Using participatory GPS methods to develop rich understandings of people's diverse and complex livelihoods in the global south

Book or Report Section

Accepted Version

Chapter 14 Using participatory GPS methods to develop rich understandings of people's diverse and complex livelihoods in the Global South

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Abstract

This chapter will explore the use of participatory GPS in relation to livelihoods and their associated mobilities in global South contexts. Recent advancements in GPS technology have presented exciting opportunities for social scientists to expand their 'methodological toolkits'. These methods have been innovatively adapted in diverse ways to promote participation. A critical overview will be provided of the literature on livelihoods and mobilities which have used various GPS-based approaches. This will include an assessment of their opportunities and challenges, as well as discussions on the ethical considerations that should be made prior to employing GPS techniques in research. Previous studies which have utilised participatory GPS have gained detailed insights into people's spatial knowledges and strategies which they draw on in relation to their complex livelihoods. These understandings have been crucial in advancing both theoretical and practical interpretations of the multifaceted nature of income generation. As contemporary challenges such as high rates of urbanisation and climatic changes continue to impact populations across the global South, it will be crucial to draw on these knowledges whilst also continuing to develop and employ participatory GPS methods for future research into how livelihoods are sustained and adapted in response to these vicissitudes.

Introduction

Recent advancements in GPS technology have presented exciting opportunities for social scientists to expand the methods they use in their research. This chapter provides a critical overview of literature employing Global Positioning System (GPS) method approaches to develop insights into livelihoods and mobility. Opportunities and challenges of using GPS techniques in research are reviewed, as well as ethical considerations that need to be assessed prior to their employment. In response to an uptake of participatory approaches in development-related research, some, although not all, social scientists have begun to innovatively adapt these methods to promote the input(s) of participants in research processes who rely on mobility to undertake their livelihoods. Discussions in literature highlight how detailed insights into people's spatial experiences, knowledge and strategies in relation to their livelihoods can be gained through application of participatory GPS approaches. This is important so that theoretical and practical interpretations of the multifaceted nature of people's livelihoods can continue to be advanced. Moreover, as contemporary challenges such as high rates of urbanisation and climatic changes continue to impact populations across the Global South, it will be important to understand how livelihoods are being sustained and adapted in response to these vicissitudes; the chapter explores how participatory GPS approaches can be used to develop these understandings.

GPS use and developments in research practice

Originally used for military purposes, GPS technology is now widely available for public use and has been extensively employed in empirical studies over the last few decades (Shoval et al. 2018). This technology has enabled researchers and members of the public to produce high resolution spatial and temporal data of both human and object movements (Goodchild, 2007; Shoval, 2008). Understanding time-space patterns has been of particular interest to social

scientists, and the employment of GPS methods has been especially beneficial to geographical and mobility research (Janusz et al., 2018). These methods have allowed for locational information of local environments to be produced (Oloo, 2018), and for people's individual patterns of movements to be greater understood (Oyana, 2017). As time has passed, GPS technology has advanced considerably and has become increasingly more affordable and easier to use. This has increased possibilities for research.

Contemporary GPS tracking

Dedicated GPS loggers have been used to track people's movements in a vast number of studies. However, these devices have been critiqued for being overly specialised and expensive (Lee et al., 2015), which has limited their use within social science research (Jones et al., 2011; Shoval et al., 2014). In recent years, advancements in smartphone technology have shown potential in being able to address these abovementioned drawbacks. Compared to stand alone GPS devices, contemporary smartphones are relatively inexpensive (Korpilo et al., 2017) and they have the capacity to run numerous mapping applications which can be repaired, replaced and updated with little cost and effort (Lee et al, 2015). GPS apps can also record multiple data in relation to movement such as the actual distances travelled, the time it took to complete a journey, the route taken and the destinations that were visited (Joseph et al., 2019). This is possible because modern smartphones have several embedded sensors that include technologies such as GPS, Wi-Fi positioning, accelerometers, gyroscopes, magnetometer, microphones and cameras (Birenboim and Shoval, 2016). These additions have also presented opportunities for real-time data to be collected through GPS enabled smartphones (Ibid). In turn, this can afford deeper understandings into people's mobile lives (Evans et al., 2018; Shoval et al., 2018).

