRT) System; the initial phase in Johannesburg, for example, emphasises development of the arteries extending east from Soweto through the CBD and north up to Alexandra Township by 2016, with a further extension to the financial centre of Sandton to follow thereafter (Gotz and Wray, 2014:2). The plan intends to touch on several important factors in inequality reduction and sustainability improvement: accessibility of mass transit, concentrated densification of mixed-use construction, connecting areas where movement under apartheid was restricted. However, many of the most impoverished areas of the city and region are not connected to this corridor, or only tangentially so; there is also a lack of both statistical and interview-based data confirming these routes are more than the obvious transit corridors between large populations in Soweto and in Alexandra. The areas of investment proposed by the major metropolitan municipalities of the GCR, currently, adhere to the typical architectural language of new urbanism; how this will affect the current residents and what kind of structures will be built in the name of densification, as well as how this will be regulated, remains under discussion. Also unknown is how densification in these areas will affect the overall urban footprint and persistent patterns of inequality.

Peripheral settlements and homogeneous enclaves that are an intrinsic part of the post-apartheid landscape in the GCR lead to extensive travel times to carry out the activities of daily life. The support networks this requires of its residents affect disadvantaged populations the most heavily. For example, planners across the GCR are aware that the majority of the population in the greater urbanised area travels by mini-bus taxis, yet little research has been conducted on the actual patterns these (flexible) systems compose, nor on the effects these modes of transportation have on the city's sustainability (ITMP 25; interview Vadi 2015; interview Walters October 2014). Recent research by the GCRO has, using the Quality of Life surveys, examined the start and end destinations of commuters and visualised these relationships, which does include taxi data; however, the specific routes are not tracked and travel decision-making processes (such as the location of transfers or multiple transit modes) are not part of the data set (GCRO 2015). This issue highlights the divide between the idea of implementing planning based on the administrative borders delineated by maps and the complex reality of movement by the majority of the region's residents.

The use of varying modes across the city-region is an aspect that has been more carefully investigated in recent reports. Particularly careful attention has been paid to the relationship between employment and mode of transportation. For example, analysis of modes from the GCRO's 2015 Quality of Life (QoL) Survey by Culwick et al. (2016) notes:

> The QoL 2015 results show that the mode used for trips to work is split between private vehicles (47%) and taxis (33%). The proportion of private vehicle use has increased from 44% in 2013, whereas taxi use has dropped from 37% (Figure 2). 94% of white respondents used private vehicles to get to work, while this is the case for only 30% of African respondents. Non-motorised travel (walking or cycling) has increased as the main mode to work from 10% (2013) to 13% (2015). Walking to work is more prevalent among African respondents (16%) than white respondents (3%). Work commutes by train remain low (4%) and commuting by other buses dropped from 4% (2013) to 2% (2015). Interestingly, new forms of publicly provided public transport (Gautrain and Bus Rapid Transit (BRT)) are starting to feature in respondents' reported work commutes. Respondents using either Gautrain or BRT as their main mode to work have doubled since 2013, from 0.4% to 0.8%.

What this implies for the everyday functioning of the GCR is one of the aspects the smartphone study aims to investigate further. The collected data can be mapped to show not just the general trends, but even the detailed individual stories of participants to reveal the impact these transportation decisions have on daily lives. This ability to conduct multi-scalar analyses within the VGI dataset is another innovation that can potentially have a high impact for future planning initiatives in the GCR.

This report is based on a VGI mobility study conducted in the Gauteng City-Region from 15 October – 15 December 2016. Smartphone technology was utilised to gather information about study participants that included both their GPS location data and mobility patterns while allowing them to report qualitative, empirical data collected through their everyday experiences of the city-region. This approach emphasises how mapping that relies on quantitative as well as qualitative methodologies can supply data in a way that not only challenges preconceived notions about how an urban region functions, but can empower planners as well as participants. For example, increased understandings of situations that are not familiar to planners, in a vastly complex urban region, are available to empower these experts. And for participants, volunteering their information allows them to be included in the process of data collection through revealing their role in urbanization processes. Potentially, their direct experiences and voices can be incorporated into planning decision-making as a result. Finally, VGI has the capacity to provide insight into the power structures that shape the city: the intents of planning versus the everyday patterns of its residents. As such, crowdsourced data (VGI) has the potential to pose a new paradigm in mapping and its ability to convey both tangible and experiential phenomena.

2. Methodology

The project objective was to utilise a smartphone tracking application to garner geographically precise and modally accurate transportation data across the many demographic groups that reside in the Gauteng City-Region (GCR). In addition to established methodologies from the fields of sociology or transportation studies, contemporary digital technologies can shed significant light into everyday mobilities. However, volunteered geographic information (VGI) and its ramifications for these types of studies remain largely unexplored (cf. Schönfelder and Axhausen 2002; Axhausen 2006; Meyer 2013). Start-and-end destination questionnaires or global positioning system (GPS) trackers, as are typical in transportation studies, are not sufficiently detailed to understand the social dimensions of space. No further available tool could report both GPS data as well as incorporate surveys on demographic information. As such, a prototype smartphone application for crowdsourcing VGI was developed for the android platform, capable of determining GPS location data and mode of mobility, as well as a user survey to gather demographic and personal information by software developer Markus Ringel. Originally formulated for doctoral research by Lindsay Howe with 30 participants focussed in the City of Johannesburg, the prototype was completely overhauled and adapted for a larger sample. The methodology is an experimental attempt to scale-up these processes and networks, addressing as wide a sample as possible. The application designed for the *myJoziMoves* project can indicate bus, car, walking, still, and cycling (train movement was added through post-processing in a data visualisation tool, as signals are highly irregular under the local conditions in the GCR).

One of the most significant challenges in collecting smartphone-based geographic information is related to mobile phone signal strength. The Vodacom Smart Mini 7 phone, which at the time of purchase cost R699 per phone, was GPS enabled (which is essential to such a process because cell signal strengths are so variable) and the price-point allowed the purchase of 150 smartphones from the available budget. There is a noticeable difference in the quality of the data collected and the quality of the phone hardware, so the Smart Mini 7 represented a compromise between quality of data and cost of phone, in particular because the goal was to be able to include people of any income group in the study. There were also additional costs for data/airtime. 1GB of data per participant was provided for R149 each, which was a 30-day data bundle, for a total cost of R848 per participant for low-income participants, for whom a phone was provided. Upon completing the experiment, these participants were also permitted to keep the phone as an additional incentive. Lack of income is often an impediment to inclusion in planning decision-making, so it was deliberately budgeted such that income would not prevent inclusion.

2.1. Project background (2014-2015)

An initial beta test of the project was first conducted in 2014: five target informal settlements in the city-region were identified in collaboration with Prof Dr Philip Harrison at the University of the Witwatersrand. One resident of each area, located on the periphery of greater Johannesburg, was selected for a test of what was entitled the *myCity* application. They were chosen to represent a wide spectrum of urban residents within the geographic areas; the settlements themselves were selected according to their varying proximity to the Central Business District and primary financial and job centres. They represented both genders (3 female, 2 male), ranged in age (20 – 55 years), and each had varying occupations (student, hip hop artist, housewife, community organisation, and unemployed). Each of the participants reported their GPS positions and modes over the course of one week, in order to further understand the spatial dimension of these practices in informal settlements. However, this

application had no feedback mechanism for the user; it was not yet capable of displaying maps or graphical information at this stage of development.

Doctoral fieldwork for the retitled *myJozi* application was conducted by Dr Howe during the winter of 2015 with 30 participants. The smartphone data was supplemented with ethnographic interview questions and extensive site visits. In this round, the participants were also selected to represent their area of residence relative to their centrality or peripherality from places of opportunity. They were selected to represent both genders (14 female, 16 male), ranged in age (20 – 67 years), and each had varying occupations (e.g. welder, mechanic, hip hop artist, student, housewife, community organisation, informal street trader, unemployed). From 8 July to 7 August 2015, the app recorded qualitative and quantitative data with these participants across 10 settlements, and a data visualisation tool was developed in collaboration Mr Ringel. Each person, or any number of sample participants, can be selected with this tool, and their paths charted as polylines with colours showing the mode of transportation. Optional additional layers include markers revealing the specific times, GPS location, and noting probability of the mode of transportation. This second test represented a significant step in understanding not just the start and end destinations of people, but the why behind their movements. Because each participant was interviewed in varying degrees of depth, in order to understand their general life stories and daily movements, allowed the quantitative data collected by the smartphone application to be greatly enriched through qualitative interviews and narrative stories.

The initial experiences with the myCity and myJozi mobile application allowed participants to become aware of their position within the greater fabric of the city, and to see their daily trajectories. During the trial, they were also able to take photos and post them to Facebook and Twitter. This immediate mapping and documenting provided people with a way to tell their own stories (ethnographically) while generating replicable movements and patterns (quantitatively). The research was planned as an anonymous test; however, participants used the phones to set up their own Whatsapp accounts and began interacting with the primary on-site researcher, texting updates about the app and their activities. These 'citizen cartographers' thus produced a body of semi-quantitative, semi-qualitative data that redefined the parameters of the data currently available to understand poverty and inequality in urban landscapes.

2.2. *myJoziMoves* 2016

As the methodology of the application and the process of analysis were well-established through the first two trials in 2014 and 2015, the primary tasks of the research team in implementing myJoziMoves with a representative demographic sample were twofold: to further enhance the usability and graphic appeal of the application to a wider audience, and to devise a recruitment strategy with previously encountered demographic groups. When selecting participants for a representative sample, as opposed to the informal settlements targeted by Dr Howe's previous research, the highest priority was to achieve a maximum variation sampling distributed as widely and evenly as possible across the GCR. Particular care was also taken to represent vulnerable populations and an equal gender ratio reflective of the realities of demographic groups in the city-region, primarily through partnering with the NGO Planact to recruit and manage low-income participants. Project leader Mike Makwela facilitated the recruitment of participants earning less than 4 000 ZAR. Purchasing smartphones for this income group also constituted the majority of the project budget. Participants were therefore recruited according to a dual approach, reflecting the necessity for inclusion of a highly variable range of urban inhabitants from low-income Gauteng residents not necessarily possessing a smartphone to technologically knowledgeable

residents and significantly higher income groups. No direct benefit applied to any participants other than the qualified low-income participants as previously indicated; however, each participant completing the experiment for at least 25 days out of the total two months was eligible for prize winnings, with a grand prize of R10 000.

