A new approach to spatial analysis of motorcycle taxis activities – the case of Port-au-Prince, Haiti

Rémi Jaligot, Armel Kemajou and Jérôme Chenal

Urban and Regional Planning Community, Swiss Federal Institute of Technology Lausanne, Lausanne, Switzerland

ABSTRACT

Motorcycle taxis operate in a non-regulated, uncontrolled environment, raising public health, environmental and economic issues. Consideration of such issues requires an in-depth understanding of motorcycle taxis’ organizational and operational features. Urban sprawl, a difficult economic context and demographic pressure have led to an increase in motorcycle taxi activities in the Republic of Haiti. This study presents a novel approach to analyzing informal modes of transport using qualitative data from semi-directive interviews and observations with a spatial analysis of motorcycle taxi activities by GPS tracking. The analysis is comprised of three phases. First, a suitable tracking device and fixing method were tested and selected. In the second, 12 drivers were equipped with charged devices on a daily basis. The interviews were conducted simultaneously. Finally, we draw four main results using the Haversine method and calculating the inactivity rate. Given a median action range of <3 km, the lack of peak-hours observed, an inactivity rate of more than 50% and the low profitability of the current structure, the activity’s economic potential is not optimized under the current system. The poor distribution of stands across the territory and large number of drivers results in the overall inefficiency of the system.

1. Introduction

Cities’ primary modes of public transport are changing (Lombard & Ninot, 2010; Vasconcellos, 2014, p. 287). While developed countries are shifting towards collective modes of public transport, developing countries show the reverse trend, with a shift towards individual modes (Kumar, 2011; Roger, Abou, Dénis, & Koffi, 2016). Authorities in developing countries must manage the growing mobility needs of an increasingly scattered peri-urban population with limited financial and technical capacities (Khisty, 1993). The result has been the privatization of public transport services, notably by individual operators who take advantage of institutional and regulatory gaps (Kisaalita & Sentongo-Kibalama, 2007; Porter, 2014), who operate informally, as it is also the case in land tenure (Kombe & Kreibich, 2000) and waste management (Jaligot, Wilson, Cheeseman, Shaker, & Stretz, 2016).

CONTACT Rémi Jaligot remi.jaligot@epfl.ch, rjaligot@gmail.com

© 2017 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
Private operators provide multiple services, ranging from secondhand minibuses to collective taxis to motorcycle taxis (Kumar, 2011). The marked decline in government-organized public transport, combined with the economic opportunities these activities offer for a fast-growing urban population, have led to a rapid increase of poorly regulated, non-conventional modes of public transport like motorcycle taxis (Sietchiping, Permezel, & Ngomsi, 2012; Yagi & Mohammadian, 2008). Motorcycle taxis have emerged in many cities in developing countries in the past 20 years and became one of the dominant modes of public transport (Al-Hasan, Momoh, & Eboreime, 2015; Garuba, 2006; Olvera, Plat, Pochet, & Maïdadi, 2012). This phenomenon has opened a wide field of research, due in particular to its rapid development and economic potential, as well as its negative impacts on public health and the environment (Cervero & Golub, 2007). Several studies on this growing phenomenon – typically qualitative – have been done in Africa (Olvera et al., 2012; Porter, 2014; Sahabana, 2006) and Asia (Godard, 2008; Oshima, Fukuda, Fukuda, & Satiennam, 2007; Tuan & Mateo-Babiano, 2013), in an attempt to understand its origin and coordination. This informal mode of transport is also widespread in Latin America, especially in the Caribbean (Schipper, Deakin, McAndrews, Scholl, & Frick, 2009), but lacks attention in the current literature.

Haiti’s motorcycle taxi phenomenon has its roots in the Dominican Republic starting in 1987 and has constantly grown ever since. The current context has been an improvement to impracticable, government-organized public transport. As such, motorcycle taxis are a bottom-up response to an unmet, incompressible mobility demand (Chery, 2015; Rameau, 2014), providing a temporary solution but failing to meet control measures taken by the public authorities. Moreover, the growing number of motorcycle taxi-related accidents poses a major public health challenge (Haley & Cone, 2016; McLaughlin & Rogers, 2013). However, they are often the only economic lever for many new urban dwellers from rural areas. They also allow for fast and easy travel in the Port-au-Prince metropolitan area, where transport infrastructure is poorly developed and congested, and precarious areas are built on steep terrains that are largely inaccessible to other modes of transport. Despite having identified the benefits and constraints of the spread of motorcycle taxis, the organizational and operational reality of this phenomenon are still little understood at the municipal scale. Studies focusing on an in-depth spatial and quantitative understanding of this activity are lacking in the existing peer-reviewed literature. The aim of this paper is to apply a novel spatial analysis approach and to initiate the creation of a database on the activities of motorcycle taxis in Port-au-Prince.

