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RESEARCH ARTICLE

Urban Form and Transportation Energy Consumption in Depok, Indonesia

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Abstract. By combining transportation energy use per capita for main, side, and weekend activities, this study explores the correlation between transportation energy consumption and urban form at a village scale. Conducted in Depok, a satellite city of the Jabodetabek metropolitan area, Indonesia, four different urban form variables were measured, including population density, land use mix, street connectivity, and public transportation range area. Four other socio-economic variables, i.e., private vehicle ownership, driving license ownership, job type, and monthly income, were also considered in the analysis. Data on individual energy consumption in the transportation sector was acquired through an online questionnaire. The results of correlation analysis and one-way analysis of variance highlighted three main findings related to transportation energy consumption. First, the population density and the street connectivity were found to be correlated with the amount of transportation energy consumed. Second, the middle urban form compactness level outweighed the high compactness level in terms of energy consumption per capita per week. Finally, differences in private vehicle ownership, driving license ownership, and job type resulted in different transportation energy usage.

1. Introduction

Cities require energy as the main factor that drives their development, irrespective of its source. Energy, both as embodied energy and energy in use, is necessary for transportation, commercial, and industrial activities, buildings and infrastructure, water distribution, and food production, many of which occur in or around cities (UN Habitat, 2012). Of the aforementioned sectors, the building sector consumes the most energy, however, the transportation sector, in terms of reducing energy consumption in cities, is considered to be a higher priority due to its effects such as local pollution, easier vehicle regeneration, and other impacts, e.g., traffic congestion (Steemers, 2003). In addition, in cities, transportation systems represent an important type of infrastructure that supports development as well as improves the city's quality of life and livability; furthermore, transportation systems represent tools that allow citizens to overcome distance, interact, and participate in activities (Moore and Pulidindi, 2011; Tamin, 2000). Accordingly, cities require a huge supply of energy to ensure that activities within them can be undertaken reliably and consistently. Cities account for around 80% of the total global energy consumption and are responsible for a similar proportion of greenhouse gas emissions (World Bank, 2010). Fossil fuels still fulfill 80% of global prime energy, including coal, oil, and gas, thus, factors including import dependency and rising fossil fuel prices globally can threaten cities' growth (UN Habitat, 2012).

With large populations and rapid urbanization, cities need to expand for accommodating the growing demands for food, water, and energy consumption (Kennedy et al., 2007). Urbanization and city population growth also implicate physical and spatial aspects of cities through the development of urban sprawl. This phenomenon generates negative externalities, including, in the transportation sector, the necessity for increased travel distance, which in turn affects transportation energy consumption, traffic congestion, and air quality when urbanization is accompanied by insufficient public transport development (Bengston et al., 2005; Yang and Jinxing, 2007). A study conducted in China (Qu et al., 2017) showed that there is a significant, positive relationship between environmental pollution and energy consumption, as well as public health in both the short and long term. Other studies have also shown that energy consumption affects the level of pollution emissions, air quality, and environmental costs (Chen et al., 2013; Li-me, 2014; Ozturk & Acaravci, 2013). Energy consumption is strongly influenced by urban energy demand, especially the needs of buildings and transportation (Hickman and Banister, 2014). Furthermore, the impacts of ineffective transportation development, as discussed above, especially in urban areas, may contribute to anthropogenic climate change in the long term. Passenger and freight transport were responsible for 22% of global carbon dioxide emissions in 2008, thus, mitigating the effects of climate change will require significant improvements in the sustainability of the transportation sector (UN Habitat, 2012). The choice of urban transportation modes, especially for public transport, is a key element in transportation planning due to its direct impact on the design of urban transportation system structures and its role as the basis for policymaking related to urban transportation planning and management (Chen and Li, 2017). Transport mode choice has received the most attention among all decision processes in transportation behavior-related literature; this focus is because the analysis and prediction of mode choice strongly relate to transportation system policies and mitigation strategies for traffic congestion (Zenina and Borisov, 2011).

When considering energy consumption in cities, especially in the transportation sector, the influence of urban form remains a matter of considerable debate. Urban form is identified as a factor of high importance in mature cities due to its impacts on travel patterns and other energy use (Seto et al., 2014). Some previous studies have identified that urban form affects transportation activities, both in terms of the distance traveled and mode choice (e.g., Zhao et al., 2014; Zhao, 2014; Milakis et al., 2015; Song et al., 2017; Kandt, 2018; Zhao, et al., 2018; Shaheen, et al., 2021), as well as transportation energy consumption (e.g., Baker and Steemers, 2000; Perkins et al., 2009; da Silva et al., 2007; Yin et al., 2017; Nichols and Kockelman, 2015; Guhathakurta and Williams, 2015; Permana et al., 2008; Silva et al., 2017; Rodrigue et al., 2017; Kaza, 2020). However, most of these studies were conducted in developed countries at household or city scales of urban form. Some studies did not quantify the urban form variable or interpreted this variable as two or three different development types (e.g., city center and suburban). As noted by da Silva et al. (2007), similar studies are rarely conducted in developing countries, including Indonesia, due to the difficulties associated with the energy consumption data gathering process. Studies that focus on supporting cities, instead of the center of metropolitan areas, are also scarce.