Collaboration with Planact

Planact assisted with managing participant recruitment for the project, primarily for two reasons. Because they work to build capacities across such a wide range of spaces and conditions in Gauteng, they benefit from an understanding of how flows of informality function across this whole. Moreover, they are also interested in potential tools that can advance their analysis processes and that can act as a networking platform for the residents of the settlements with whom they engage. The project management team consisted of the primary research team, ten geographically distributed local area leaders, the recruitment team for non-low income participant target groups, and Planact project manager Mike Makwela. The local leaders were tasked with recruiting 15 participants, according to a demographically representative population sample (see Annex). These recruits were approved by Planact. Managing these participants so personally was intended to generate social cohesion, as a motivation to interact with the group and complete the trial.

The phones were set up and distributed by a team of ten geographically dispersed local leaders and overseen by technology manager Lucky Nkali, who assisted in the field with the previous trials. Planact ensured a spatial distribution across the Gauteng City-Region aligned with the overall population demographics within this sub-group of the sample. They also conducted introductory and conclusion workshops instructing participants about the relevance of the research project and communicated regularly with their group to encourage lasting participation. Aligned with the official start of the study, Mr Makwela and technology manager Lucky Nkali began distributing the first round of 100 Vodacom smartphones purchased by the research team to the target areas. These phones were set up with the respective local area leader and distributed to each participant to take back to their place of residence. On 15 October 10 participants began in Vosloorus, and 10 further began in Wattville. On the morning of 16 October, Mr Makwela and Mr Nkali distributed further 6 phones in the Pretoria CBD, where 12 participants from Atteridgeville also joined the group to begin. The same afternoon, 10 were distributed in Bekkersdal and 9 in Orange Farm. On 22 October 14 phones were distributed in Soweto and Orlando East, and 10 further in Thembelihle and Lenasia. That evening, 10 were distributed in Tembisa. The remaining 19 phones from the first batch of 100 were distributed on 23 October and 24 October to the same locations

Figure 2. Locations of local area leaders and phones distributed to these leaders. The locations were selected due to their widespread accessibility for low-income users across the GCR, as the purpose of the local leaders was to serve as a contact point and provide in-person support for this subset of users (often as first-time smartphone users) if necessary.

Area of Leader	Distributed Round 1	Distributed Round 2	
Vosloorus	10	7	
Wattville	14	1	
Pretoria	6	9	
Atteridgeville	12	4	(one phone lost)

Bekkersdal	10	5	
Orange Farm	9	6	
Orlando East	14	1	
Thembelihle	10	5	
Tembisa	8	7	
Etwatwa	12	0	
	105	**45**	

Mr Nkali, who conducted regular interactions with the local leaders and their respective participants, estimated that 75% of participants who had little or no previous experience with smartphones easily understood the project objective and the application itself. On some occasions, curious family members, friends and neighbours of recruited participants also attended the installation sessions and voluntarily downloaded the application to participate. For those outside the recruited group, Mr Nkali noted that their enthusiasm was primarily a chance to win prize money, while the core group was primarily motivated by the chance to participate in research and interact with the team. Finally, he observed that the elderly in particular were curious about the project, due to their previous lack of exposure to the technology, and interest in a non-conventional methodology.

Mass recruitment challenges

In order to recruit participants beyond the low-income demographic group, a promotion campaign primarily based on social media and radio was executed. A recruitment team headed by Olga Koma was tasked with ensuring local knowledge underpinned the recruitment strategies and contacted radio stations, mobile phone companies, and other potential sources to advertise the study. To target the desired spatial distribution, flyers and advertisements were distributed in key nodal areas, such as malls and neighbourhood markets. Social media also served as an important means of communication for recruitment as well as for the group as a whole, creating a platform accessible to all participants and allowing exchange between them. The original intent was for this group to represent 80% of the total participants. This number was sourced from the income levels broken down according to the 2015 GCRO QoL Survey (GCRO 2015). As outlined in the next section, due to recruitment challenges with higher income groups (which were initially ineffective when approached as research rather than marketing) this group represented 50% of the total sample instead.

Olga Koma, formerly of the South African Cities Network, was tasked with managing the recruitment of non-Planact participants and was assisted by Seyco Manyaka. Because this represented a new phase of the project with which the international research team had no previous experience, local knowledge and partners were considered essential to successful recruiting. A strategy and timeline were established for the recruitment team to contact potential further sponsors and secure promotion through social media, radio, flyer distribution, 'flash' recruitment events, and follow-up contacts from the GCRO Quality of Life Survey (see Annex). The team took promotional meetings with the City of Johannesburg, the Johannesburg Roads Association, the South African Cities Network. They also contacted a range of government institutions and corporations for potential further sponsorship or promotion, unfortunately to no avail: the municipalities of Ekhuhuleni, Tshwane and the West Rand; Standard Bank, ABSA and FNB; Cell C, Vodacom and MTN; Uber, Transnet, Gautrain,

Alstom and Metro Bus. They also took part in the City of Johannesburg's Kasi to Kasi transportation month networking and challenge event.

Facebook and Twitter were actively managed by the team; Facebook proved to be much more effective than Twitter. Facebook became the primary focus for social media after the first few weeks of the study. The social media campaign yielded significantly more results once some of the posts and the page itself was financially promoted; however it was difficult to ascertain if people who liked or followed the project indeed downloaded the application, or whether increases in the numbers occurred organically (see Annex). Radio proved to be difficult for the team to access. Conventional radio stations required a significant advertising budget to promote the project on-air or grant interviews. Community radio was successfully targeted in the Vaal Triangle; a live interview with Ms Koma was granted in early December by Vaal Radio Station and several new participants in the area joined directly after her contribution. This indicates that there is potential for this method of recruitment moving forward; however, as with the social media strategy, the approach of research recruitment seems to be considerably less effective than embracing a marketing-based approach.

Posters were secured in strategic buildings, for example within City of Johannesburg offices, Pick n Pays, Checkers and tuck shops, as well as parks, malls and transit hubs. 250 were printed and distributed; while this method proved to be relatively time-consuming for the recruitment team, Ms Koma deemed it effective to target strategic places. However, she also noted that it was not possible to directly correlate the effectiveness of this strategy with increases in number of original users. The most effective method noted by the team was distributing flyers at taxi ranks, in particular, asking drivers' permission to speak to their passengers while waiting. If they were interested, they could be handed a flyer with information and directly assisted with downloading and installing the application. Because this did generate more measurable results, Ms Koma and Mr Manyaka arranged to set up tables at the Neighbourhood Market on two Sundays in December, so they could personally attempt to recruit new participants visiting the popular market.

This also presented one of the challenges generally for recruiting: the privatisation of urban space. The team requested permission to distribute, for example from several malls; this was either denied or they were removed from these locations by security while distributing. As such, the numbers of non-Planact recruits was significantly lower than originally targeted: out of 368 recruited participants, 150 were managed by Planact and 203 occurred either organically or through the efforts of the recruitment team. Ms Koma noted that people who were willing to download the application primarily did so out of interest for the project and its goals, rather than interest in prize winnings. She also noticed that younger people were significantly more willing to listen to details about the project, take a flyer, and even download the application directly than older demographics. Her final observation was that males were more likely to do so than females.

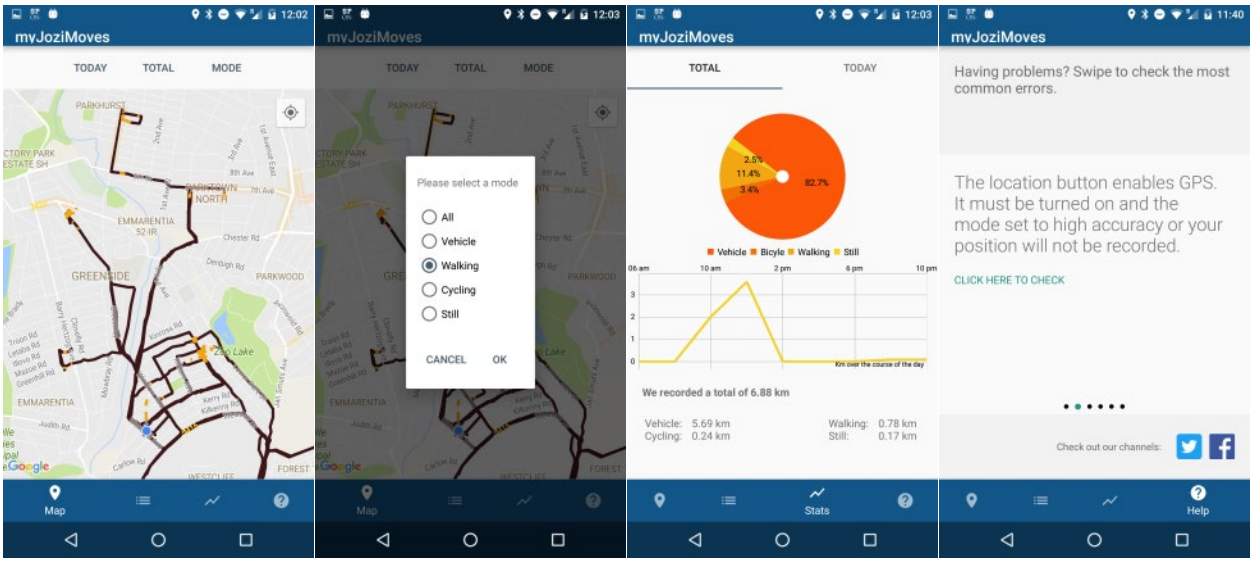
Technical details

The application was designed by Mr Ringel such that as little background knowledge and effort by the user was required for the application to function. Upon opening the program, a user survey automatically initiated and was required for each participant. After this was completed, all that was required to track GPS positions and frequencies of movement was running the program in the background; while participants were encouraged to check in with the program and use its features, it required no further interaction. The information was anonymously uploaded to a server for analysis by the research team, and also displayed the information as a map to each participant, making their position and movements visible to

them, in some cases for the first time. Additional features were integrated into the application to create a broad-based appeal to end users from any demographic; this included automatic mapping of paths and modes of transportation for the end user directly on their device, graphics indicating distances and modes travelled to foster an internal motivation to continue the study, and a user-friendly interface aligned with applications such as Whatsapp.