This research seeks to bridge the gap between a superficial understanding of the system due to the lack of reliable data and the reality in the field. Its offers an innovative methodology for analyzing informal modes of transport based on a mixed-method approach. First, we gathered quantitative data using a GPS tracking system to support qualitative data from our semi-directive and non-directive interviews. Then we performed analyses of four key indicators identified during the interview process: motorcycle taxis’ action range, their inactivity rate, peak-hours and the system’s overall profitability.
2. Study area

2.1. Metropolitan area

The study area covers 735.78 km² and includes eight Port-au-Prince metropolitan area municipalities, namely Carrefour, Cité-Soleil, Delmas, Gressier, Kenscoff, Pétion-Ville, Port-au-Prince and Tabarre, based on the definition of the Metropolitan Service for Solid Waste Collection (Figure 1) (Lombart, Pierrat, & Redon, 2014). Opting for an extended study area was relevant because it provides a larger sampling of the activity, as its true scope is still relatively unknown.

2.2. Location of motorcycle taxi stand

The selection of a suitable motorcycle taxi stand for this study was based on two main criteria: size and feasibility. The location of the stand known as Delmas 31 in the eponymous municipality is central in the inter-municipal commuting network (Figure 1) (Joseph Duval, 2015), and provides a sound basis for centralised analysis of the spatial coverage of motorcycle taxis and trips between municipalities. The stand is also one of the oldest and most easily accessible in the metropolitan area, which allowed for efficient, safe data collection in an informal sector where operators and local authorities tend to be suspicious.

3. Material and methods

3.1. Selection of the tracking device

The initial task was selecting the appropriate tracking tool to meet the aim of this research and which would take into account the spatio-temporal context. The informal setting was key in the selecting of the appropriate device. The tool also needed to meet prerequisites of practicality, ergonomy, reliability and autonomy. Several studies in the field of public transport use GPS tracking devices to geo-reference points (Akpomere & Nyorere, 2013) or, more frequently, to track trips in a continuous way (Elgethun, Yost, Fitzpatrick, Nyerges, & Fenske, 2007; Flamm, Jemelin, & Kaufmann, 2008; Fleischer, Nelson, Sowah, & Bremang,
An extensive review of the previously cited peer-reviewed and grey literature allowed us to make a preliminary selection of suitable tracking devices. The GPS Columbus V-990 device was tested in Switzerland, France, the Ivory Coast and Benin under different climatic conditions, such as heavy rainfall. The arbitrary choice to affix the device to the motorcycle to avoid tracking drivers’ ancillary movements created an additional challenge. Thus, preliminary testing of the fixation method was done; the latter needed to be unobtrusive and subtle while ensuring sufficient exposure to maximise the reception of satellite signals. Finally, we chose to affix the device to the motorcycle handlebar using black waterproof tape.

### 3.2. Tracking process and interview

The fully-charged tracking devices of the 12 motorcycle taxis drivers provided the material basis of the tracking data collection. The pilots were selected from among a sample of 50 pilots from the Delmas 31 stand. The latter were chosen based on criteria of seniority, experience and carefulness in conducting their activity. Note that the terms driver and pilot are used in this paper. The experiment lasted for six days, and tracking devices were exchanged every day. Subjects had to activate the feature to create a new data-set at each customer pick-up and drop-off. The objective was to clearly distinguish between trips with customers and without customers. This unique rule was the focus of a half-day training session before beginning the experiment. Two batches of tracking devices were used to allow for constant rotation between devices, as well as systematic data collection.

In addition, field observations and one semi-directive interview were conducted on a daily basis with a driver following a standard questionnaire designed to capture relevant information and allowing for cross-comparison with spatial data. Similar questions were asked during non-directive interviews with other drivers. All aspects of drivers’ social and economic life (e.g. family status, place of residence, technical information on motorcycles, suggestions to improve working conditions, education level and behavior towards informal activities) were explored. As such, both simple and detailed qualitative information were gathered in order to be combined with quantitative data from tracking activities. This allowed us to derive a set of key indicators, which became the focus of the quantitative analysis, and identify gaps between drivers’ perception of their activities and actual measurements of these activities. The objective was to gather qualitative data and support our findings with quantitative data analysis (see Section 3.3).