To address these issues, this research aims to explore the correlation between urban form and transportation energy consumption in Depok, Indonesia. In addition, some socio-economic variables (private vehicle ownership, driving license ownership, job type, and monthly income) were also included in this research, as these variable types were found to affect transportation energy use based on previous research in developing countries (da Silva et al., 2007). The lack of studies on this topic in Indonesia and satellite cities was the starting point of this research. Four urban form variables were explored and quantified, including population density, land use mix, street connectivity, and public transportation range area. These variables, among all possible urban form attributes, were selected based on the data available in the study area and observation scale, which, at a village area scale, differ from other prior studies. Depok city in West Java province was chosen as the study area; this area represents a satellite city supporting Indonesia's capital city of Jakarta in the Jabodetabek Metropolitan Area (JMA). Unlike Jakarta, Depok has a relatively low-quality and unsystematic public transportation system and street network. Each village within Depok city also has various density and diversity levels in terms of urban form. Its citizens have high mobility each day, especially for daily roundtrips between home and transportation hubs to Jakarta (such as train stations, the Transjakarta bus shelter, etc.) and for weekend entertainment needs within Depok city. In addition, given the focus of much research on the correlation between urban form and transportation energy consumption is limited to intracity mobilization, a satellite city may yield more insights as a research location, rather than the main city where intracity daily movements dominate.

This paper is structured as follows. In the second section, we briefly describe our findings from the literature review stage. Next, the methodology used in this research is elaborated in the third section, including data gathering, processing, and analysis methods. The results of this work are then presented and discussed in the fourth and fifth sections, respectively. Finally, conclusions and recommendations represent the closing remarks of this paper.

2. Methods

This research was performed using a quantitative approach and correlative research design, which investigated the relationship between two concepts and tested objective theories through a statistical procedure (Walliman, 2011; Creswell and Creswell, 2014; Dawson, 2007). Primary data were collected to obtain information concerning the transportation mode used and distance traveled by 105 respondents through an online questionnaire; these respondents were selected by purposive sampling, where the samples were picked based on a certain consideration (Eriyanto, 2007). The respondents in this research are those who fulfilled two criteria: (1) they are formal citizens of Depok and (2) routinely travel within the city for their main workday activities (Monday to Friday). Online questionnaires were chosen due to time and funding limitations when conducting this research, as well as the wide research area (van Selm, 2006; Sue et al., 2007; Fox et al., 2003). The questionnaire results were used to calculate the energy consumption of transportation activities per week per capita, as well as to identify traveler characteristics (i.e., private vehicle ownership, driving license ownership, job type, and monthly income). In addition, urban form-related data were gathered from city government institutions.

There are numerous ways to measure urban form, as well as many of its attributes (Dempsey et al., 2010; Oliveira, 2016; Bowyer, 2015; Sipe et al., 2011; Nedovic-Budic et al., 2016). The approaches used in this research were chosen based on the unit analysis scale, i.e., village-level, and the data availability in Depok. The attributes and measurements of urban form used in this study are listed in Table 1. In addition to being analyzed per attribute, all urban form variables were also combined to gain insights into urban form compactness based on all the explored attributes.

Transportation energy consumption was measured based on the transportation mode used by respondents, the distance traveled, and how many days they travel each week. Transportation activities were divided into main routine, side routine, and weekend routine classes. The survey respondents were required to fill in information about the first of these categories, while the latter two were optional. As well as private motorcycle, private car, and taxi, three other transport modes operate in Depok: (1) *ojek*, individuals who offer transportation services using motorcycles; (2) online ride-hailing, both by car or motorcycle (the online version of *ojek*); and (3) *angkot* *(small public transport)*, the only public transportation mode available within Depok in the form of a car with around a 14 -person capacity. Each transportation mode has different energy efficiency per km traveled. Based on the User Guide of Transportation Sector, Indonesia 2050 Pathway Calculator released by the Indonesian Ministry of Energy and Mineral Resources in 2015, we calculated the energy consumed per capita per km traveled by each transportation mode (Table 2).

To address the research question, all data were analyzed using two analysis approaches. First, correlation analysis, using the Pearson correlation method, was performed with a significance level of 90% to explore the correlation between urban form variables/monthly income and transportation energy consumption. Subsequently, a one-way analysis of variance (ANOVA) was also conducted to investigate the correlation between transportation energy consumption and urban form compactness, private vehicle ownership, driving license ownership, and job type, with the same significance level (i.e., 90%).

Study Area

Depok is a city located in the southern part of Jakarta, the capital city of Indonesia. Its 200.29 km^2 area consists of 11 districts and 63 villages. Depok is populated by more than 2.2 million citizens (around 11.256 citizens/km^2) with a population growth of around 3.48% (Statistics Indonesia, 2018). Settlement, either organized or unorganized, represents the predominant land use in Depok. Universitas Indonesia, one of the most famous state universities in the country, is located in this city, along with several major private universities. Therefore, boarding houses and apartments have developed rapidly, especially near Margonda Raya street, where commercial activities are concentrated. According to the Depok land use data, agglomeration of industrial activities can also be found along Jalan Jakarta-Bogor. In terms of public transportation, the *angkot* is the only public transportation mode operating inside Depok, with a total of 6.431 units, both within the city and across the border route. Based on a 500-m buffer of the *angkot* route, 73.7% of the Depok area is served by public transportation. A train station of the JMA railway system can also be found in the Depok city area.