In terms of accuracy and sampling rate, it had been identified that dedicated GPS devices had more superior GPS capabilities than smartphones (Birenboim and Shoval, 2016). Yet, this gap has narrowed over time, and recent research has shown that smartphone-based GPS apps are able to produce accurate and detailed spatial and temporal information (Korpilo et al., 2017). Using these smartphone-based applications also requires less expertise than is required to use a GPS device, which makes it more accessible for both researchers and participants to engage in spatially contextualised research (Jones et al., 2011). However, researchers must also be mindful not to exclude participants by using approaches which demand smartphone ownership (Birenboim and Shoval, 2016; Joseph et al., 2019). Although smartphones are becoming cheaper throughout global South contexts, there are still many who do not have access to such devices. The later sections of this chapter detail the ways in which smartphone-based GPS methods can be adapted so that participation can be promoted and sustained.

Using GPS technology to develop livelihood mobility research

The development of GPS tracking methods in research has coincided with a conceptual turn within the social sciences, the 'new mobilities paradigm', which emphasise the need to move beyond an over reliance on sedentary research practices within academia (Kusenbach, 2012). Previous approaches were critiqued for being unable to understand people's diverse and complex movements, and the connections that people have with local environments (Sheller and Urry, 2006). Consequently, social scientists have innovated their methodologies so that participants' mobilities and their engagements with different spaces can be better understood (Hein et al., 2008). Innovative GPS approaches, along with developments in mobile methods, have proliferated allowing social researchers to advance insights into people's diverse lived experiences as they perform different types of mobility across time and space (Jones and Evans, 2012).

Yet, contemporary mobilities research has been slow to investigate the interrelationship between livelihoods and mobility. As Esson et al. (2016: 187) claim, 'the new mobilities paradigm itself neglects the essential livelihood dimensions underpinning much mobility'. This is surprising, given that almost two decades ago research recognised that livelihoods and mobility intersect in multiple ways (Bryceson et al., 2003). It has also been widely acknowledged that mobility supports and defines livelihoods, especially across the Global South (Gough, 2008; Rigg, 2007). Within these contexts, there has been a growing number of contemporary studies which have begun to advance insights into people's livelihood mobilities through using GPS methods. These have identified the importance of mobility in relation to livelihood strategies, as well as the role of mobility in shaping people's work opportunities and challenges (Janusz et al., 2018; Naybor et al., 2016). Other research which has used tracking technology has also highlighted that mobile livelihood practices, such as transportation services, are a crucial component to the survival and development of many communities (Evans et al., 2018).

Nevertheless, more research into people's mobile livelihoods across Global South contexts is required (Lund, 2014). To date, much mobility theory has been founded on understandings developed in the Global North (Esson et al., 2016), which cannot adequately represent mobility experiences and practices in the Global South. Mobility is socially and culturally constructed, meaning that it is experienced differently depending on factors such as a person's age, gender, class, ethnicity and geographical location (Lund, 2014). As such, the mobilities people undertake in relation to their livelihoods will differ enormously depending on who they are and where in the world they are. The following discussion explains how GPS methods can be used

to highlight the heterogenous and context specific nature of people's mobile livelihood practices.

Contextualising GPS data

Although GPS methods can allow for accurate and high-quality data to be produced, this technology does not ascribe meaning(s) to the data (Christensen et al., 2011). If an itinerant vendor's route is being tracked for example, a geographical pattern of this will be produced. However, this alone cannot reveal why this person chose to walk the route they did, nor will it be able to detail the environments that they walked through and their experiences of these (Christensen et al., 2011). For this reason, researchers have been using methods such as participant observation and go-along interviews in combination with GPS tracking to contextualise maps. Situating themselves within the environments through which participants navigate can afford researchers richer insights into livelihood mobilities and practices (Janusz et al., 2018). Naybor et al. (2016) integrated GPS tracking with several methods including ethnographic observation and participation to contextualise women's livelihood patterns in rural Uganda. Through this approach, they observed that it was common for these women to carry on foot the crops and other goods they wanted to sell. The women were physically limited by the amount of stock they were able to carry, therefore they had to make multiple trips which resulted in them tiring thus restricting the distances they were able to walk. The authors note that this forced them to sell their goods to nearby friends and neighbours at lower prices than they would have been able to get if they could travel further distances to markets. Used alone, GPS tracks would not have been able to produce this level of detail.