### 3.3. Data treatment

A point with geographical coordinates, speed, altitude and time were recorded by the tracking device every second. Systematic collection was done for all drivers on a daily basis.

The exploratory nature of this research opens new perspectives on using complementary analyses to determine factors affecting motorcycle taxis’ activity, including standard analytical tools as well as more complex tools for spatial data treatment and visualization. Before proceeding with data analysis, preliminary treatment was necessary to format the data. This included data cleaning, adapting data titles and extracting the different trips to ensure the robustness of subsequent analyses. The angular ‘longitude’ measurement encompasses the cardinal direction West (variable W), which was not compatible with the QGIS© geographic information system. Each ‘longitude’ element was formatted to replace the cardinal point
by a negative component, for instance 72°W was substituted for −72°. The time (variable ‘time’) was also changed to correspond to the local time zone.

Next, combined files of daily trips and the Haversine method (Chen et al., 2006) were plugged into RStudio 3.3.3©, allowing us to obtain the total distance travelled and distance travelled for each trip. The Haversine method is accurate for small distances and was appropriate here as points were recorded every second. It is important to note that some drivers did not separate their trips as instructed. The four drivers involved were not included in order to avoid biased analysis.

The inactivity rate ($T_{iw}$) of each driver is an indicator for the functioning of this mode of transport, whose rapid growth was not founded on adequate structural organization or legal framework. It also indicates the activity’s temporal distribution. The inactivity rate was calculated based on Equation (1). The duration of inactivity at night was subtracted from the total duration of inactivity. The remaining time reflects the inactivity rate for the work day and was converted to a rate/percentage of inactivity for the entire day and brought back to the work day only.

$$T_{iw} = \frac{((t_{total} - t_a) \div t_{total} \times 100) - (t_n \div t_{total} \times 100)) \times (t_{total} \div 100)}{(t_{total} - t_n)} \times 100 \quad (1)$$

Here, $T_{iw}$ = rate of inactivity at work, $t_{total}$ = total duration of tracking period, $t_a$ = duration of activity during tracking period, $t_n$ = duration of inactivity at night.

Data are presented for a work day starting from when the tracking device was affixed to the motorcycle at 9:30 in the morning until 22:30. The selection of the time boundaries for a work day was based on a preliminary analysis of tracking data and interviews, which revealed that most drivers worked until approximately 22:30. None of the drivers worked at night, and morning trips were not significant. In this respect, excluding data after 22:30 did not affect the robustness of results.

The main advantages of combining qualitative information from interviews and quantitative data from the tracking process are: (1) they make it possible to establish clear trends, (2) identify key organizational and operational features and (3) validate results. Combining qualitative and quantitative research in the study of a single phenomenon allows for the cross validating of results (Campbell & Fiske, 1959; Jick, 1979). The tracking process, interviews and observations were the three complementary used to examine the motorcycle taxi phenomenon and validate the results. This approach is similar to the triangulation method, whose goal is to increase understanding of complex phenomena to confirm validity. The technique also allows for enhanced accuracy of results (Malterud, 2001).

4. Results

Gaining an in-depth understanding of motorcycle taxis requires spatially explicit analyses as well as analyses of times and distances. Our analysis focuses on the four indicators identified during the interview process: action range, peak hours, inactivity rate and the profitability of the current structure. The indicators were analyzed separately and cross-validated based on the interviews and field observations.
4.1. **Limited action range**

The total distance travelled and number of trips allowed us to calculate the average distance travelled per trip for eight drivers, also called action range. Forty-four action ranges were obtained for our study after careful data cleaning. Two distance-based results reflect motorcycle taxis’ action range, i.e. the median action range and maximum action range. The median action range was preferred to the average action range to attenuate the impact of outliers.

The median action range was equal to 2.35-km, which is relatively small. It is worth noting that approximately 80% of trips were less than 3-km. The maximum action range was slightly less than 10-km, and corresponds to the longest trip departing from the Delmas 31 stand. Longer trips were recorded but were excluded because they did not depart from Delmas 31 and did not fit into the maximal action range. The significant difference between the median action range and maximal action range did not support the common belief that motorcycle taxis have no boundaries and operate freely within the entire urban perimeter. This also supports the interviews results wherein all drivers stated that they occasionally travelled across the entire city, but that this was a rare occurrence.