Indonesia is the country with the highest energy consumption in Southeast Asia and the fifth-highest in the Asia Pacific region and its energy sources are still dominated by oil (47%), which also primarily supplies the needs of the transportation sector, representing the most energy-consuming sector (42%) (BPPT, 2018). Despite the strategic role of this city, the absence of systematic and integrated public transportation facilities in Depok pushes citizens to increasingly use private motorized vehicles instead of shared ones. In addition, the street growth per year is only 0.7%, a value markedly less than the motorized vehicle growth of 9% per year. Because Jakarta is a center of employment and commerce located to the north of Depok, it is easy to travel from the south to the north of Depok, as well as vice-versa. However, east–west travel in the city does not share the same level of ease, meaning that longer routes must be taken. These conditions lead to daily traffic congestion, especially in areas where the government has focused on the development of commercial activities, such as Jalan Margonda Raya, thus also increasing energy consumption in the transportation sector.

4. Results and Discussion

Urban form in Depok

On a village scale, in terms of the density attribute, Depok has an average population density of up to 9.659 people per km^2. The population density varies from its minimum value (2.497 people/km^2) in Tapos village (H3) to its highest value (22.794 people/km^2) in Abadijaya village (E4). Based on plot 1 in Figure 2, villages with high population density tend to be located in the central and eastern parts of the city, whereas those with low density can be found in peripheral areas.

In this study, the diversity attribute was explored in terms of the land use mix, measured by the number of different land use types in each village administration area. There are two villages with the lowest category of diversity (four land use types), i.e., Duren Seribu village (B1) and Pondok Jaya village (D3). The highest diversity level was identified in 30 out of 63 villages in Depok, with eight different types of land use. No particular pattern was identified in the distribution of the diversity level, however, five of the villages in the lowest diversity category are located in the southern part of the city (Figure 2, plot 2).

Street connectivity in Depok was measured by the number of intersections per km^2 in each village administration area, including primary, secondary, and local streets. Tolls were excluded from the measurement due to access limitations, unlike any other street type. The average intersection density at a village scale in Depok is 65 intersections per km^2. Like the diversity attribute, no strong spatial pattern is identified, however, the villages with high connectivity tend to be located in the central and northern parts of the city (Figure 2, plot 3).

The public transportation range area was measured as the percentage of village administration area included within the 500-m buffer area of the *angkot* route, as this is the only mode of public transportation that operates within Depok. The results show that 75% of the village

Table 1. Urban form attributes and measurements used in this research

Attribute	Variable	Measurement
Density	Population density	Population per square meter in the village area
Diversity	Land use mix	Number of different land use types in the village area
Connectivity	Street connectivity	Number of intersections per square meter in the village area
Distance to public transportation	Public transportation range area	Percentage of the village area covered by a 500-m buffer from the public transportation route

Source: secondary data processing

Table 2. Transportation mode energy consumption per capita per km

Transportation mode	Energy per capita per km (BOE)
Private motorcycle	1.73×10^{-4}
Private car	5.23×10^{-4}
'Angkot' (small public transport)	1.77×10^{-5}
Online motorcycle ride-hailing	1.04×10^{-4}
Ojek	1.04×10^{-4}
Online car ride-hailing	3.40×10^{-4}
Taxi	3.40×10^{-4}

Source: Indonesian Ministry of Energy and Mineral Resources, 2015

Figure 1. Jabodetabek Metropolitan Area and the location of the study area (shown in green)

administration areas have average public transportation service levels. There are two villages in Depok where the entire area (i.e., 100%) falls within the *angkot* service area, namely, Curug village (G1) and Depok Jaya village (C5). In contrast, there are three villages where less than 10% of the area falls within the public transportation range area, namely, Pasir Putih village (A3), Cimpaeun village (H2), and East Beji village (I2). No clear spatial pattern is identified based on this attribute (Figure 2, plot 4).

The urban form data of all attributes were then combined to identify the urban form compactness level at a village area scale. The higher the category of urban form attributes in a village area, the more compact the urban form becomes. As shown in Figure 3, the villages in the northern and central parts of the city tend to have high urban form compactness, whereas those with lower values are mainly distributed in the eastern and southern parts of the city.

Traveler characteristics in Depok

The highest number of research respondents own a private motorcycle (46 respondents), in addition to a similar number who own both a private car and motorcycle (43 respondents). Only a few respondents have only a private car (eight respondents) or no private vehicle (eight respondents). Driving license ownership exhibits a different pattern, where 36 out of 105 respondents did not own any driving license, whereas 11, 24, and 34 other respondents, respectively, owned a car driving license, motorcycle driving license, and both license types. In terms of job type, 74 of 105 respondents had a formal job, including civil servant, private employee, and teacher/lecturer. Of the other respondents, 31 had a non-formal job type (student, entrepreneur, and stay-at-home mom/dad). On average, the survey respondents had a monthly income of 5.96 million rupiahs, with a minimum value of 0 rupiahs and a maximum of 50 million rupiahs per month.