However, researchers do not necessarily need to be present for a detailed context of people's spatial journeys and experiences to be gained. Birenboim and Shoval (2016) claim that

smartphones offer exciting opportunities through which contextual information and subjective insights into spatial journeys can be obtained. Self-reporting on smartphones has been recognised as a useful technique in combination with GPS tracking, which enables participants to report what they see, smell, hear, as well as how they feel, as they move through certain places (Birenboim and Shoval, 2016). This method has shown to be useful in understanding mobile experiences which are marked by irregularity and changeability (Sugie, 2018). Additionally, surveys can also be used on a smartphone device with participants, which can be triggered by location and/or time of day (Shoval et al., 2018). Advancing technology is giving researchers opportunities to be creative and innovative with GPS methods, which is furthering understandings into how people engage with, and interpret, the spaces they traverse (Jones et al., 2011).

Participatory GPS approaches

Participatory research places emphasis on working 'alongside' people and communities so that their knowledge and experiences, as well as the issues that are of concern to them, can be understood (Kesby et al, 2005). According to Oyana (2017), GPS methods offer unique opportunities for participants to actively engage and contribute to research processes. Little expertise is required for participants to be involved in these approaches, which can be beneficial for promoting high levels of participation within research (Jones et al., 2011).

In Global South contexts, participatory GPS approaches are starting to be used more frequently to understand people's livelihoods. Navarrete et al. (2017) undertook research around the Spermonde Archipelago, Indonesia, where they equipped artisanal fishermen with GPS devices so that they could map their spatial fishing practices. The authors note that the fishermen were keen to play an active role in this study, because a lack of regulation in this area had led to

ecosystem degradation which threatened the future of their livelihoods and others who lived in surrounding local communities. The data which the fishermen played a vital role in collecting, produced findings which could then be used to inform policies and/or management strategies in the region.

In Brazil, Offenhuber and Lee (2012) employed participatory GPS mapping with informal recyclers, locally known as ‘catadores’, so that they could understand the detailed knowledge of the city which these workers possessed. This approach allowed the tacit knowledge of the ‘catadores’ to be documented and mapped in ways which was explicit and accessible to ‘everyone’, including the workers themselves, and to leaders and policymakers who it was hoped would be able to offer them support. Participatory mapping helped to validate the work of these informal recyclers by demonstrating the vital services they provide throughout the city. This was crucial, because often these workers are criminalised as they do not fit the modern image that many cities are trying to create (Offenhuber and Lee, 2012), thus mapping was able to show the work the ‘catadores’ do from a different perspective, marking their place in the city.

Similarly, Lee et al., (2015) undertook research with informal waste pickers in Mombasa, Kenya, who used their own mobile phones to map the routes they undertook. Through visualising waste pickers’ routes, it was revealed that in certain areas of the city they had to walk long distances to reach open dumping points. Thus, this information suggested that open dumping points could be more equally spread throughout the city, which would save the pickers both time and effort whilst undertaking their work. The visualisation of these journeys also promoted participatory dialogue between several actors (waste collectors, municipal authorities

and communities) in this study, regarding current practices and challenges of waste collection, as well as the future directions that should be taken in relation to waste management in the city.

In the above examples, participatory GPS was used in ways which can promote dialogue regarding context specific issues which people face in relation to their livelihoods. In turn, this can lead to interventions which can help to tackle issues faced by certain groups of people and communities (Oyana, 2017). Policymakers and other actors are becoming increasingly interested in the meaning and value of spaces (Hein et al., 2008), and GPS applications are one way through which the realities that people face can be better understood and engaged with (Joseph et al., 2019).

Increasing participation: a case study from Tanzania

I undertook ethnographic research in Dar es Salaam and Arusha, Tanzania, for one year from August 2018. In this study I utilised a range of methods including participant observation, participatory diagramming, semi-structured interviews and mobile-based GPS tracking. I employed GPS mapping with 8 youth participants (aged 15-35) across both cities. This method was used to develop understanding into young vendors' experiences, knowledge and practices of itinerant street vending. However, because of funding constraints (Evans, 2016), it was not possible to equip participants with their own GPS devices and none of these 8 participants owned their own smartphones. I had to use my own personal smartphone device, which meant that I had sole control of mapping. Because of this, I would accompany participants during their working days, which typically lasted 6-8 hours, but could last up to 12 hours. I used Strava, a free mobile-based fitness tracking application, which I was familiar with prior to using it in the field. This application was also chosen as it was easy to use and provided a simple yet

effective visualisation of participants' routes. However, there are now an abundance of other free-to-download applications that are available to researchers for tracking purposes.