One of the primary sources of error during the first tests was human rather than technical: simple mistakes such as accidentally turning off the data bundle or failing to carry the phone at all times significantly influenced data collection at this scale of accuracy. The program ran automatically unless closed by the user, which for example would occur if the phone was shut down or ran out of battery power. This led to occasional errors in the 2016 iteration of *myJoziMoves* as well. In this round, which did solve many of the previous human errors, participants had the capacity to diagnose errors directly through the application. Furthermore, geographically distributed local leaders were also accessible to quickly and efficiently deal with technical problems during the study, which primarily arose for first-time smartphone users in the Planact-managed group. Even carefully managing the group did, however, fail to completely prevent human error. As became evident two weeks into the study, some of the participants in the Planact-managed group were instructed by their local leader to circumvent the user survey by restarting the phone several times after installing the application to speed up the process of smartphone dissemination. As such, percentages and statistics on the survey data reflect a total survey sample of 352 rather than 368 participants. Although some of the survey information was supplemented retroactively, without answering the survey, these participants were rendered ineligible to win any prizes.

Figure 3. Application interface. The application interface for the end-user. The primary functionality comprised a mapping function that displayed the user's path to themselves. It could be filtered not only by time frame, but also by mode, as indicated to the far left where all walking is highlighted in the pale orange colour, while other modes remain black. The application also included a graphic representation of total modes, averages times of activity, and percentages either per day or for averages of the total use. Finally, a self-help section was enable to diagnose the most common human errors during the process, including direct links to the project's social media accounts on Facebook and Twitter, as well as a screen to Whatsapp the technology manager directly with unsolvable errors.



The project timeline was conceived to take place over the course of the spring and summer of 2016, wrapping up in advance of the holiday season and its significantly different travel patterns.

Figure 3. Prize winnings distributed by use of a random algorithm to all participants who showed data for over 25 total days during the 60 days of the study.

Prize Number	Amount	Number Awarded
1	R10 000	1
2	R 5 000	1
3-12	R 1 000	10
13-32	R 500	20

3. Mapping results

Historically, unequal power relations between racial and socio-economic groups have resulted in vastly different levels of spatial and economic development across the Gauteng City-Region (GCR) and beyond, which are interconnected through infrastructure. This makes the GCR a particularly compelling example of how mobility plays a key role in socio-spatial inequality, because urban regions are not fixed spatial clusters, but rather, are shaped by the everyday movements of their residents. The central thesis of the project, postulating that mobility reproduces and reinforces patterns of urban inequality, can be confirmed by the collected data set in three primary ways:

1. Spatial inequality patterns derived from apartheid racial segregation, as predicted, largely persist. There is still a dominant flow between historically repressed, more peripheral areas and historically privileged, more central areas. The primary mode of transportation still correlates to race in addition to income. While this is commonly assumed, the maps reveal it in much more detail, as well as its impact on everyday life.
2. Income inequality is correlated with activity space in two primary ways: range of movement and regularity of movement. These relations are not linear, and highlight how much time and proportional income are invested into transport by low-income job seekers.
3. There were almost no spaces of nodal encounter between demographic groups. Establishing such moments is key in addressing inequality through planning, and could become an express objective of transportation planning.

In order to reach these conclusions, first the dataset gathered during the project implementation phase was turned into maps. The smartphone application sent the collected datasets every six hours to a secure server located in Switzerland. In total, 634 383 datasets were collected from 368 users. In order to analyse this dataset, a data visualisation tool was developed to automatically generate maps corresponding to the attributes selected by the mapper. For example, demographic information from the user survey such as gender or income can be selected, and filtered by further attributes. The tool is constructed on a multi-layer software architecture with powerful frameworks including Leaflet and Esri to ensure the precise visualisation of the data. An algorithm specifically engineered for the project transforms (parses) the data into a multi-coloured graph, in order to display the different modes of transportation. The total number of participants, their information, and the maps that resulted from this process are delineated in this section. Within this process, if a particularly interesting map was identified, it could be investigated in detail through additional follow-up with the participant. This section concludes with an example of such a narrative, in order to illustrate the extent of everyday mobility in the GCR and the potentials of the smartphone methodology across multiple scales.

3.1 Participant profiles

The weekly development of the recruits began rapidly, in part because such a large number of the recruits were managed by Planact. On the first day of the project, 15 October 2016, 42 participants actively downloaded the application (and used it at least once). One week later, 127 were recorded. By the third week of the trial, the number increased to 181, and by the conclusion of the first month, 230 users were reached. During the first week of the second study month, the 'flash recruitment' initiative gained 51 additional users to reach 281. One week later, the number had increased again to 318; with two weeks remaining, at the cut-off point for prize qualification, 325 users had downloaded and used the application. At this point,

new recruits continued to increase gradually (and organically) until the end of January, to a total number of 368.

Figure 4. Participation accrual, as well as the active number of users on that particular day and the total increase in number of datasets (the GPS location and mode).

Day	Total Users	Active Users	Total Datasets
1	42	31	15 937
10	129	86	99 105
20	170	110	216 949
30	219	63	324 640
40	281	76	400 875
50	320	96	520 530
Total	368	66	634 383

The distribution of participants was most heavily concentrated within the Johannesburg metropolitan boundaries. Overall, the distribution reflects the social densities anticipated by the research team because of the anticipated challenges with recruiting higher income demographics.

Figure 5. Distribution of participants across the primary metropolitan areas of the Gauteng City-Region (GCR) compared to census data on the GCR (SSA 2011).

Municipality	Per cent of Total	Per cent in the GCR
Johannesburg	50.3	36.2
Ekurhuleni	21.2	25.9
Tshwane	17.7	23.8
Sedibeng	4.9	7.5
West Rand	6.0	6.6

Overall, the sample reflects the racial composition of the Gauteng City-Region. The racial distribution of the sample indicated 71.7% of the respondents identify with African heritage; this is just slightly lower than the African population recorded for Gauteng at 74.1% in the most recent 2011 National Census (SSA 2011). Similarly, the reported white population of 18.6% is just lower than the 19.1% recorded by the census. Coloured respondents were slightly more numerous than the 3.5% recorded in the census, with 5.5% of the sample; Indian/Asian respondents were also slightly higher than the 2.6% recorded in the census, with 3.4% of the sample. Less than 1% identified in the 'other' category.

Figure 6. Racial composition of sample compared to the distribution in the GCR.

Race	Per cent of Total	Per cent in the GCR
African	71.7	77.3
Coloured	5.5	3.5
Indian/Asian	3.4	2.9
White	18.6	15.6
Other	0.8	0.7

The employment levels of the sample also reflect those of the Gauteng City-Region. According to the Quarterly Labour Force Survey, unemployment in Gauteng was at 28.4% in January 2015 and reached 30.1% by March 2016 (SSA 2016:xiii). The highest unemployment rates within the province are within Ekurhuleni, at 34.4% (ibid: xiv).

Figure 7. Employment levels of sample.

Employment	Per cent of Total
Not currently employed	30.8
Employed full time, formal sector	36.7
Employed part time, formal sector	15.6
Employed full time, informal sector	3.4
Employed part time, informal sector	1.7
Self-employed, own business, NOT working from home	5.9
Self-employed, own business, working from home	5.9

Finally, the income distribution of the sample is also relatively closely aligned with the overall statistics for the Gauteng City-Region (GPRT 2014). This study reflects a lower percentage within the income ranges of R1 601-R3 200 and R3 201-R6 400 than survey data (which are around 18% and 15% respectively). The percentage in the range of over R25 601 in the sample is 23.5%, whereas in survey data this number is around 7% of the total sample. The survey data originating from the Gauteng City-Region Household Travel Survey (HTS 2016:8) includes 14% who did not respond to the income question, while there was not an option in the myJoziMoves survey to refuse to respond.

Figure 8. Income distribution of sample compared to the GCR.

Income Level	Per cent of Total	Per cent in GCR (rounded off)
R0-R1 600	33.2	23.0
R1 601-R3 200	12.8	20.0
R3 201-R6 400	11.9	15.0
R6 401-R12 800	11.1	11.0
R12 801-R25 600	7.6	7.0
R25 601-R51 200	13.6	7.0
More than R51 201	9.8	3.0
No response	0.0	14.0

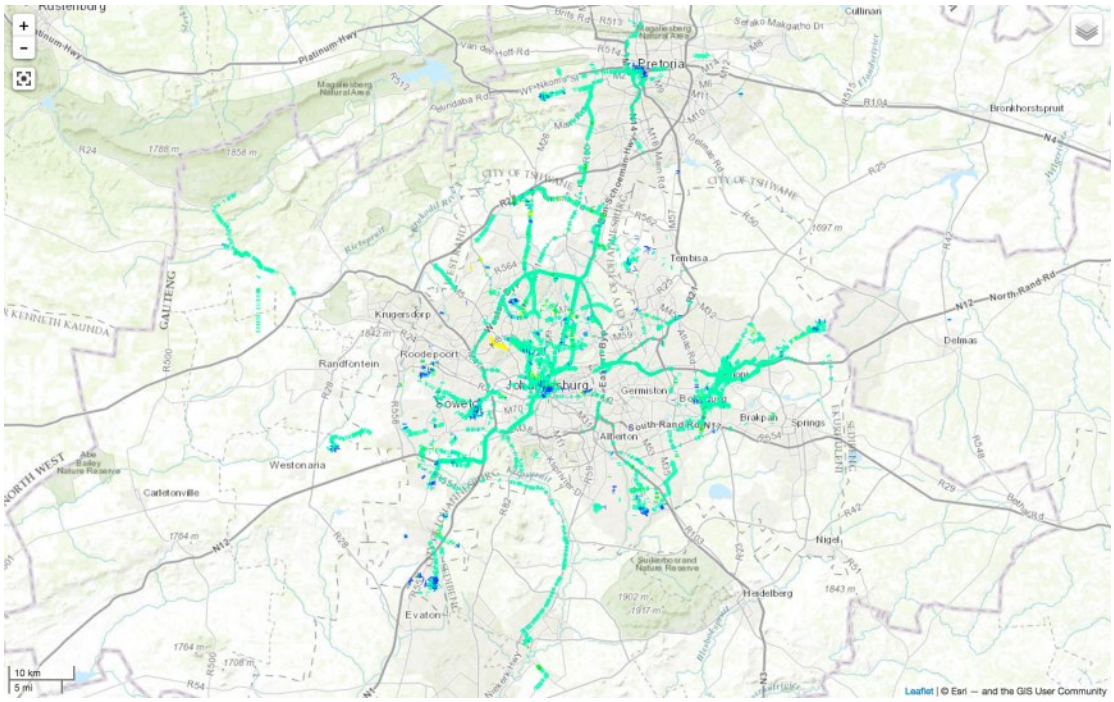
3.2 Findings

As Harley (1989:279) notes, 'in the map itself, social structures are often disguised beneath an abstract, instrumental space, or incarcerated in the coordinates of computer mapping'. The intent of this type of data collection is therefore describing and mapping the everyday patterns of life in order to reveal and describe these hidden patterns and tensions. As opposed to established methods of transit surveying, showing the information as accurate GPS tracks highlighting modes allows additional layers of meaning about the impact of mobility on everyday life. The maps generated from the database show a strong correlation between income level and everyday 'activity spaces'—the geospatial locations as well as tendencies towards modal choices and the kind of activity conducted at the travel destination. This also related to the overall travel time and percentage of income spent on transport, which, while to be expected based on existing travel survey data (GCRO 2015; GPRT 2016), can be mapped directly onto space with the data visualisation tool. The four findings deduced from this process are described in this section.