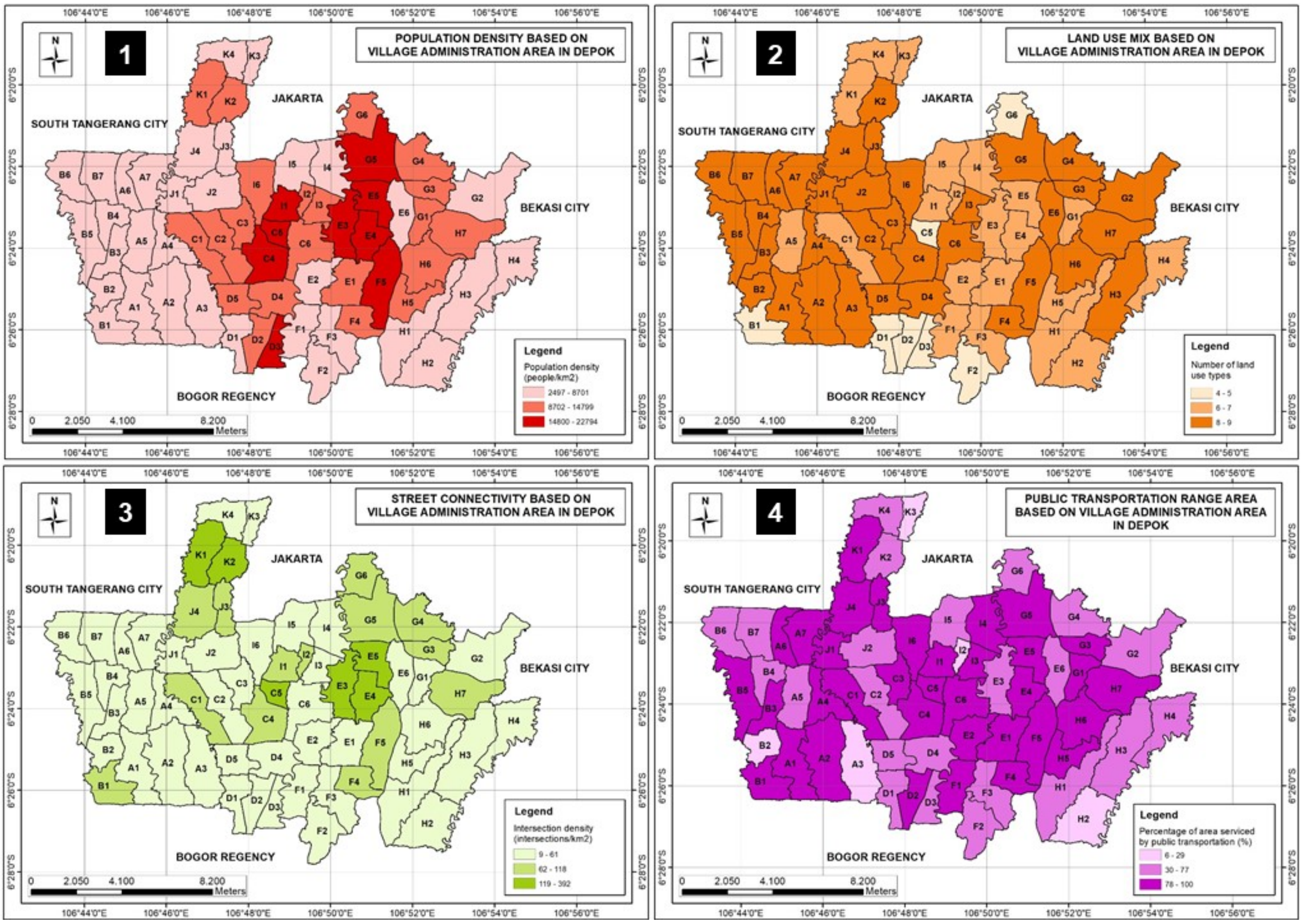

Figure 2. (1) Population density, (2) land use mix, (3) street connectivity, and (4) public transportation range area based on village administration areas in Depok

Transportation energy consumption in Depok

The transportation energy consumption in this work was calculated based on the number of days when the activities were performed, distance traveled, and transportation mode used to do the activities. The activities were divided into three types: main activities, side activities, and weekend activities. The shortest, longest, and average distance traveled for each activity are listed in Table 3. In terms of transportation mode, six modes were chosen by respondents — private motorcycle, private car, online motorcycle ride-hailing, online car ride-hailing, taxi, and *angkot*. Private motorcycle was the most popular mode (41.8% of all travel activities in this research used this mode), followed by online motorcycle ride-hailing (32%). Based on the activity type, online motorcycle ride-hailing was used the most for main activities, while private motorcycles were used most for side and weekend activities. In addition, there is a notable increase in private car usage for weekend activities (36.9%), compared to main and side activities (10.5% and 12.7%). After calculation, the lowest energy consumption for transportation activities was found to be 7.40×10^{-4} BOE, while the highest was 8.76×10^{-2} BOE per week per capita.

Statistical analysis of energy consumption

The result of bivariate correlation analysis illustrates that transportation energy consumption is negatively correlated with population density and street connectivity at the scale of village administration areas, with Pearson correlation scores of -0.190 and 0.176, respectively (Table 5). The other variables analyzed using this method (land use mix, public transportation range area, and monthly income) show no correlation with the energy consumed per capita per week for transportation activities. However, using one-way ANOVA (Table 6), transportation energy consumption was found to differ significantly based on urban form compactness, private vehicle ownership, driving license ownership, and job type. Furthermore, according to the post-hoc tests, transportation energy consumption in villages with high urban form compactness is lower than the usage in those with medium compactness. In terms of the private vehicle ownership variable, the energy consumption of traveling activities by respondents whose household owns a private car is higher than those that own only motorcycles or no private vehicle. Respondents who own a car driving license consume more energy in traveling relative to those with only a motorcycle driving license or those without a driving license. Meanwhile, based on the job type, respondents who work as a teacher/lecturer have higher transportation energy consumption values than civil servants or private employees.