Mindful of participants' lack of participation in mapping their routes, I adapted the GPS method at later stages of the research process, to promote greater participant involvement. During follow-up interviews, participants were invited to annotate the GPS maps that had been created of their routes. Through prompts, I would ask participants whether their movements were strategized, why they chose to walk the routes they did and what parts of their journeys they found easiest/hardest, and why. This allowed subjective experiences into participants' livelihood practices and experiences to be gained (Birenboim and Shoval, 2016). The maps that were created were clear and appealing (Hansson and Roulston, 2017), which assisted participants in interpreting their routes and assigning meaning to parts of the city they navigated through (Offenhuber and Lee, 2012).

Figure 14.1 shows a map annotated by Godfrey (pseudonym), an itinerant vendor in Arusha, who sold oranges using a metal cart. In his map interpretations, Godfrey highlighted where he would expect to find customers whilst undertaking his route. Unsurprisingly, locating customers was a crucial aspect of his livelihood activities, and his knowledge of where they were most likely to be found determined which part of the city he would navigate through. In this instance, the location of customers gave meaning to his livelihood mobilities (Langevang and Gough, 2009). Furthermore, the value vendors assign to city spaces differs. Areas of the city which are beneficial for one business will not necessarily be good for another. GPS mapping and annotations can be used to capture this heterogeneity.