1. Spatial inequality patterns derived from apartheid racial segregation, as is commonly assumed, largely persist, and mode of transportation is related to race and income level.

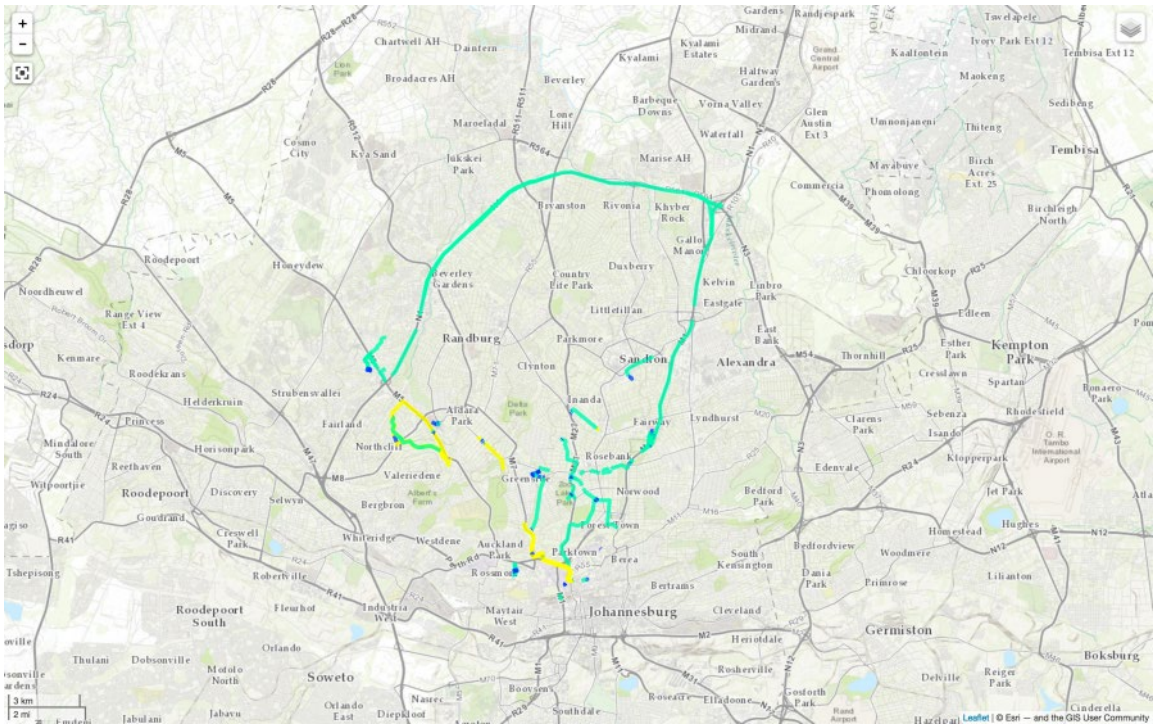
There is still a dominant flow between historically repressed, more peripheral areas and historically privileged, more central areas. For example, it is widely assumed that the Johannesburg CBD plays a central role as the 'command centre' of the city-region, with strong remaining relationships between former township areas and their respective metropolitan centres. Ventner and Badenhorst (2015:31) note 'Johannesburg clearly remains the heart of the province in terms of providing access to jobs and services to people across a large part of Gauteng…In fact, in terms of movement, Ekurhuleni is virtually indistinguishable from Johannesburg'. While the composite maps of all participants over the course of the study confirm that all of the metropolitan (as well as the peri-urban and rural) areas interact, there are more subtle patterns that arise here. While historic linkages between township areas and centres persist, there is significant regular travel across the overall urban region. Many participants exhibit complex patterns of movement across modes and metros: for example, in the survey participants have reported their most frequent trip typically to the next urban centre, but their end destination is often elsewhere, and the routes are not necessarily straightforward.

Figure 9. Composite map of all modes of transportation by all participants from 15 November – 27 November 2016. Spaces of walking are clearly juxtaposed in dark blue, with the green colour indicating vehicular travel. (This is the maximum amount of days possible to process with the web-based data visualization tool.)



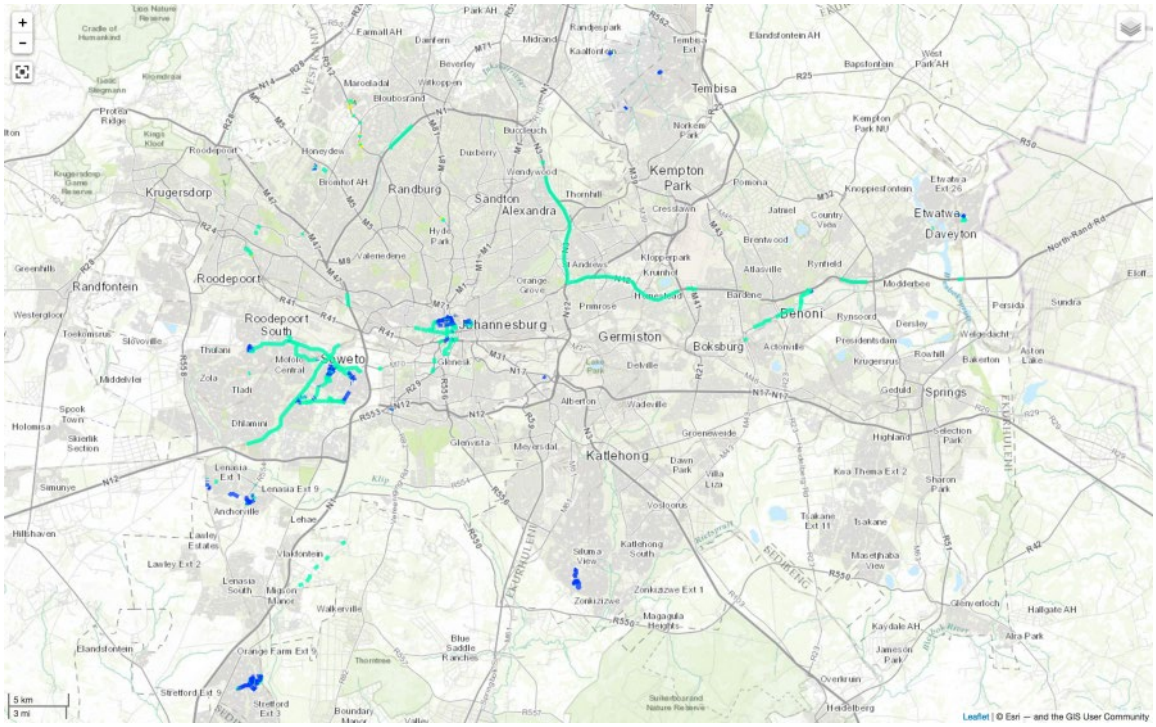
Juxtapositions are evident particularly related to income, and to a large extent, reflect ingrained patterns of inequality. For the month of November, for example, participants earning more than R102 400 per month primarily move throughout the northern suburbs. Walking is primarily restricted to malls and recreation areas (parks and golf courses). Lines recorded are consistent and strong, corresponding to phones with high-quality GPS chips.

Figure 10. Highest income pathways. All participants earning more than R102 400 from 1 November to 1 December 2016.



In contrast, participants reporting no income during this same period of time are concentrated in historic township locations. Their mobility range is either restricted to pedestrian travel within their areas of residence, or longer trips in search of work.

Figure 11. Lowest income pathways. All participants earning no income from 1 November to 1 December 2016.



Another similar juxtaposition is evident in the analysis of cycling compared when filtered by race. Cycling by those identifying as White occurs in areas of recreation or as a primary means of travel to work. Cycling by those identifying as African primarily occurs within their residential areas and is frequently used as a means of accessing another means of transportation.

Figure 12. Participants identifying as African using cycles from 15 November to 15 December 2016.