Next, a combination of all trips were analyzed for individual drivers to determine the main differences in how they worked. Two drivers showing significant disparities in terms of spatial distribution and distance travelled per trip were selected. The data for both drivers allowed us to formulate explicative hypotheses on different strategies, e.g. making short trips or long trips. Figure 2 shows a combination of all trips for the two pilots selected. Pilot 1 shows that density of trips was high in a limited area to the north of Delmas 31 (Figure 2(a)). Pilot 2 seemed to make longer trips that were not as restricted to a specific area (Figure 2(b)). This result enables further analyses.

4.2. **Inactivity rates**

Figure 3 shows two main elements. The first corresponds to the different $T_{in}$ between both drivers. A marked difference of up to 15 points was recorded on day 4 but was not observed on the other days. We should point out that there was heavy rainfall on day 4, which reflects

![Figure 2. Spatially explicit combination of trips for pilot 1 (a) and pilot 2 (b). Source: Haiti Geodata Information Center, 2017.](image-url)
the potential impact of climatic conditions in this line of work. We observed that rain, in fact, tends to increase the level of activity, as is evident in $T_{i\text{w}}$’s high variability. In addition, pilot 2’s $T_{i\text{w}}$ was always higher than pilot 1’s. We noted that $T_{i\text{w}}$ for pilot 1, who did shorter trips, dropped drastically on day 4, resulting in a 25% difference in the inactivity rate compared with pilot 2, which normally varied between 2 and 13%.

The second element relates to daily variations in the inactivity rate. $T_{i\text{w}}$ tended to stabilize during the week, but a shock in the system was also capable of triggering significant variation of $T_{i\text{w}}$ (e.g. climatic conditions, national holidays). For example, $T_{i\text{w}}$ was highest on day 6, reflecting a decline in demand recorded on the national holiday.

The curves of the cumulative distances travelled show long phases of stagnation, implying both drivers were idle (Figure 4). These phases represent periods where the motorcycle was not moving. We assumed that breaks not directly related to the activity, or ‘annex breaks’ (lunch, technical issues, etc.), were equivalent for both pilots. This confirms the drivers’ assertions during the interviews that they did not take ‘annex breaks’ longer than 15 min, which had no significant impact on the results in Figures 3 and 4. Overall, the inactivity rate ranged from 48.9 to 84.7%, which is relatively high and far surpasses the perceived inactivity reported by the drivers themselves.

### 4.3. Absence of observed peak-hours

Figure 4 shows the cumulative distances travelled by both pilots for each day, to identify the number of trips, waiting times and working periods. Both drivers started their working day time in the morning at the same, after the affixing of the tracking device. The curves tend to display gradual, stepwise increments with no long phases of inactivity during off-peak hours (10:00–12:00 and 14:00–16:00). Similarly, the curves indicate no phase of significant intensification of activity during peak-hours (07:00–10:00 and 16:00–19:00). It is worth noting that no intensification was observed before 09:30 before fixing of the new device. Such trends show that the pilots worked in a steady manner and did not take long breaks during the day (i.e. at lunchtime).
4.4. Profitability

The analysis of the cumulative distance travelled by both pilots show a recurring difference that can be observed on each day of the experiment. Pilot 1, who made mostly short trips – as evidenced by the more gradual increase in the cumulative distance travelled, travelled *in fine* more kilometres than pilot 2 (Figure 4). The collecting of quantitative data from the tracking process and semi-directive interviews indicates that the kilometric cost is nearly constant, at around 40 Haitian Gourdes (HTG\(^1\)), independent of the distance travelled during individual trips and preliminary negotiations between the driver and customer. It is important to specify that the kilometric cost corresponds to a single trip, and that a 25% discount was usually offered for customers who took the same motorcycle taxi for a return trip. Nevertheless, pilot 2 quit work before pilot 1, around 19:30 each day (Figure 4). By

---

**Figure 4.** Cumulative distances travelled on each day of the experiment by pilot 1 (blue curve) and pilot 2 (orange curve). Notes: For clarity, the legend is only included on the curve *Cumulative Distances (Day 1).* The legend is similar in other curves.
this time, pilot 2 had usually travelled a greater distance than pilot 1. The latter could only exceed this distance by extending his working day by at least 2 h. The strategy of pilot 2 to operate over longer distances appears more profitable than that of pilot 1, who operated mostly over short distances.