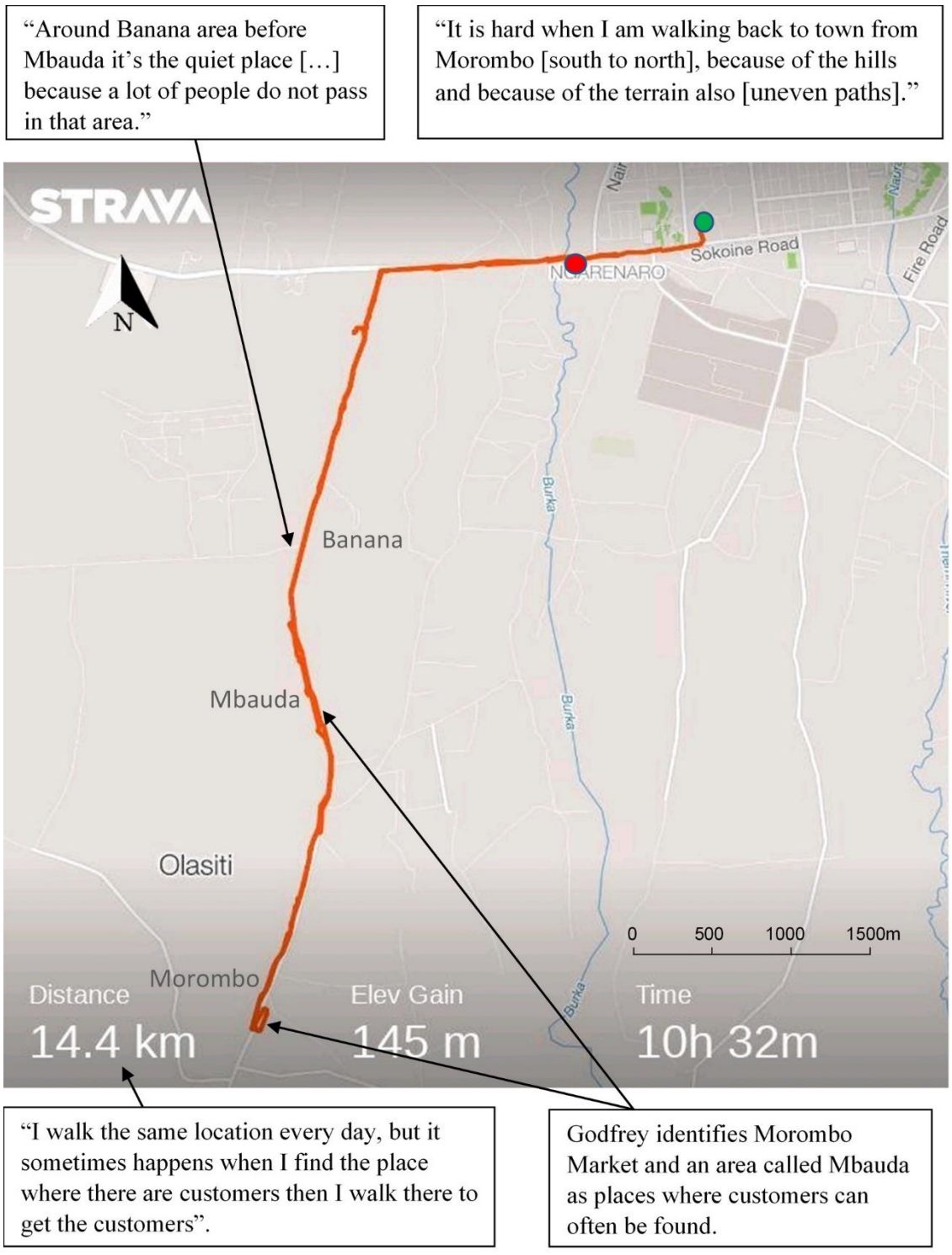

Figure 14.1: Annotated GPS map of Godfrey's route (an itinerant vendor who sold oranges in Arusha)

(Source: Author)

Godfrey's annotations also highlighted an area of the city which he found physically difficult to navigate, due to the steep hilly terrain he was confronted with. Godfrey's inclusion of these embodied encounters in his annotations, suggests that his interactions with urban environments, which evoked specific feelings, were an important aspect of his livelihood practices and experiences. Again, these insights are not generalisable and people's reactions and interpretations to space will vary (Porter et al., 2010). Yet, this further demonstrates the capability of GPS methods in being able to gain subjective insights into people's diverse experiences as they perform livelihood mobilities.

This case study demonstrates the versatility of GPS methods in that they can be adapted to include participation at later stages of a research process. Through using these approaches, detailed insights can also be gained into the knowledge and strategies which people employ to maintain their livelihoods.

Practicalities and ethics

Mapping the routes of participants using GPS devices/applications does not demand very much of participants during the data collection process (Shoval, 2008). As discussed previously, other methods can be used to contextualise participants' routes whilst they are 'on the move'. However, the suitably of including these with GPS tracking depends on the purpose of the research and the activities that participants are performing. Through my own experiences, I found that when undertaking research with participants who moved around in search of income it was not possible for them to stop, complete surveys, write down their thoughts, and/or have regular and detailed conversations with me during their working day. Thus, contextualising maps after they were created was the most suitable approach to take during my research. It is imperative that researchers consider how they will implement GPS methods in a research

process, ensuring that participants do not become overburdened and/or disadvantaged because of the use of these techniques.

As noted previously, a growing number of development-related studies are adopting approaches whereby participants are involved in most, if not all, stages of a research process (Chambers, 2008; Kesby et al., 2005). Participants are often given possession of GPS devices to track their own routes. From an ethical perspective, giving participants control over mapping allows them to choose when they record their journeys. Research by Naybor et al. (2016) found that this approach afforded their participants with privacy as they were able to stop recording whenever they did not want something to be mapped, such as when they travelled to a HIV/AIDS clinic or to an illegal alcohol vendor. Yet even when participants have control over tracking, researchers must be mindful that participants' routes can still reveal locations such as their homes or places of work, which could expose their identity (Korpilo et al., 2017). As Taylor (2016) states, human mobility is becoming more legible and detailed through using technology such as GPS. Researchers should thoroughly consider the use of these methods before employing them to ensure that participant anonymity can be maintained. Participants also need to be informed as to why this data is being collected and how it will be used; will maps of their routes feature within a thesis, publications or/and reports? How will the data be stored, and who will be able to access this data? In relation to the latter point, Taylor (2016) states that such data can be used to survey and control unwanted movement. This can result in the movements of certain groups of people being restricted and/or stigmatized. Because data can be accessed and used in 'unknown ways', different from its intended purpose(s), it could be argued that gaining informed consent is not possible with research and data which involves the use of tracking technologies. However, participants can be made aware that the full

consequences of their participation cannot be fully known and with this knowledge still agree to partake in research processes.

Tracking technology may also lead to the increased illegibility of certain people's mobilities. Actors who have and maintain power over smartphone devices will be able to use the technology to map their mobilities, which may be taken as representative of the community/society they are in. This can overlook the heterogeneity of movements within a specific location, and may work to further marginalise and underrepresent the mobilities of those who may be in less powerful positions due to their (dis)ability, age, class, ethnicity and/or gender, among other attributes. For example, Alozie and Akpan-Obong (2017) identify that throughout much of Africa, women are less likely to own and use ICT technology, compared to men, due to having lower levels of education and economic status.