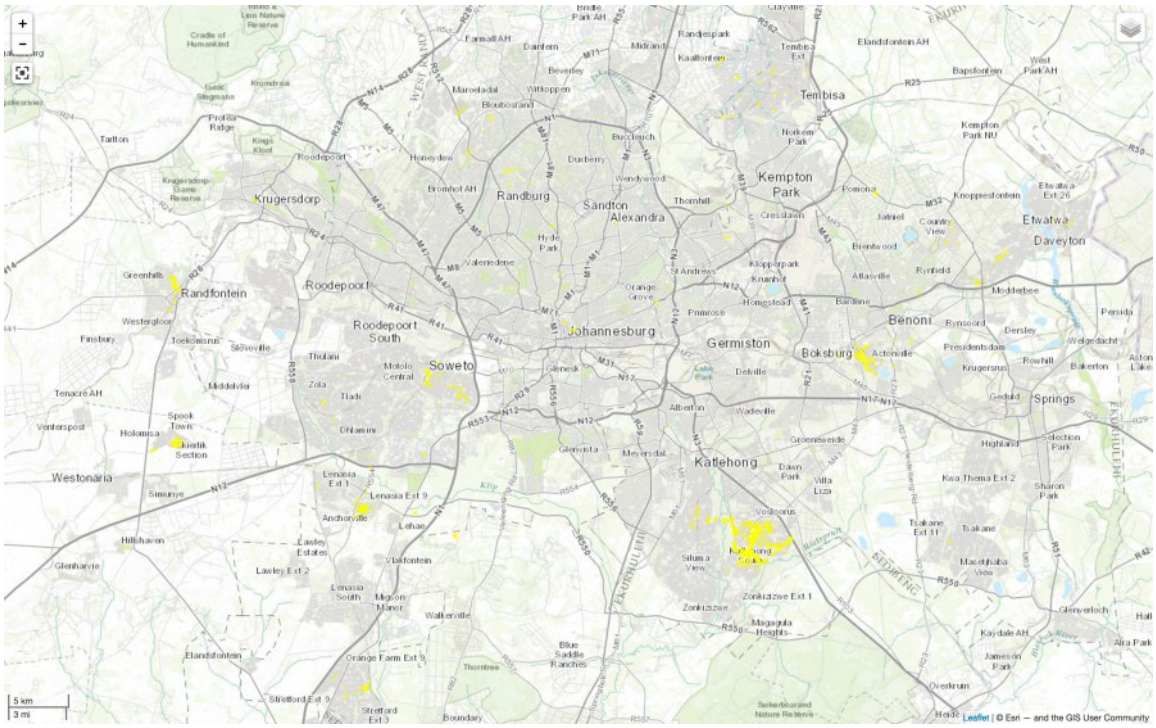
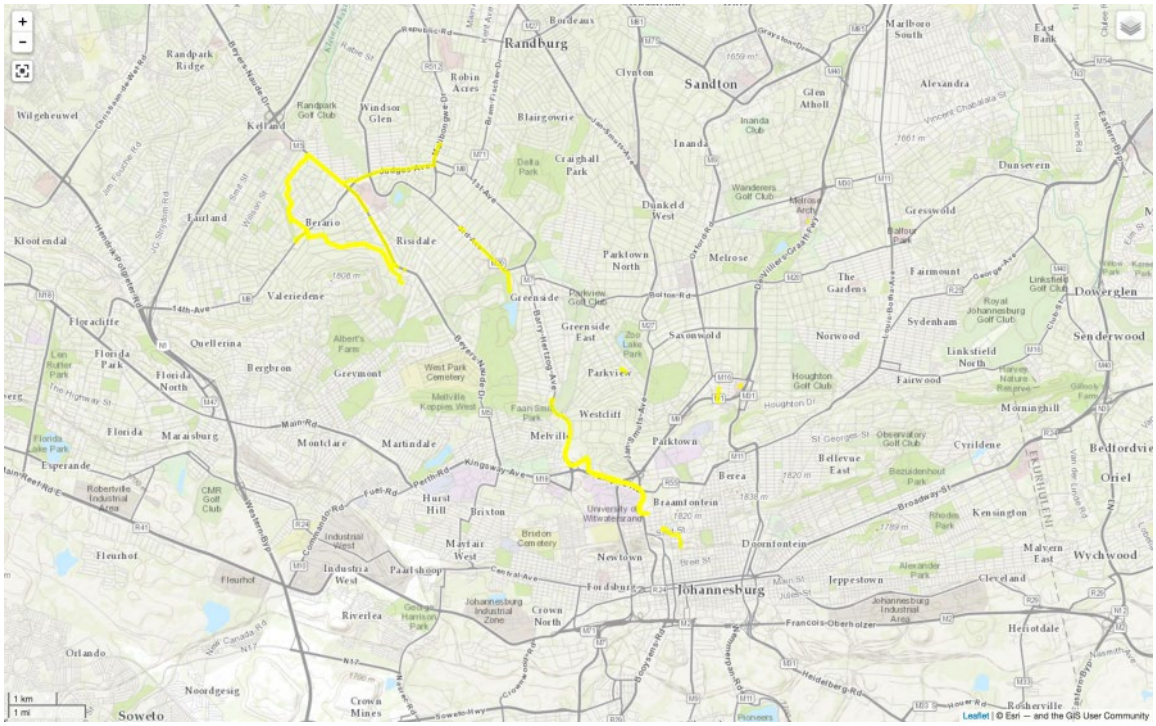


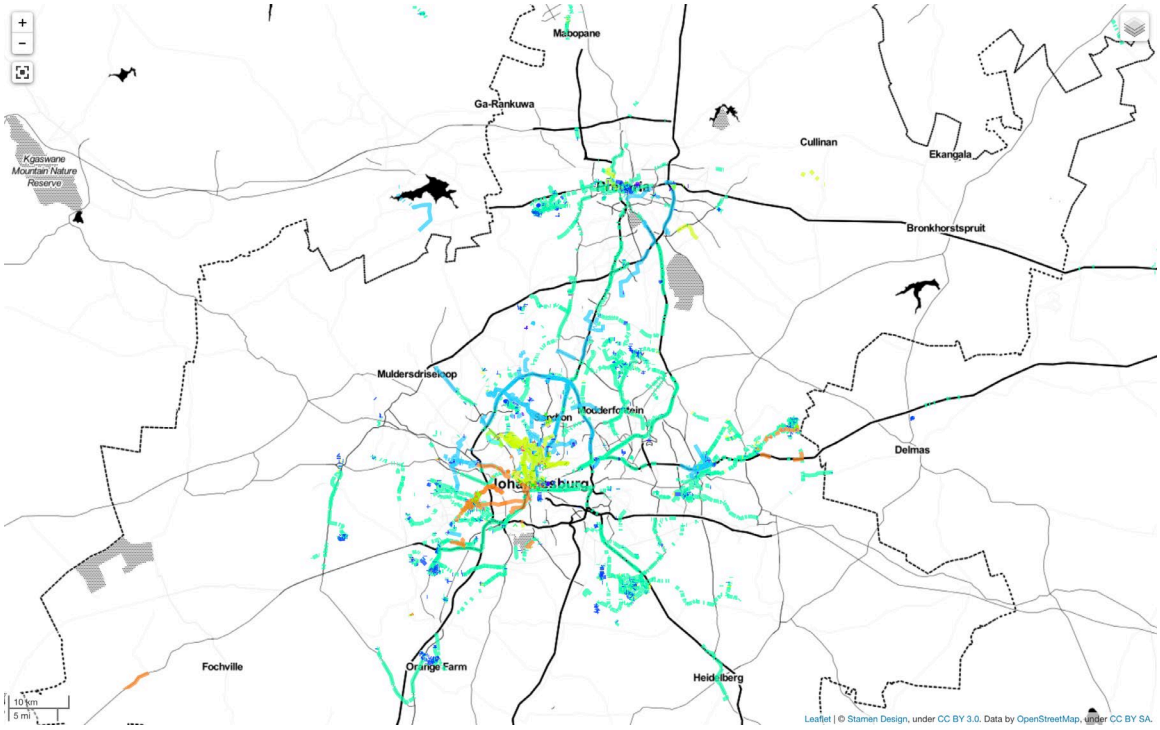
Figure 13. Participants identifying as White using cycles from 15 November to 15 December 2016.



2. Income inequality is correlated with activity space in two primary ways: range of movement and regularity of movement.

The movements of a participant in this project reflect not just the physical amount of travel they undertake, but also their socio-economic circumstances. The maps also contain survey information with the lines generated by the data visualization tool: each length of a trip represented by a line therefore has the potential to create a representative snapshot of the social structures in the GCR. To understand how the different aspects of movement interact with this demographic information, an *activity space* was calculated (Axhausen 2006). The activity space of the overall sample comprises the total trip length, time, and the mode. After this was calculated, the exercise was repeated by the demographic characteristics of race and income. These maps reflect the aim to shed light into what contemporary inequality looks like in the GCR; it is possible to create a customised range of maps with the data visualisation tool.

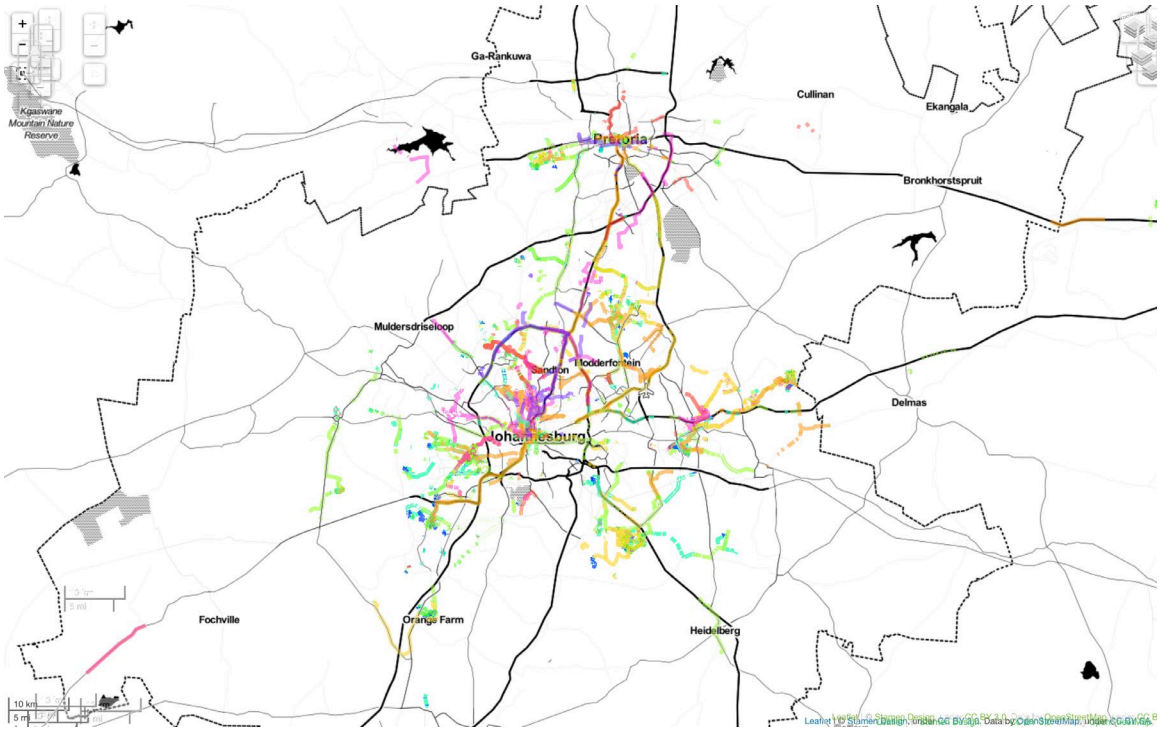
Figure 14. Total movements by racial group from 1 November to 1 December 2016. The modal bright green/dark blue tones indicate the African race, light blue indicates White, orange is for Coloured and yellow is for those identifying as Indian/Asian.



The everyday patterns of the sample reveal that the total amount of travel time does not tend to reflect poverty—but a wide and irregular distribution of destinations does. This is referred to as the range and regularity of movement throughout the GCR.