5. Discussion

5.1. Discussion of the results

Motorcycle taxis mostly operate in the same zone north of Delmas 31. The high concentration of trips in this zone can be explained by the unofficial rule that compels the pilots to return to their base after each trip. However, this concentration of trips north of the stand is also the result of the major traffic junction south of Delmas 31 and the other stand located on the other side of this junction. Therefore, the supply is concentrated around busy roads and junctions that sometimes limits drivers in their work. These observations were valid for both pilots, but different strategies nonetheless emerged. One (pilot 1) made numerous short trips while the other (pilot 2) performs fewer but longer trips. Several studies mention that the total cost is logically and positively correlated with the distance travelled (Olvera et al., 2012; Sahabana, 2006), meaning that drivers fixed higher prices for longer trips. Nevertheless, this does not provide any indication of the kilometric cost, which should be negatively correlated with the distance travelled. We show here that the latter remains stable, regardless of the distance travelled. It is important to note the difference between the drivers’ perception reported in qualitative studies and the analysis of hard data. Consequently, operating over longer distances is more profitable due to a stable kilometric cost, even if short distances allow for the possibility of making more trips.

The detailed analysis of individual trips shows that both strategies are similar when one breaks down the activity, with long waiting periods equally distributed over the course of a day. The lack of intensification of activity during peak-hours (07:00–10:00 and 16:00–19:00) reflects the fact that the supply is constantly greater than the demand. It is accepted that the motorcycle taxi phenomenon has amplified in developing countries in the past two decades due to an increase in the number of operators (Atubi & Ali, 2016; Kumar, 2011; Pucher, Korattyswaropam, Mittal, & Ittyerah, 2005) coupled with an increase in demand (Boko, Bunch, Suresh, & Kumaran, 2003; Sengers & Raven, 2014). However, no study to our knowledge, postulates that the supply could be greater than the demand, notably during peak-hours. The rise in potential customers appears to be absorbed by the large number of motorcycle taxis and, as such, is no longer correlated to an intensification of activity.

The results point to the fact that drivers are active for less than 50% of the working day. Waiting periods range from 5 min to an hour. In a logic of systems optimisation, the number of motorcycle taxis would be at least two times greater than necessary to meet the demand of the population located near the stand. This corroborates the idea that the number of drivers is too high for the municipal scale at which they operate (Sahabana, 2006). Indeed, the unemployment rate in Haiti incites a portion of the unskilled labor force with no job opportunities to take up informal activities (Sahabana, 2006). Driving a motorcycle taxi requires no particular skills, and thus is an important resource for young, unemployed men in Haiti.
High inactivity rates also reflect the poor distribution of motorcycle taxis stands across the municipal territory. Although their emergence may be linked to the demand foreseen in a given area (Guézéré, 2013), their location is essentially arbitrary. This results in an unbalanced spatial distribution of stands whose action ranges overlap or merge. Delmas 31 is located less than a kilometer from several other major stands that it most likely shares customers with. Obviously, this density of supply is beneficial for customers. However, it also impedes the activity of operators and is less profitable. The climatic conditions could also justify a better distribution of stands. High rainfall in the Port-au-Prince area is a key factor; contrary to common belief, high rainfall can actually increase motorcycle taxi activity rate, especially for short distances. This was observed on day 4, when the inactivity rate of pilots dropped significantly. A higher demand due to the difficulty of walking even short distances could explain this empirical trend. Our results offer promising perspectives for future research focusing on several motorcycle taxis stands simultaneously in order to identify interactions between neighboring stands and refine the overall understanding of the system.

5.2. Discussion of methods

The methodology applied here produced an important volume of data, notably regarding speed and location, which allows for the development of new indicators to analyze motorcycle taxis’ activity. Information regarding the action range, peak-hours, inactivity rate and profitability of the system gave us an in-depth understanding of the system. We thus conclude that the spatial distribution of stands is not optimal at the municipal scale, and that different strategies in the operationalisation of the activity affect its profitability, for example the choice of trip distances. The aim of this paper is to bridge the gap between a simplistic understanding of this field and the reality by implementing a mixed method approach for analysing informal modes of transport. Quantitative data from our tracking of motorcycle taxis were used to support the qualitative information gathered during interviews, and is also instrumental in validating the results. Due to the exploratory nature of this approach, we did not seek to conduct exhaustive research using complex statistical modelling, which usually results from a common and concerted effort by all stakeholders. The methodological approach and exclusion of statistical modelling did not require the use of sensitivity analysis to determine how the uncertainty of the results can be attributed to different inputs.