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Our findings confirm the results of Ding et al. (2017), which show that a high population density correlates to a lower probability of owning a vehicle, as well as lower income. However, population density is not related to the choice of travel mode type and does not affect the travel distance; in addition, mixed land use does not significantly reduce vehicle ownership and travel distance will increase energy consumption. A study by Stevens (2016) confirmed that the features of a compact city do not have a significant influence on citizens' behavior in terms of using motorized transportation modes. However, Ding et al. (2017) suggested that mixed land use is still required to reduce the distance between origin and destination.

Transportation energy consumption in Indonesia as a developing country

This study, based in Depok, verifies that two out of four urban form attributes explored correlation with the amount of transportation energy consumption, in addition to the level of urban form compactness and three of the four socio -economic variables (i.e., private vehicle ownership, driving license ownership, and job type). The city is part of the largest metropolitan area in Indonesia, however, as a satellite city, the transportation facilities are of a consistent standard with other cities in the country. Accordingly, the broader overview achieved in this study can be said to be representative of Indonesian cities more generally.

The research findings show both similarities with and differences from previous related studies. Several previous works did not investigate the correlation between transportation energy consumption and connectivity or found no correlation between these factors (da Silva et al., 2007; Yin et al., 2017; Nichols and Kockelman, 2015; Guhathakurta and Williams, 2015). However, the findings of this study indicate that the density attribute correlates with the amount of energy consumed for transportation, a conclusion that is consistent with previous studies, even