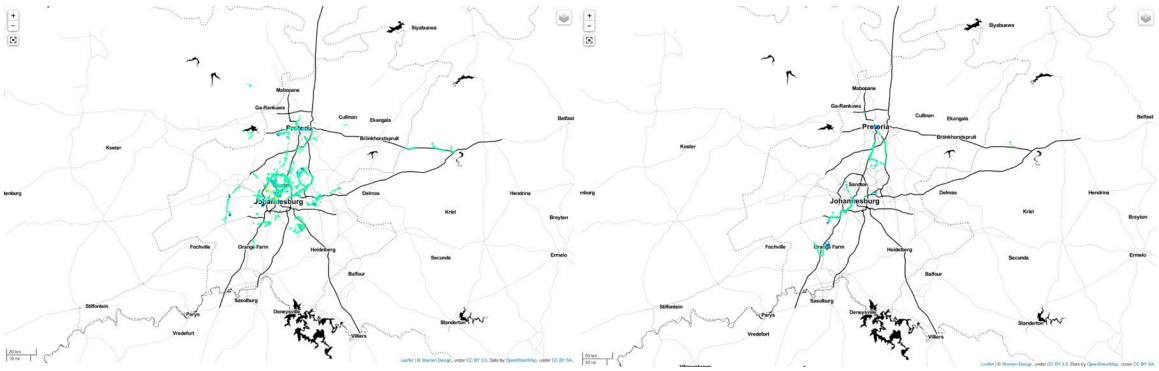
Figure 15. Total movements by income group from 1 November to 1 December 2016. The modal bright green/dark blue tones indicate a monthly income of R0-R1 600, light green is R1 601-R3 200,

light orange is R3 201-R6 400, dark orange is R6 401-R12 800, red is R12 801-R25 600, pink is R25 601-R51 200 and purple indicates a monthly income of more than R51 200.



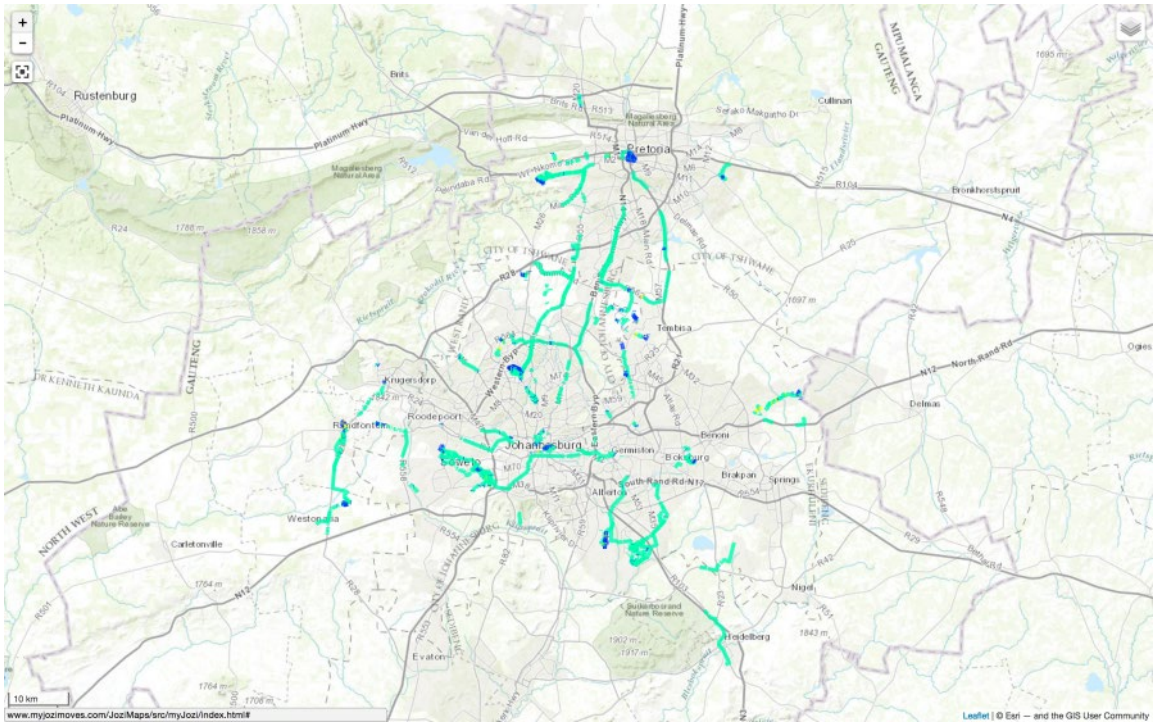
While much more information about the movements of the various income groups can be gleaned from the data set, depending on the research question targeted, even this overview provides insight into the spaces through which various groups move. Filtering by another layer, for example with employment, is also possible to investigate the contemporary picture of inequality as a function of mobility.

Figure 16. Participants employed full time in the formal sector (top left) compared to participants employed full time in the informal sector (top right). Filtered by further attributes such as race and income show the spaces of Africans earning over R51 200 (bottom left) and of Whites earning over R51 200 (bottom right).



For example, for participants with income levels of less than R400 per month, their levels of mobility were nearly stationary. However, once income began gradually increasing, so did the level of mobility. Peak activity spaces were generated by the income segment of R1 600 to R3 200, after which the size gradually decreased again. This phenomenon did not necessarily correspond with job seeking, but applied to participants across the board regarding employment level and race. What did correspond to employment was the regularity of movement. These participants were primarily travelling to destinations in the Johannesburg and Germiston industrial areas.

Figure 17. Low-income pathways. All participants earning R1 600 to R3 200 from 1 November to 1 December 2016.



The regular activity space of those earning between R1 600 and R3 200, proportional to their income, is significantly larger than any of the other income groups, encompassing expansive daily commutes and high costs of travel. Walking is higher in both of these categories than in the highest income groups; it also occurs under everyday rather than leisure conditions, and is more extensive. This has potential applications for policy. For example, it indicates that locating more affordable public transportation in their areas could effectively target these populations, or creating incentives for companies to locate the kinds of jobs they are seeking

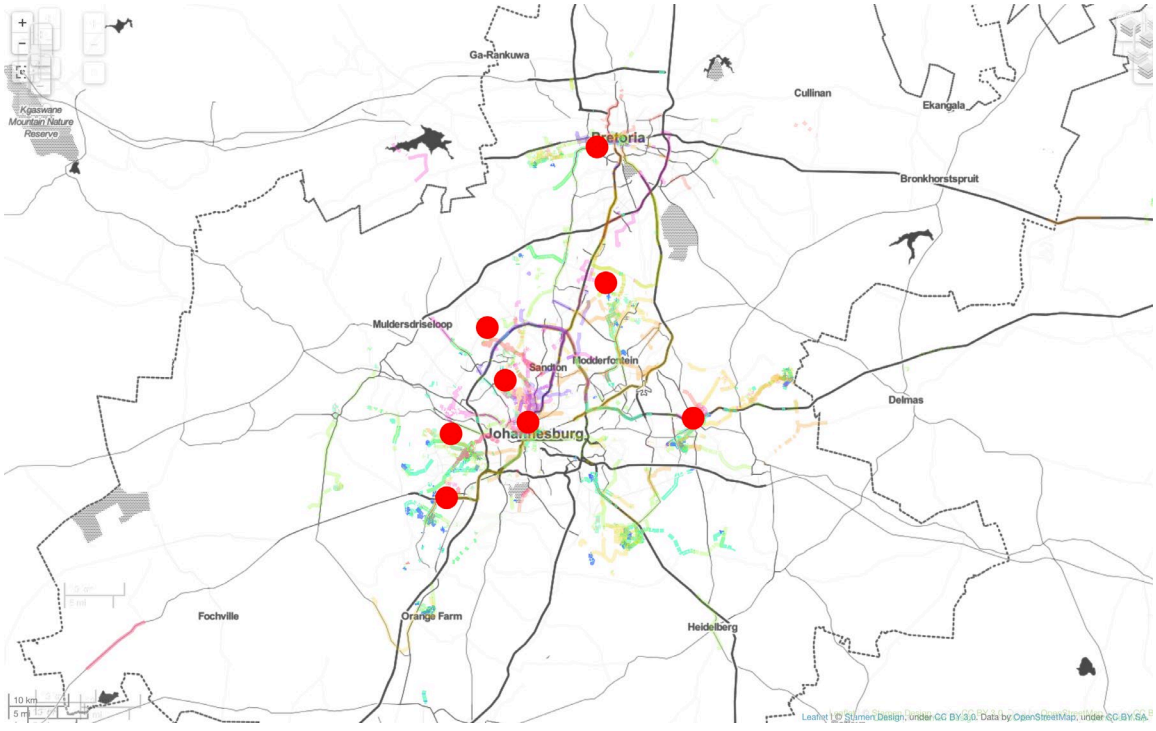
in their areas. While this information can also be derived from more traditional surveying methods, here, the specific pathways and potential nodes can be easily located in space.

3. There are almost no spaces of nodal encounter between demographic groups.

Across the sample, and throughout the course of the study, few spaces of encounter between demographic groups were recorded. 'Spaces of encounter' refer to places in which difference between groups can emerge in a democratic manner (cf. Merrifield 2013), which is essential to the equal representation of those residing in an urban area. Demographic groups still remain highly fixed to single modes of transportation, in which no nodes overlap with other modes or demographic groups.

It is common knowledge that the mini-bus taxi system transports much of the population from former township areas. As also indicated by recent Quality of Life Surveys, perceptions on transportation are slowly beginning to change (GCRO QoL 2015). Where once low-income trips were almost solely executed by taxis (or state-financed bus travel from extremely peripheral areas), people are increasing their use of BRT across the GCR. Users of the BRT and Gautrain were not as effectively targeted for this study, in part because underground train use complicates collecting data based on a mobile signal, but it bears further study to see how this efficient and more sustainable form of transportation is beginning to impact the GCR.

Figure 18. One possible application for the collected data is to determine where in the GCR different demographics could potentially encounter one another. The red dots indicate interstices where different income groups in the study were in near proximity to one another. Utilising the data visualisation tool, these points can be investigated in further detail as potential locations for interactions, such as transport nodes or government services.



This is particularly true because modal change nodes can also act as public spaces for exchange and encounter. Establishing such moments of encounter is key in addressing inequality through planning, and could become an express objective of transportation planning. For example, government services could be planned at nodes, also encouraging

businesses that span demographics and provide the physical space for different social groups in an urban environment to encounter one another.

3.3 Micro-analyses

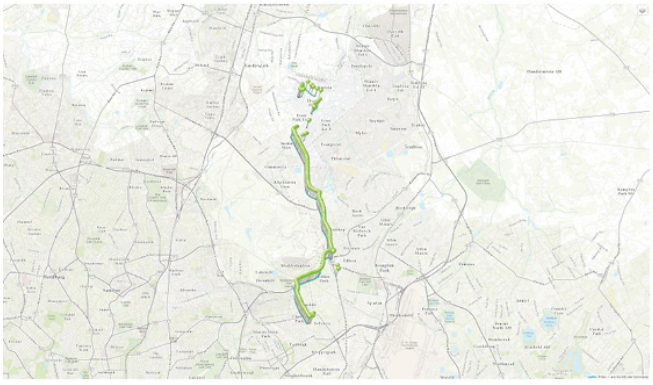
After analysing the overall results of the sample, some of the individual participants' pathways emerged as particularly representative of movement in and around the GCR. One was particularly captivating, as it showed long and repeated movement between the provinces of Mphmalanga and Gauteng. Because the smartphone methodology can operate on multiple scales, further research was conducted into the story of this particular participant, whose contact could be isolated from the details voluntarily provided in the application. The name Lindiwe has been provided to protect her identity, as agreed during the interview process, and her story is narrated below.