Despite the methodology’s effectiveness and efficiency – proven by our robust results – limitations nonetheless exist and should be pointed out for transparency and further research. The size of the sample could be expanded for motorcycle taxi drivers and stands. Stands in different parts of the metropolitan area (central, peri-central, peripheral, informal districts or planned districts) and different-sized stands could temper some of the results presented in this paper. Finally, the operational strategies could be improved to reduce a number of potential biases, such as human error. Reducing the time of the experiment to maintain a high level of motivation among the subjects or implementing a completely passive tracking process are possible ways of improving the methodology.
6. Conclusion

An innovative mixed approach using GPS tracking and semi-directive interviews was applied to gain an in-depth understanding of the organisational and operational structure of motorcycle taxi services in the Port-au-Prince metropolitan area. Quantitative data from the tracking process were used to support qualitative information and validate the results. Limited action range, lack of observed peak-hours, high inactivity rate and the low profitability of the current organizational structure were the four major results of this research. The latter show that drivers based at the same stand at the heart of the inter-municipal commuting network use different strategies. Making longer trips appears more profitable than making shorter ones due to a stable cost per kilometer. This contradicts the belief that the cost per kilometer is negatively correlated with distance. However, differing strategies show similar behaviors when the activity is broken down and is distributed homogenously throughout the working day. The absence of significant intensification of activity questions the existence of peak-hours for motorcycle taxis. The supply seems greater than the demand due to the sharp increase in the number of pilots over the past decade and easily absorbs the higher demand during peak-hours. This is also related to high inactivity rates (more than 50%). The waiting periods recorded are as long as some trips with customers. Therefore, we postulate that the activity’s economic potential is not optimised in the current configuration due to the large number of drivers and poor distribution of stands taxis in the territory. The research recommends that some stands should be decentralised to balance the supply, especially towards peripheral areas, and that the number of drivers be monitored more efficiently.

The methodology was exploratory; it proved effective, robust and transparent for addressing the goals of the research. We nonetheless pointed out certain limitations relative to transparency and future research. For example, it would be interesting to conduct a more exhaustive analysis to trigger a change in the system. This would mean reproducing a similar study at a larger scale involving several stands in central areas and peripheral areas simultaneously.

Note

1. HTG 1 = $65 in July 2017.

Acknowledgments

The authors wish to thank Carline Joseph Duval and Dr Anie Bras Jopesh at Quisqueya University in Port-au-Prince for their helpful advice and assistance relative to the fieldwork in Haiti. All views expressed in this paper are those of the authors alone.

Disclosure statement

No potential conflict of interest was reported by the authors.
Funding

This work was funded by the delegation of the European Union in the Republic of Haiti [FED/2014/338-974].

References

Akpomrere, O. R., & Nyorere, O. (2013). Bus rapid transit (BRT) and railway transport system in Lagos: Geographic information system approach. International Journal of Economic Development Research and Investment, 4(1), 53–63.

Al-Hasan, A. Z., Momoh, M., & Eboreime, L. (2015). Urban poverty and informal motorcycle transport services in a Nigerian intermediate settlement: A synthesis of operative motives and satisfaction. Urban, Planning and Transport Research, 3(1), 1–18.

Atubi, A. O., & Ali, A. O. (2016). Motorcycle taxis in Enugu: Implications for development. Sustainable Human Development Review, 1(4), 133–148.

Boko, G., Bunch, M. J., Suresh, V. M., & Kumaran, T. V. (2003, December). Air pollution and respiratory diseases in African Big Cities: The CASE of Cotonou in Benin. In Proceedings of the Third International Conference on Environment and Health, Chennai, India (pp. 15–17).

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. Psychological Bulletin, 56(2), 81–105.

Cervero, R., & Golub, A. (2007). Informal transport: A global perspective. Transport Policy, 14(6), 445–457.