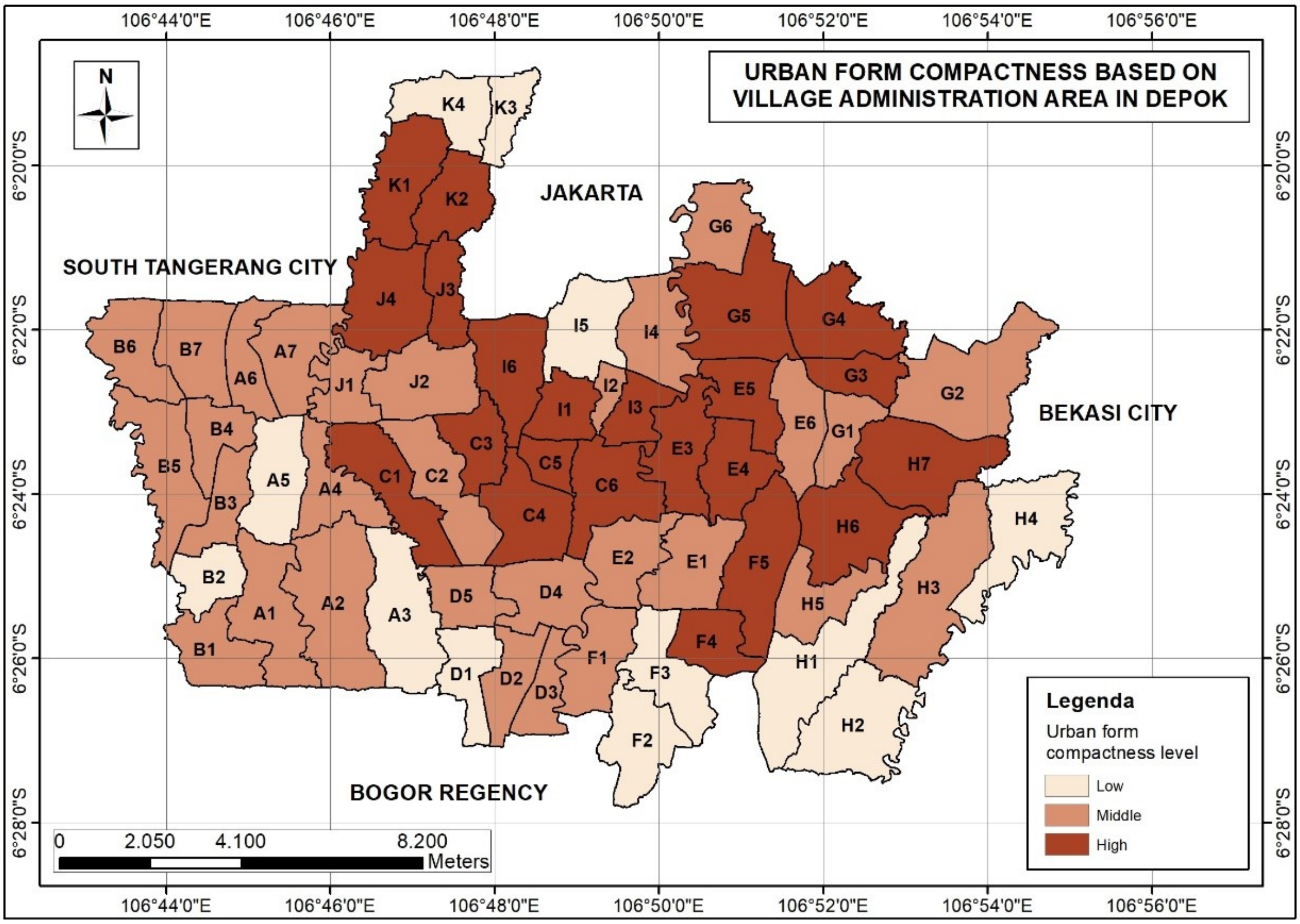

Figure 3. Urban form compactness based on village administration area in Depok

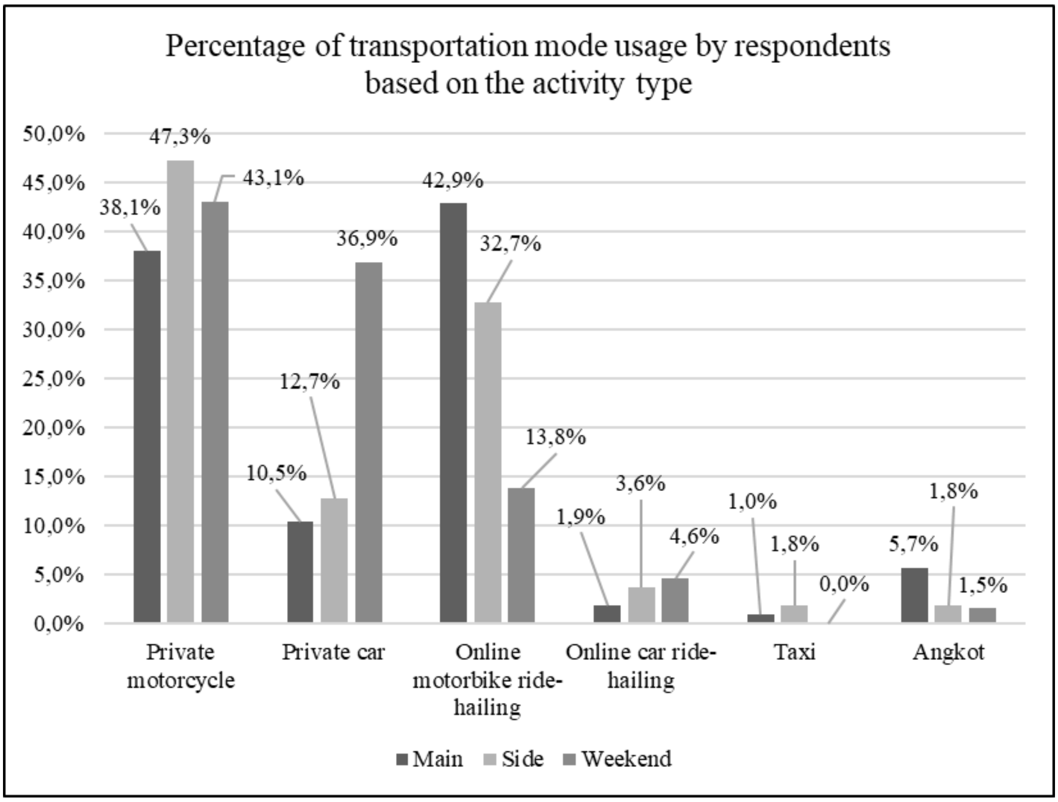

Figure 4. Percentage of transportation mode usage by respondents based on activity type

Table 3. Distance traveled by respondents

	Main activities	Side Activities	Weekend activities
Shortest	400 m	500 m	500 m
Longest	13.1 km	12 km	19 km
Average	5.2 km	4.1 km	5.6 km

Source: primary data processing

Table 4. Transportation energy consumption by respondents per week per capita

Transportation energy consumption per week per capita	Number of respondents
0 – 0.01 BOE	51
0.011 – 0.045 BOE	48
0.046 – 0.09 BOE	6

Source: primary data processing

Table 5. Correlation analysis results

	Transportation energy consumption	
	Pearson Correlation	Sig. (2-tailed)
Population density	-0.190	0.052
Land use mix	0.056	0.569
Street connectivity	-0.176	0.073
Public transportation range area	-0.024	0.809
Income	0.090	0.359

Source: data analysis

though different measurement metrics were used (employment density and housing density). In addition, the correlation between urban form compactness and transportation energy consumption that was found in this work was also recognized in previous studies (Baker and Steemers, 2000; Perkins et al., 2009; Kaza, 2020).

Compared to previous works, in this study, the role of urban form attributes is relatively low in influencing transportation energy consumption (only two out of four variables are proven correlated), although the attributes are correlated when they are combined as urban form compactness. In contrast, the socio-economic variables are also significant, even though the strength of this correlation cannot be described. In terms of previous energy consumption analyses in developing countries, a study by Permana et al. (2008) showed that different urban development forms have different energy consumption levels, including consumption in the transportation sector. This is consistent with how different urban form compactness levels result in different transportation energy consumption values in this work. This result is also similar to the findings from research conducted in Brazilian cities (da Silva et al., 2007), where socio-economic attributes were found to have a relatively stronger influence than urban form ones. This implies that in developing countries' cities, especially in Indonesia, transportation energy consumption tends to be influenced more by the combination of urban form attributes than factors on an individual attribute basis and that socio-economic factors play a much more important part.