Lindiwe is thirty-six years old and calls multiple places in the urban region home, a poignant reminder that the commuterised patterns of apartheid relegations persist in the urban fabric today. She grew up in a small Setswana-speaking village named Seabe, located in the contemporary province of Mpumalanga, northeast of Pretoria near the intersection of the Gauteng, Limpopo, and Mpumalanga Provinces. A series of villages exist along this strip between Pienaarsrivier in the west, on the N1, and the former Bantustan of KwaNdebele, approximately a 30-minute drive away; this strip of land was the easternmost islet of Bophuthatswana. Lindiwe's parents were not farmers by nature, and the fact that their village was part of a Bantustan meant that they typically applied for work permits in Pretoria, travelling there with state-subsidized buses. Now, Lindiwe splits her life between her family in the former Bantustan, as a periphery-beyond-periphery of the GCR, and the rest of her family in Tembisa, in Ekurhuleni.

She and her husband are both from Seabe, and now have a house on the land given to his grandmother during the apartheid restructuring of rural space. As noted by Desmond (1971), the relocations for example to Bophuthatswana received little public attention at the time, aside from activist groups. Relocations were so peripheral that they had little impact on the daily lives of the white and urban populations. Similarly, the people that commute on a daily and weekly basis from these spaces into the GCR today remain largely invisible.

As the GSDF (2013:6) states: 'To the north east of the province lies a vast expanse of semi-urban settlements that are functionally connected to the Gauteng economy by subsidized bus transport routes that have historically ferried thousands of workers into central Pretoria on a long-distance daily commute'. Lindiwe typically commutes to Pretoria Central, where she is self-employed registering businesses with the South African Revenue Service. She can only work a maximum of four hours per day in Pretoria, because she travels over three hours in each direction to get there from Seabe. She typically departs at 6.30, and catches a taxi within fifteen minutes. The taxis either go west from Seabe to the N1, and then south to Hammanskraal, or wind southwest through a series of villages and the Dionkeng Game Reserve to Hammanskraal. The former route is approximately ninety kilometres and the latter eighty-five; it takes approximately one-and-a-half hours either way. Lindiwe prefers to take the route through the game reserve, explaining that she sometimes sees animals there. Giraffes and antelope are visible often; sometimes, in the morning, lions can even be seen warming their bodies on the street pavement. There is no cost to enter the reserve for less than thirty minutes, so the taxis take a ticket and pass through the area.


Unnamed Road
2 h 29 min
171 km
3 h 7 min
200 km
2 h 8 min
152 km
207 Thulare Street

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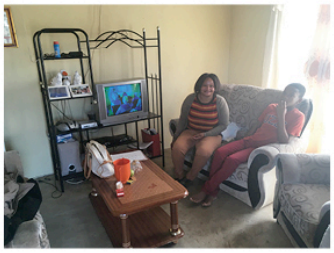

Parts of Lindiwe's journey were difficult to monitor, because she had no mobile signal. Between Seabe and Hammanskraal, she regularly loses service, and her modal lines re-emerged when she neared Hammanskraal. There, around approximately 8.15, she transfers taxis within ten minutes and continues to Pretoria. Lindiwe wishes the train were still running, because after this section, traffic increases exponentially and her arrival time becomes unpredictable. 'But they had to close it down, because of violence', she continues, 'because too many people were getting stabbed and robbed'. Depending on traffic, these final fifty kilometres in the taxi typically require anywhere from an additional forty-five minutes to an hour-and-a-half. This trip crosses through all three provinces, and Putco-brand buses follow the same routes as the taxis to the villages. Both systems cease running relatively early in the evening due to the one-dimensionality of the commuter flows. As such, Lindiwe must depart Pretoria by approximately 14.15, such that she can get a taxi from Hammanskraal by 16.00. If she misses the last taxi, she may be stranded there until the next day.

During the majority of the smartphone study, Lindiwe temporarily resided in Tembisa with her husband and eldest daughter just prior to becoming self-employed. Her two sons remained in Seabe with her husband's mother, and she travelled home once a month to visit. Lindiwe's husband, Thabo, has been living separately in Tembisa for twenty years and working as a gas station attendant near the airport, earning a steady salary of 3 000 Rand per month. Their daughter works as a waitress in a Midrand restaurant earning 4 200 Rand per month. At the time, Lindiwe worked at MECS Contract and Manufacturing in Sebenza, near the airport in Ekurhuleni, managing government contracts for RDP houses and earning 2 600 Rand per month. With a household income level of 9 800 Rand, they could easily pay their rent in Tembisa, daily living expenses including transportation, and save enough money to expand their property in Seabe. This is precisely what they did, and Lindiwe moved back home after a new two-room house was completed just before Christmas in 2016. Out of twenty-seven days she reported data points during the study, seventeen consisted of visits to her office, three were travelling to Seabe, and one was at The Boulders mall for Saturday shopping.

This kind of commuting exists at extreme peripheries all around the GCR. Villages without self-sufficient economies, particularly in the former Bantustans, were inherent to the apartheid strategy and these patterns of development persist today. They remain tied into commuter networks; as long as a taxi drives there, it is connected to the urban region. This phenomenon calls into question where the boundaries of the urban region actually exist, because these villages, with populations typically of several thousand residents (Firth 2011), are also relevant to the everyday production of the region. The damaging spatial legacy of apartheid did not only affect the territorial formation of space, but had a significant impact on family structures and individual lives. Lindiwe and her family represent this disjuncture in lived space, permanently locked into separate lives and cycles of semi-migration.

4. Evaluating the use of VGI in the GCR

The goal of conducting this research was to see what sort of information could be garnered through volunteered geographic information (VGI), such that it could become more useful for concrete planning initiatives. These policies should be more thoroughly grounded in the everyday lives of the *representative majority* of area residents. Envisioning a more equal, 'good' city (Amin 2006) relies in such more inclusive means of not only interpreting but also producing data (Howe 2017). While it has been postulated that immobility is one of the main causes of social exclusion (Massey 1994), these findings (and numerous other studies of the GCR) indicate that mobility alone is not enough to redress entrenched spatial inequality. It is not just access, but *equal* access to valuable parts of the urban area that counts. As noted by Rokem and Vaughan (2017:6): 'Social inclusion is about being a part of the networks that matter to the persons involved…depending on the extent to which transportation connects to certain parts of the city and not to others'. In an urban area like the GCR, where historically underprivileged populations remain located on the peripheries and must seek opportunities in more central areas, improved mobility alone is not sufficient to significantly shift patterns of inequality. This is particularly true when considering inequality in terms of access and opportunity, and whether they result in urban areas that promote co-presence through spaces of encounter. The findings of the study show that, despite its experimental nature and the specific limitations of the applied methodology, VGI does have significant potential to contribute to discussions on the GCR and on other urban areas worldwide.

4.1. Challenges and lessons learned

As discussed in the implementation and results, the primary challenges of conducting a smartphone data collection project in general are threefold: the reliance on mobile phone signal strength, human error with technologies, and issues of recruitment and motivation. Most issues were related to technological errors within the first two categories, including categorically weak signal areas and relatively simple mistakes by first-time smartphone users, for example, accidentally turning off the data bundle. This requires that a certain level of people-management is available, or for more advanced users, that an effective self-help function is integrated into application, as was the case with myJoziMoves. The recruitment and motivation issue is centred on the fact that the higher level of social cohesion any sample has, the more likely they are to use the app on a daily basis. For example, the sample of 30 participants in 2015 regularly encouraged each other to participate, checking in with one another on Whatsapp and sending photographs of their lives, and kept in touch long after the study ended. The research team had a personal relationship with each participant and visited most at the homes, so they were well versed with the purpose of the research and understood their role was in the project.

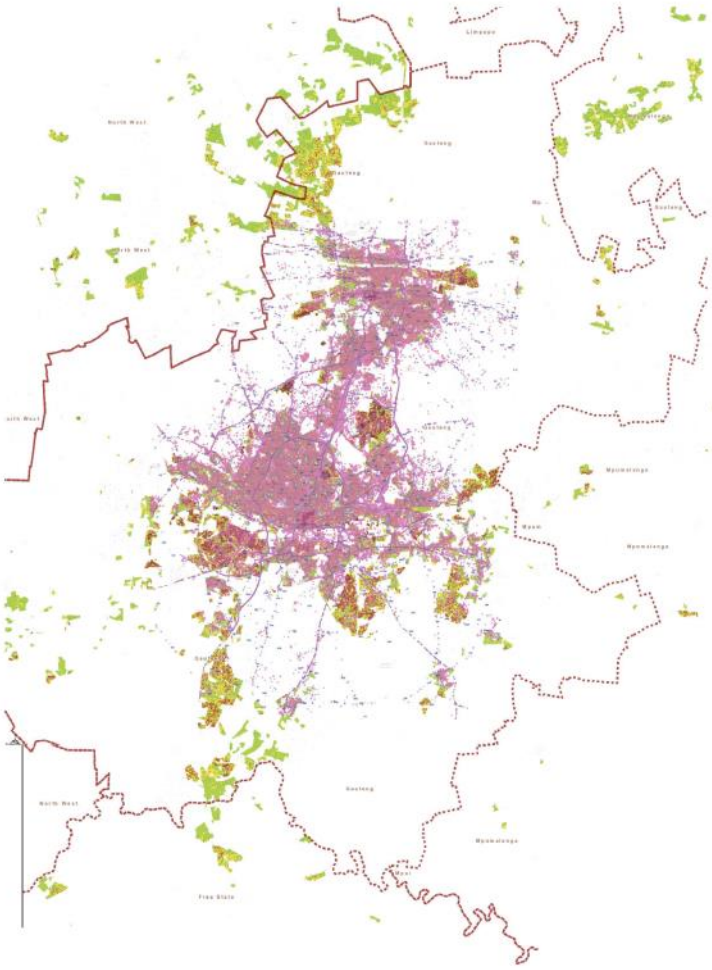

Figure 19. Map comparing the concentration of poverty in the region with the strength of cell phone signals. Signal strength from opensignal.com. Map base by the Gauteng City-Region Observatory 2015, based on Quality of Life census data from 2013.