Moreover, the act of carrying a GPS device may be unusual for participants. It has been suggested that the presence of recorders may influence participants' movements, resulting in them walking further distances, for longer lengths of time, or to different places than they would have done without possession of such a device (Christensen et al., 2011). Yet, Birenboim and Shoval (2016) argue that the growing popularity of mobile-based GPS applications to track movements is reducing these influences because people are increasingly used to carrying a mobile device with them everywhere.

Although GPS technology has advanced considerably in recent years (Korpilo et al., 2017), there are still environments, such as dense urban areas, where the GPS signal can be blocked (Shoval, 2008). During fieldwork in Arusha in 2019, I had trouble obtaining GPS signal in an area of the city where I was surrounded by three storey buildings. On this occasion, after some

perseverance and constant refreshing of the tracking application, I was able to acquire signal further down the road and begin tracking. However, participants cannot constantly monitor the GPS application to ensure that it is working properly, as they will be engaged in their own activities. Moreover, I have also had situations whereby I have not been able to acquire a GPS signal at all, meaning that the routes of some participants were not tracked. Research contexts vary enormously, and through my own experiences, a lack of GPS signal cannot always be attributed to 'obvious reasons' such as high building density or tree cover; it can sometimes be unclear as to why GPS signal cannot be obtained, which can make it difficult to resolve such issues. Thus, for studies which rely heavily on GPS tracking, piloting the technology where possible is crucial to ensure that it works within the environment(s) in which research is taking place.

Conclusion

As this chapter has demonstrated, participatory GPS methods are becoming an important way through which insights into people's livelihoods can be developed. These approaches are particularly beneficial in developing understandings of the complex and diverse mobilities which many people across Global South contexts perform in relation to their livelihoods (Gough, 2008; Rigg, 2007). The knowledge, strategies and practices which people employ in relation to managing and sustaining their livelihoods is important to understand given that people across Global South contexts are having to confront contemporary challenges such as rapid urbanisation and climatic changes. Gaining insight into people's spatial knowledge(s) and subjective insights of the spaces they frequent can also shed light on how (if at all) they are adapting and managing their livelihoods. In turn, these understandings can be used to develop theoretical understandings of contemporary livelihoods, which can also be of importance to both policymakers and development agencies alike.

Of course, GPS methods do not provide the only means through which understandings into people's livelihoods can be developed. These methods have shown promise in being able to interrogate the complexity and diversity of livelihoods through providing accurate and robust spatial and temporal data which does not require high levels of expertise to produce.

Key points

- GPS methods can be used and adapted in multiple ways to complement studies which aim to develop understandings into people's livelihoods – the appropriateness of these approaches depends on aims and of a research project, and the participants that will be involved.
- GPS technology is relatively easy to operate and it is becoming more affordable over time.
- Participatory GPS enables participants to have greater input into research processes which can afford studies with subjective insights into people's livelihood experiences, knowledge, strategies and practices.
- Participatory mapping can detail and visualise people's livelihood mobility practices and it can highlight the challenges they face. This can lead to targeted policy interventions and support.
- Consideration is required prior to GPS use, because these approaches can increase participants' visibility, which can raise several ethical dilemmas.

Further Readings

Birenboim, A. and Shoval, N. (2016) ‘Mobility Research in the Age of the Smartphone’, *Annals of the American Association of Geographers*, *106*: 283-291. https://doi.org/10.1080/00045608.2015.1100058

Hansson, U. and Roulston, S. (2017) ‘Evaluations of diaries and GPS-enabled trackers to plot young peoples’ geographies – asking the participants what they think’, *Children's Geographies,* 15: 517-530. https://doi.org/10.1080/14733285.2016.1272915

Joseph, L., Neven, A., Martens, K., Kweka, O., Wets, G. and Janssens, D. (2019) ‘Measuring individuals' travel behaviour by use of a GPS-based smartphone application in Dar es Salaam, Tanzania’, *Journal of Transport Geography*, 88: 102477. https://doi.org/10.1016/j.jtrangeo.2019.102477

Shoval, N., Schvimer, Y. and Tamir, M. (2018) ‘Tracking technologies and urban analysis: Adding the emotional dimension’, *Cities,* 72: 34-42. https://doi.org/10.1016/j.cities.2017.08.005

References

Alozie, N.O. and Akpan-Obong, P. (2017) 'The Digital Gender Divide: Confronting Obstacles to Women's Development in Africa', *Development Policy Review*, *35*: 137-160. https://doi.org/10.1111/dpr.12204