5. Conclusion

At least three main conclusions can be drawn from our study of Depok. Out of the four urban form attributes observed, the population density and street connectivity were found to be correlated with the transportation energy

Table 6. One-way ANOVA results

Variable	Source of Variation	SS	df	MS	F	Sig.
Urban form compactness	Between Group	0.001	2	0.000	2.419	0.094
	Within Group	0.020	102	0.000		
	Total	0.021	104			
Private vehicle ownership	Between Group	0.003	3	0.001	4.706	0.004
	Within Group	0.019	101	0.000		
	Total	0.021	104			
Driving license ownership	Between Group	0.002	3	0.001	3.099	0.030
	Within Group	0.020	101	0.000		
	Total	0.021	104			
Job type	Between Group	0.003	5	0.001	2.746	0.023
	Within Group	0.019	99	0.000		
	Total	0.021	104			

Source: data analysis

consumed by citizens traveling within the city. When those urban attributes are integrated as the urban form compactness level, different category levels were found to have different transportation energy consumption values. In terms of the correlation with socio-economic variables, different job types, private vehicle ownership, and driving license ownership were also proven to relate to different energy usage levels in the transportation sector.

Based on the findings above, in order to reduce transportation energy consumption, some potential policies are recommended. First, city development, if possible, should focus on increasing the density and connectivity at a village area scale. Second, simultaneously, compact city development should be encouraged, considering how villages with high urban form compactness have lower transportation energy consumption compared to middle-level compactness. Third, the regulation of private car ownership should be tightened, in addition to the regulation of driving license ownership. Fourth, adequate public transport facilities especially to and from schools and campuses should be provided, given the finding from this research that teachers or lecturers typically have higher transportation energy consumption compared to other job types.

References

Baker, N., and Steemers, K. (2000). *Energy and Environment in Architecture*. London: Taylor & Francis.

Bengston, D. N., Potts, R. S., Fan, D. P., and Goetz, E. G. (2005). An analysis of the public discourse about urban sprawl in the United States: Monitoring concern about a major threat to forests. *Forest Policy and Economics*, *7*(5), 745-756.

Bowyer, D. (2015). *Measuring Urban Growth, Urban Form, and Accessibility as Indicators of Urban Sprawl in Hamilton, New Zealand* (master thesis). LUP Student Papers. (GISM01 20152).

BPPT (2018). *Outlook Energi Indonesia 2018: Energi Berkelanjutan untuk Transportasi Darat*. Jakarta, DKI: Pusat Pengkajian Industri Proses and Energi. Retrieved from https:// www.bppt.go.id/outlook-energi/bppt-outlook-energi-indonesia-2018.

Chen, J., & Li, S. (2017). Mode choice model for public transport with categorized latent variables. *Mathematical Problems in Engineering, 2017*.

Creswell, J. W., and Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

da Silva, A. N. R., Costa, G. C. F., and Brondino, N. C. M. (2007). Urban sprawl and energy use for transportation in the largest Brazilian cities. *Energy for Sustainable Development*, *11*(3) 44-50.

Dawson, C. (2007). *A practical guide to research methods: A user-friendly manual for mastering research techniques and projects*. How To Books.

Eriyanto, A. (2007). *Teknik Sampling-Analisis Opini Publik*. Yogyakarta: LKiS Pelangi Aksara.

Dempsey, N., Brown, C., Raman, S., Porta, S., Jenks, M., Jones, C., and Bramley, G. (2010). Elements of urban form. In *Dimensions of the sustainable city* (pp. 21-51). Springer, Dordrecht.

Ding, C., Wang, D., Liu, C., Zhang, Y., and Yang, J. (2017). Exploring the Influence of Built Environment on Travel Mode Choice Considering the Mediating Effects of Car Ownership and Travel Distance. *Transportation Research Part A-Policy and Practice*, *100*, 65–80.

Fox, J., Murray, C., and Warm, A. (2003). Conducting research using web-based questionnaires: Practical, methodological, and ethical considerations. *International journal of social research methodology*, *6*(2), 167-180.

Guhathakurta, S. and Williams, E. (2015). Impact of urban form on energy use in central city and suburban neighborhoods: lessons from the phoenix metropolitan region. *Energy Procedia*, *75*, 2928-2933.

Hickman, R., & Banister, D. (Eds.). (2014). *Transport, Climate Change and the City*. London and New York: Routledge.

Kandt, J. (2018). Heterogeneous links between urban form and mobility. *Journal of Transport and Land Use*, *11*(1), 721-745.

Kaza, N. (2020). Urban form and transportation energy consumption. *Energy Policy*, *136*, 111049.

Kennedy, C., Cuddihy, J., and Engel-Yan, J. (2007). The changing metabolism of cities. *Journal of industrial ecology*, *11*(2), 43-59.

Li-me, M. (2014). The Spatial Effect of China's Haze Pollution and the Impact from Economic Change and Energy Structure. *China Industrial Economy*, *4*, 19–31.

Milakis, D., Cervero, R., and Van Wee, B. (2015). Stay local or go regional? Urban form effects on vehicle use at different spatial scales: A theoretical concept and its application to the San Francisco Bay Area. *Journal of Transport and Land Use*, *8*(2), 59 -86.

Ministry of Energy and Mineral Resources (2015). *Panduan Pengguna untuk Sektor Transportasi, Indonesia 2050 Pathway Calculator*. Jakarta, DKI: Kementerian ESDM RI. Retrieved from http://calculator2050.esdm.go.id/assets/mini_paper/energy/ id/ Panduan%20 Pengguna%20untuk%20Sektor% 20Transportasi.pdf.

Moore, T. and Pulidindi, J. (2011). *Understanding Urban Transportation Systems*. Center for Research and Innovation, National League of Cities: Washington, DC, USA.