Chen, M., Sohn, T., Chmelev, D., Haehnel, D., Hightower, J., Hughes, J., … Varshavsky, A. (2006). Practical metropolitan-scale positioning for gsm phones. In P. Dourish & A. Friday (Eds.), UbiComp 2006: Ubiquitous computing, 225–242. Heidelberg: Springer.

Chery, R. (2015). Haïti société/ Circulation/ Moto-taxi Vie d’un chauffeur de moto-taxi [Haiti’s society/ traffic/ Motorcycle taxi: the life of a motorcycle taxi driver]. Quotidien Le National. Retrieved from http://www.lenational.org/haiti-societe-circulation-moto-taxi-vie-dun-chaufeur-de-moto-taxi/

Elgethun, K., Yost, M. G., Fitzpatrick, C. T., Nyerges, T. L., & Fenske, R. A. (2007). Comparison of global positioning system (GPS) tracking and parent-report diaries to characterize children’s time-location patterns. Journal of Exposure Science and Environmental Epidemiology, 17(2), 196–206.

Flamm, M., Jemelin, C., & Kaufmann, V. (2008). Travel behaviour adaptation processes during life course transitions. A methodological and empirical study using a person-based GPS tracking system. Lausanne: Laboratoire de Sociologie Urbaine (LASUR). Retrieved from infoscience.epfl.ch: https://infoscience.epfl.ch/record/128461/files/COST355-RapportLaSUR.pdf

Fleischer, P. B., Nelson, A. Y., Sowah, R. A., & Bremang, A. (2012). Design and development of GPS/GSM based vehicle tracking and alert system for commercial inter-city buses. In Adaptive Science & Technology (ICAST), 2012 IEEE 4th International Conference on (pp. 1–6). IEEE.

Garuba, D. S. (2006). Survival at the margins: Economic crisis and coping mechanisms in Rural Nigeria. Local Environment, 11, 17–36.

Godard, X. (2008). Transport artisanal, esquisse de bilan pour la mobilité durable [Artisanal transport, outline of summary for a sustainabile mobility]. In Codatu XIII. Hồ Chí Minh Ville (Vietnam). Retrieved from codatu.org: http://www.codatu.org/wp-content/uploads/Transport-artisanal-esquisse-de-bilan-pour-la-mobilit%C3%A9-durable-Xavier-GODARD.pdf

Guézéré, A. (2013). Deux roues motorisées et étalement urbain à Lomé, quel lien avec la théorie des « trois âges » de la ville ? [Motorised two-wheelers in Lomé, what is the link with the theory of ’three ages’ in the city?]. Norois, 1/2013 (n°226), 41–62. Retrieved from cairn.info: http://www.cairn.info/revue-norois-2013-1-page-41.htm

Haley, J. M., & Cone, P. H. (2016). Mobile clinics in Haiti, part 2: Lessons learned through service. Nurse Education in Practice, 21, 66–74.

Jaligot, R., Wilson, D. C., Cheeseman, C. R., Shaker, B., & Stretz, J. (2016). Applying value chain analysis to informal sector recycling: A case study of the Zabaleen. Resources, Conservation and Recycling, 114, 80–91.
Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly, 24*(4), 602–611.

Joseph Duval, C. (2015). Enquête exploratoire auprès des étudiants sur les principaux territoires des taxismotos dans l’Aire Métropolitaine de Port-au-Prince [Exploratory survey among students on the main territories of motorcycle taxis in the Port-au-Prince metropolitan area]. In ResearchGate. Port-au-Prince: PRCU. Retrieved from researchgate.net: https://www.researchgate.net/publication/314072503_Enquete_exploratoire_aupres_des_etudiants_sur_les_principaux_territoires_des_taxis-motos_dans_l%27Aire_Metropolitaine_de_Port-au-Prince

Khisty, C. J. (1993). Transportation in developing countries. Obvious problems, possible solutions. *Transportation Research Record, 1396*, 44–49.

Kisaalita, W., & Sentongo-Kibalama, J. (2007). Delivery of urban transport in developing countries: The case for the motorcycle taxi service (boda-boda) operators of Kampala. *Development Southern Africa, 24*(2), 345–357.

Kombe, W. J., & Kreibich, V. (2000). Reconciling informal and formal land management: An agenda for improving tenure security and urban governance in poor countries. *Habitat International, 24*(2), 231–240.