Birenboim, A. and Shoval, N. (2016) 'Mobility Research in the Age of the Smartphone', *Annals of the American Association of Geographers*, *106*: 283-291. https://doi.org/10.1080/00045608.2015.1100058

Bryceson, D.F., Mbara, T.C., and Maunder, D. (2003) 'Livelihoods, daily mobility and poverty in sub-Saharan Africa', *Transport Reviews*, *23*: 177-196. https://doi.org/10.1080/01441640309891

Chambers, R. (2008) *Revolutions in Development Inquiry*. Earthscan: Routledge. https://doi.org/10.4324/9781849772426

Christensen, P., Mikkelsen, M.R., Nielson, T.A.S., and Harder, H. (2011) 'Children, mobility, and space: Using GPS and mobile phone technologies in ethnographic research', *Journal of Mixed Methods Research*, *5*: 227-246. https://doi.org/10.1177%2F1558689811406121

Esson, J., Gough, K.V., Simon, D., Amankwaa, E. F., Ninot, O. and Yankson, P.K.W. (2016) 'Livelihoods in motion: Linking transport, mobility and income-generating activities', *Journal of Transport Geography, 55:* 182-188. https://doi.org/10.1016/j.jtrangeo.2016.06.020

Evans, J., O'Brien, J., and Ng, B. C. (2018) 'Towards a geography of informal transport: Mobility, infrastructure and urban sustainability from the back of a motorbike', *Trans Inst Br Geogr,* 43: 674–688. https://doi.org/10.1111/tran.12239

Evans, R. (2016) 'Achieving and evidencing research 'impact'? Tensions and dilemmas from an ethic of care perspective', *Area*, 48: 213-221. https://doi.org/10.1111/area.12256

Goodchild, M.F. (2007) 'Citizens as sensors: the world of volunteered geography', *GeoJournal*, 69: 211-221. https://doi.org/10.1007/s10708-007-9111-y

Gough, K.V. (2008) '"Moving around": the social and spatial mobility of youth in Lusaka', *Geografiska Annaler: Series B, Human Geography*, 90: 243-255. https://doi.org/10.1111/j.1468-0467.2008.290.x

Hansson, U. and Roulston, S. (2017) 'Evaluations of diaries and GPS-enabled trackers to plot young peoples' geographies – asking the participants what they think', *Children's Geographies*, 15: 517-530. https://doi.org/10.1080/14733285.2016.1272915

Hein, J.R., Evans, J. and Jones, P. (2008) 'Mobile Methodologies: Theory, Technology and Practice', *Geography Compass*, 2(5): 1266-1285. https://doi.org/10.1111/j.1749-8198.2008.00139.x

Janusz, K., Kesteloot, C., Vermeiren, K. and Rompaey, A.V. (2018) 'Daily mobility, livelihoods and transport politics in Kampala, Uganda: A Hagerstrandian analysis', *Tijdschrift*

voor Economische en Sociale Geografie, Royal Dutch Geographical Society KNAG, 111: 412-427. https://doi.org/10.1111/tesg.12349

Jones, P., Drury, R. and McBeath, J. (2011) 'Using GPS-enabled mobile computing to Augment qualitative interviewing: Two case studies', *Field Methods*, 23: 173-187. https://doi.org/10.1177%2F1525822X10388467

Jones, P. and Evans, J. (2012) 'The spatial transcript: analysing mobilities through qualitative GIS', *Area*, 44: 92-99. https://doi.org/10.1111/j.1475-4762.2011.01058.x

Joseph, L., Neven, A., Martens, K., Kweka, O., Wets, G. and Janssens, D. (2019) 'Measuring individuals' travel behaviour by use of a GPS-based smartphone application in Dar es Salaam, Tanzania', *Journal of Transport Geography*, 88: 102477. https://doi.org/10.1016/j.jtrangeo.2019.102477

Kesby, M., Kindon, S. and Pain, R. (2005) 'Participatory approaches and diagramming techniques', in Flowerdew, R. and Martin, D. (eds.) *Methods in human geography*. London: Pearson Publishing.