Nedovic-Budic, Z., Knaap, G. J., Shahumyan, H., Williams, B., and Slaev, A. (2016). Measuring urban form at community scale: Case study of Dublin, Ireland. *Cities*, *55*, 148-164.

Nichols, B. G., and Kockelman, K. M. (2015). Urban form and life-cycle energy consumption: Case studies at the city scale. *Journal of Transport and Land Use*, *8*(3), 115-128.

Oliveira, V. (2016). *Urban morphology: an introduction to the study of the physical form of cities*. Springer.

Ozturk, I., and Acaravci, A. (2013) The long-run and causal analysis of energy, growth, openness, and financial development on carbon emissions in Turkey. *Energy Economics*, *36*, 262–267.

Perkins, A., Hamnett, S., Pullen, S., Zito, R., and Trebilcock, D. (2009). Transport, housing and urban form: the life cycle energy consumption and emissions of city centre apartments compared with suburban dwellings. *Urban Policy and Research*, *27*(4), 377-396.

Permana, A. S., Perera, R., & Kumar, S. (2008). Understanding energy consumption pattern of households in different urban development forms: A comparative study in Bandung City, Indonesia. *Energy Policy*, *36*(11), 4287-4297.

Qu, W., Xu, L., Qu, G., Yan Z., and Wang, J. (2017). The impact of energy consumption on environment and public health in China. *Natural Hazards*, *87*, 675–697.

Rodrigue, J. P., Comtois, C., and Slack, B. (2016). *The geography of transport systems*. Routledge.

Seto, K.C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G.C., Dewar, D., Huang, L., Inaba, A., Kansal, A., Lwasa, S., and McMahon, J. (2014). Human settlements, infrastructure and spatial planning. Climate change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA*.

Shaheen, S., Martin, E., & Hoffman-Stapleton, M. (2021). Shared mobility and urban form impacts: A case study of peer-to-peer (P2P) carsharing in the US. *Journal of Urban Design*, *26*(2), 141-158.

Silva, M., Oliveira, V., and Leal, V. (2017). Urban form and energy demand: a review of energy-relevant urban attributes. *Journal of Planning Literature*, *32*(4), 346-365.

Sipe, N. G., Mayere, S., and Dedekorkut-Howes, A. (2011) Measuring urban form: a comparative analysis of South East Queensland and South Florida. In *The 3rd World Planning Schools Congress*, 4-7 July 2011, Perth, WA.

Song, Y., Shao, G., Song, X., Liu, Y., Pan, L., and Ye, H. (2017). The relationships between urban form and urban commuting: An empirical study in China. *Sustainability*, *9*(7), 1150.

Statistics Indonesia (2018). *Kota Depok dalam Angka Tahun 2018*. Depok: BPS Kota Depok. Retrieved from https:// depokkota.bps.go.id/publication/2018/08/16/ cb3fbb2cd33244bf5f2e8 53c/kota-depok-dalam-angka-2018.html.

Steemers, K. (2003). Energy and the city: density, buildings and transport. *Energy and buildings*, *35*(1), 3-14.

Stevens, MR. (2016): Does Compact Development Make People Drive Less? *Journal of the American Planning Association, 83*, 1 -12.

Sue, V. M., Ritter, L. A., and Lois, A. (2007). *Conducting online surveys*. Thousand Oaks: Sage.

Tamin, O. Z. (2000). *Perencanaan and pemodelan transportasi*. Bandung: Penerbit ITB.

UN Habitat (2012). *Sustainable Urban Energy, A Sourcebook for Asia*. Nairobi, Kenya: United Nations Human Settlements Programme (UN Habitat). Retrieved from http:// mirror.unhabitat.org/list.asp?typeid=15&catid=356.

Van Selm, M., & Jankowski, N. W. (2006). Conducting online surveys. *Quality and quantity*, *40*(3), 435-456.

Walliman, N. (2011). *Research Methods: The Basics*. New York: Routledge.

World Bank (2010). *Cities and Climate Change: An Urgent Agenda (Urban development series; knowledge papers no. 10)*. Washington, DC: World Bank. Retrieved from https:// openknowledge.worldbank.org/handle/10986/ 17381.

Yang, J. and Jinxing, Z. (2007). The failure and success of greenbelt program in Beijing. *Urban forestry & urban greening*, *6*(4), 287-296.

Yin, Y., Mizokami, S., and Maruyama, T. (2013). An analysis of the influence of urban form on energy consumption by individual consumption behaviors from a microeconomic viewpoint. *Energy Policy*, *61*, 909-919.

Zenina, N., and Borisov, A. (2011). Transportation Mode Choice Analysis Based on Classification Methods. *Scientific Journal of Riga Technical University*, *45*(1), 49-53.

Zhao, C., Nielsen, T. A. S., Olafsson, A. S., Carstensen, T. A., & Meng, X. (2018). Urban form, demographic and socio-economic correlates of walking, cycling, and e-biking: Evidence from eight neighborhoods in Beijing. *Transport Policy*, *64*, 102-112.

Zhao, J., Xiao, L., Tang, L., Shi, L., Su, X., Wang, H., Song, Y. and Shao, G. (2014). Effects of spatial form on urban commute for major cities in China. *International Journal of Sustainable Development & World Ecology*, *21*(4), 361-368.

Zhao, P. (2014). The impact of the built environment on bicycle commuting: Evidence from Beijing. *Urban studies*, *51*(5), 1019-1037.