Kumar, A. (2011). Understanding the emerging role of motorcycles in African cities. *Sub-Saharan Africa Transport Policy Program*. Retrieved from ssatp.org: https://www.ssatp.org/sites/ssatp/files/pdfs/Topics/urban/DP13-Role-Motorcycles%5B1%5D.pdf

Lombard, J., & Ninot, O. (2010). Connecter et intégrer. Les territoires et les mutations des transports en Afrique [Connect and integrate: Territories and transport mutations in Africa]. *Bulletin de l’Association de géographes français, 87*(1), 69–86.

Lombart, M., Pierrat, K., & Redon, M. (2014). Port-au-Prince: un «projectorat» haïtien ou l’urbanisme de projets humanitaires en question [Port-au-Prince: a Haitian project or the urbanism of humanitarian projects into question]. *Cahiers des Amériques latines, 2014*(75), 97–124.

Malterud, K. (2001). Qualitative research: Standards, challenges, and guidelines. *The Lancet, 358*(9280), 483–488.

McLaughlin, N., & Rogers, H. (2013). Helping Haiti’s transportation issues: Increasing Haiti’s medical liabilities. *Journal of Global Health, 3*(1), 010304.

Olvera, L. D., Plat, D., Pochet, P., & Maïdadi, S. (2012). Motorbike taxis in the “transport crisis” of West and Central African cities. *EchoGéo, 20*, 1–18.

Oshima, R., Fukuda, A., Fukuda, T., & Satiennam, T. (2007). Study on regulation of motorcycle taxi service in Bangkok. *Journal of the Eastern Asia Society for Transportation Studies, 7*, 1828–1843.

Porter, G. (2014). Transport services and their impact on poverty and growth in rural sub-Saharan Africa: A review of recent research and future research needs. *Transport Reviews, 34*(1), 25–45.

Pucher, J., Korattyswaropam, N., Mittal, N., & Ittyerah, N. (2005). Urban transport crisis in India. *Transport Policy, 12*(3), 185–198.

Rameau, R. (2014). Un système de transport adapté aux besoins de circulation à Port-au-Prince [A transport system tailored to the traffic needs in Port-au-Prince]. *Problématique des transports à Port-au-Prince*. Retrieved from haitiperspectives.com: http://www.haitiperspectives.com/pdf/3.2-systeme.pdf

Roger, D. M., Abou, D., Dénis, H. K., & Koffi, B. É. (2016). Émergence De Taxi-Motos Et Recomposition SpatioÉconomique À Korhogo: Les Taxi-Villes Entre Stratégies D’adaptation Et Désespoir [Emergence of motorcycle taxis and socio-economic reconfiguration in Korhogo: motorcycle taxis between strategies of adaptation and despair]. *European Scientific Journal, ESJ, 12*(35), 190–208.

Sahabana, M. (2006). *Les motos-taxis à Douala et leur perception par les pouvoirs publics: entre tolérance d’un secteur pourvoyeur d’emploi et de transport et volonté d’éradiquer une activité incontrôlable* [Motorcycles taxis in Douala and their perception by public authorities: between tolerance of a job- and transport-providing sector, and willingness to eradicate an uncontrollable activity]. Communication aux Secondes rencontres internationales CIDEGEF/Ville management Evolutions institutionnelles et gouvernance dans le système de transports en Afrique Sub-Saharienne, Douala, 20–24.

Schipper, L., Deakin, E., McAndrews, C., Scholl, L., & Frick, K. T. (2009). *Considering climate change in Latin American and Caribbean urban transportation: Concepts, applications, and cases*. Berkeley:
Sengers, F., & Raven, R. (2014). Metering motorbike mobility: Informal transport in transition? *Technology Analysis & Strategic Management, 26*(4), 453–468.

Sietchiping, R., Permezel, M. J., & Ngomsi, C. (2012). Transport and mobility in sub-Saharan African cities: An overview of practices, lessons and options for improvements. *Cities, 29*(3), 183–189.

Tuan, V. A., & Mateo-Babiano, I. B. (2013). Motorcycle taxi service in Vietnam – Its socioeconomic impacts and policy considerations. *Journal of the Eastern Asia Society for Transportation Studies, 10*, 13–28.

Vasconcellos, E. A. (2014). *Urban transport environment and equity: The case for developing countries* (p. 287). London: Routledge.

Yagi, S., & Mohammadian, A. (2008). Joint models of home-based tour mode and destination choices: Applications to a developing country. *Transportation Research Record: Journal of the Transportation Research Board, (2076)*, 29–40.