Korpilo, S., Virtanen, T. and Lehvavirta, S. (2017) 'Smartphone GPS tracking – Inexpensive and efficient data collection on recreational movement', *Landscape and Urban Planning*, 157: 608-617. https://doi.org/10.1016/j.landurbplan.2016.08.005

Kusenbach, M. (2012). Mobile methods. In: Delamont, S. (eds.) *Handbook of Qualitative Research in Education* (pp. 252-264). Cheltenham: Edward Elgar.

Langevang, T., and Gough, K.V. (2009) ‘Surviving through movement: the mobility of urban youth in Ghana’, *Social & Cultural Geography*, 10: 741-756. https://doi.org/10.1080/14649360903205116

Lee, D., Kung, K. and Ratti, C. (2015) ‘Mapping the Waste Handling Dynamics in Mombasa Using Mobile Phone GPS’, *The 14th International Conference on Computers in Urban Planning and Urban Management*: CUPIM 2015.

Lund, R. (2014) ‘Gender, mobilities and livelihood transformations: An introduction’, in Lund R., Kusakabe, K., Panda, S.M., Wang, Y. (eds.) *Gender, Mobilities, and Livelihood Transformations: Comparing Indigenous People in China, India, and Laos*. New York: Routledge, pp. 1-20.

Navarrete Forero, G.N., Miñarro, S., Mildenberger, T.K., Breckwoldt, A., and Sudirman, S. and Reuter, H. (2017) ‘Participatory boat tracking reveals spatial fishing patterns in an Indonesian artisanal fishery’, *Frontiers in Marine Science*, 4: 409. https://doi.org/10.3389/fmars.2017.00409

Naybor, D., Poon, J.P. H. and Casas, I. (2016) ‘Mobility Disadvantage and Livelihood Opportunities of Marginalized Widowed Women in Rural Uganda’, *Annals of the American Association of Geographers*, 106: 404-412. https://doi.org/10.1080/00045608.2015.1113110

Offenhuber, D. and Lee, D. (2012) ‘Putting the informal on the map: Tools for participatory waste management’, *In Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases*, 2, PDC ’12. New York: ACM, pp. 13 – 16.

Oloo, F. (2018). Mapping Rural Road Networks from Global Positioning System (GPS) Trajectories of Motorcycle Taxis in Sigomre Area, Siaya County, Kenya. *International Journal of Geo-Information*, 7: 309-324. https://doi.org/10.3390/ijgi7080309

Oyana, T. J. (2017) ‘The use of GIS/GPS and spatial analyses in community-based participatory research’, in Coughlin, S.S., Smith, S. and Fernandez, M.E. (eds.) *Handbook of community-based participatory research*. Oxford: Oxford University Press. https://doi:10.1093/acprof:oso/9780190652234.003.0004

Porter, G., Hampshire, K., Abane, A., Munthali, A., Robson E., Mashiri, M., and Maponya, G. (2010) ‘Where dogs, ghosts and lions roam: learning from mobile ethnographies on the journey from school’, *Children's Geographies*, 8: 91-105. http://dx.doi.org/10.1080/14733281003691343

Rigg, J. (2007) ‘Moving lives: migration and livelihoods in the Lao PDR’, *Population, Space and Place*, 13: 163-178. https://doi.org/10.1002/psp.438

Sheller, M., and Urry, J. (2006) ‘The New Mobilities Paradigm’, *Environment and Planning A*, 38: 207-226. https://doi.org/10.1068%2Fa37268

Shoval, N. (2008) ‘Tracking technologies and urban analysis’, *Cities*, 25: 21-28. https://doi.org/10.1016/j.cities.2007.07.005

Shoval, N., Kwan, M-P., Reinau, K. H., and Harder, H. (2014) ‘The shoemaker’s son always goes barefoot: Implementations of GPS and other tracking technologies for geographic research’, *Geoforum*, 51: 1-5. https://doi.org/10.1016/j.geoforum.2013.09.016

Shoval, N., Schvimer, Y. and Tamir, M. (2018) ‘Tracking technologies and urban analysis: Adding the emotional dimension’, *Cities*, 72: 34-42. https://doi.org/10.1016/j.cities.2017.08.005

Sugie, N.F. (2018) ‘Utilizing Smartphones to Study Disadvantaged and Hard-to-Reach Groups’, *Sociological Methods and Research*, 47: 458-491. https://doi.org/10.1177%2F0049124115626176

Taylor, L. (2016) ‘No place to hide? The ethics and analytics of tracking mobility using mobile phone data’, *Environment and Planning D: Society and Space*, 34: 219-336. https://doi.org/10.1177%2F0263775815608851