When scaling-up the project, the previous approach of personal contact was included as far as possible by designating 10 local area leaders, many of whom participated in the previous round of research, who met at Planact to establish a baseline of social cohesion. What was significantly more challenging was motivating additional demographic groups, without a personal connection and little or no personal management to the project, despite prize money. While most of the Planact group participated for over 20 days, in non-managed segments participants either had very high participation rates or ceased participation after just a few days. In the future, the approach must incorporate a marketing strategy for a smartphone application rather than a research recruitment strategy. The recruitment team also suggested that, in the future, free Wifi hotspots could encourage contacted users to download the application in-person; offering the platform on additional operating systems (Blackberry and iOS) would increase the overall number of participants; and finally, that direct interaction yielded the best results. It was easier for the team to explain the value of the project in person than with other means, according to Ms Koma and Mr Manyaka.

Because of these factors, the overall sample size remained at 368 participants. However, in light of the experimental nature of the project, the commitment required for participants, and the personal nature of the data collected, the research team was pleased with this selection. The spatial distribution of the participants, and the fact that the study largely reflects the

demographics of the Gauteng City-Region, are further positive aspects of the study that allow it to remain grounded in local realities. The maps visualised from the dataset show reveal clear patterns of inequality in regard to mobility, and can act as a starting point for discussion on the future direction of transit planning—as well as financial investment in nodes and services—that reflects these everyday movements and spaces.

4.2. Policy implications

A collaborative and cooperative approach to urban development, while by no means straightforward, could be promoted through further understanding of mapped everyday realities. Collecting VGI, gathered directly from residents of a region themselves, could be used to facilitate communication in the future and re-frame how maps are made. Citizen engagement in planning data could represent a new paradigm in the Gauteng City-Region. Moreover, a plethora of additional questions can be pursued in more detail, with the visualisations resulting from the data collection process, such as:

- Where are transfer points and where do modal switches occur?
- Where do different demographic groups overlap?
- Where are potential linkages to opportunities?
- Where are people making pragmatic choices about transit and where could public make more of an impact?
- Where are spaces of urban encounter?

These considerations could have implications for policy development and implementation to shape a common vision for the city-region in the future.

With the information that has been gathered in this study, there are three potential 'moments' of policy intervention that can be formulated to contest inequality: creating transit typologies, determining public infrastructure, and planning public spaces of encounter. The first is the potential to conduct a thorough analysis of what can be described as *transit typologies* based on the information. At present, labels such as 'commuter' or 'black' tend to be homogenizing and are oversimplified—as the narrative of Lindiwe in Seabe demonstrates, simply referring to her as a 'commuter' does not come close to revealing the impact transit has on her life, and the many who travel daily in and around the GCR. In order to describe these everyday movements, new categories should be developed. Because VGI can enrich transportation data collection with much more concrete detail, it could be extremely useful in developing these transit typologies, and using them as the basis for planning. The extensive and meticulously executed Quality of Life surveys conducted by the GCRO every two years could be supplemented with VGI to execute these tasks. Currently, their methodology utilizes questionnaires to focus on the most frequent trip taken under which transportation mode and travel time; the data thus reflects an average pathway 'as the crow flies' and an average speed of travel that cannot differentiate which modes are utilized at what times and locations. As such, if employed on a scale properly representative of the population, the application could potentially supplement QoL data with the exact routes, modes, and travel times of participants. This would greatly enhance the picture of regional mobility while involving participants in its creation, and is able to shed light into the hidden social codes that continue to permeate life in the GCR.

The second is the opportunities this kind of analysis creates for determining public infrastructure. For example, the taxi system is flexible and its passenger flows challenging to assess. VGI can shed light into the routes as well as well as the impact of this system on its riders, allowing more precise modelling. This, in turn, provides the basis for more informed

planning of public transport systems intended to incorporate (or incrementally formalize) this system. Initiatives such as transit-oriented development (TOD) have received significant attention across the GCR. This approach highlights the need for development plans thoroughly grounded in the everyday realities of the urban majority, such that capital investments are made into the routes and nodes that most address the needs of their population. Once statistically valid VGI analysis is conducted, and unique transit typologies established, infrastructure planning can determine the correct configuration of routes and programmes to connect a wide range historically marginalised areas. For example, a low-income settlement which is remotely located and largely comprised of people commuting like Lindiwe, requires not just another form of transport but also a completely different, holistic development approach than a settlement where residents commute to nearby job opportunities in Germiston. This can then be addressed by TOD policy in very specific detail.

Beyond creating more manifold possibilities for increasing individual mobility, public transit infrastructure can either segment populations or provide nodes for their encounter—spaces for both interaction and conflict are important in envisioning more equal future cities. This is the third major potential of VGI data: locating nodes that are utilized by multiple transit typologies, in order to plan new spaces of encounter. This is based around the aforementioned concept of *co-presence* as an important factor in assuring a 'right to the city' for anyone in the GCR. The idea of co-presence is grounded in the concept that general categories of urban residents will have different routines and movement, differing everyday lives. Spaces of encounter are where these differences are allowed to unfold and overlap, not just in a superficial sense, but also as a productive and interactive process between people (Sennett 1990). 'The potential for major public transport infrastructure to connect across groups and the opportunity for mobility to bridge across group difference establishes the problem of segregation as an issue of a lack of interaction and co-presence in public space' (Rokem and Vaughan 2017:2; Legeby 2013). Not only the design, but also the programme and functionalities available in public spaces can serve as a means to address socio-spatial inequality. It can serve as a basis for modelling access to key points of accessibility and nodes of encounter based on transit typologies: for example space syntax network (Vaughan 2015), movement interfaces (Hillier et al. 1987) or activity spaces (Axhausen 2006).

Mobility is an issue not only of urban development, but also of spatial and social justice. The GCR has a difficult hurdle to overcome, because the problems of socio-spatial segregation and unequal mobility are so entrenched. However, initiatives such as this project, which attempt to work directly with people and share their collective experiences of the urban, can contribute to the discourse on a more cooperative urbanism. Particularly the potential to create innovative categories of analysis, infrastructure planning, and social encounter can be used to envision and plan for the future of the Gauteng city-region.

4.3. Conclusion

Mobility trajectories and modes recorded with volunteered geographic information (VGI) reveal that transport paths and motivations for travel remain intricately linked to income level and race. This is a pressing concern for development planning, because it affects both environmental as well as economic and social sustainability. Sustainability, defined as development that meets the needs of the present without compromising the ability of future generations to meet their needs (UN 1987), is directly linked to questions of urban equality and access to the city (see also Brenner et al., 2011). The inequality of the Gauteng City-Region's socio-spatial structure, and the lack of nodal points where residents of multiple social milieus encounter one another, detracts from the city-region's long-term sustainability: a lack of equal access to resources calls into question the ability of this agglomeration to meet the

needs of current and future generations. This indicates that a city's *inequality footprint* can be an important tool in identifying the priorities that should be set in planning future development.

An inequality footprint could be defined as the extent to which low-income economic groups are concentrated as homogeneous enclaves and spatially isolated from centralities in the urban fabric. According to proponents of recent initiatives such as 'smart growth' and the 'compact city', a sustainable city has heterogeneous functions and short distances; it grows economically and spatially at a rate that does not endanger the ability of future generations to meet their needs (Farr, 2007; Danzig et al., 1974; Duany, 2000). However, these recent studies show that sustainable cities must also use urban development to actively contest its inequality footprint. To do so, urban researchers are debating strategies for retrofitting, or redeveloping, the existing urban fabric rather than allowing spatial patterns to continue. Planning experts have asserted that this process requires more than just integrated designs and the dense redevelopment of urban areas; rather, it requires careful study of a city's unique patterns and qualities, through thorough investigation of everyday lives. However, they also point out that many such elements remain to be concretely defined, and it is also unclear how to ensure that aspects like a dialogue with local communities or flexible plans can be observed over the course of long, complex planning processes (Noack, 2013). As such, the three pillars of sustainability concept – environmental, economic, and social – can be extended to the formulation of a concept for reducing a city's inequality footprint. A sustainable city must seek short distances for daily routines (Williams et al. 2000), for both the privileged and the urban poor. It must protect its least advantaged residents and evaluate its success based on the improvement of poverty (Iveson, 2009). Finally, it must embrace the *kinetic* and ephemeral informal city, rather than imposing master plans or general policies that ignore the importance of local spaces and associative values (Mehrotra, 2012).

It is at the interstice of these ideals that VGI can have the greatest impact. Because mobility is such a defining characteristic of urban areas, making new centralities possible and relegating other spaces to the periphery, understanding the everyday patterns and modal choices of a regional population is crucial to equitable urban development. Not only does VGI represent the chance to collect transit information in a much more detailed way, it also presents the opportunity to re-think the function of the map as a collective, social enterprise rather than an abstract, expert tool. Geertz (1988) describes culture as both a product and process of appropriating the surrounding environment; however, those residing in conditions of poverty lack influence on their present circumstances and are often excluded from determining their future. Incorporating, in particular, the needs of the least privileged into planning decision-making is therefore a positive step in maintaining a balance between economic, environmental, and social equity interests in pursuit of sustainable urban development.

Finally, if mapping as a social enterprise has the potential to displace the long-standing notion of a map as an authoritative power source, mappers must continue to critically reflect upon the viability and value of VGI data. It is in revealing subtleties that mapping becomes such an important tool for development and empowerment through the self-reflexive awareness of ingrained socio-spatial patterns. In mapping the landscapes of poverty and difference, one calls into question the basic constructs of administrative authority and, furthermore, questions the boundaries and definitions of the urban itself. Perhaps this inclusive intent of data collecting and accessibility of output represents the next stage in the cultural production of mapping: where geospatial sciences and visual reproductions are fused through the social enterprise. This kind of methodology is at the interstice of statistically representative and

qualitative data: as this study shows, people-driven data collection is unpredictable and can yield unexpected results. But its power to enhance existing methods and research questions indicates its value for understanding the everyday manifestations of the urban in city-regions today.

5. Project photographs

Figure 20. Team meeting. The research team and local leaders at the introductory workshop coordinated by Planact in the Johannesburg CBD.

Figure 21. Networking. The recruitment team participating in the Kasi to Kasi Challenge on the Rea Vaya sponsored by the City of Johannesburg.

Figure 22. Project preparation. Local leaders train their selected participants and draw a crowd in Vosloorus.

Figure 23. Photo sharing. Members of the Planact-managed group shared photographs of common challenges such as dumping, inadequate sanitation, safety concerns and transportation issues.

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