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Spatial Patterns of Travel Behavior in Rapidly Urbanizing Areas: A Case Study of Sango-Ota, Ogun State, Nigeria

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ABSTRACT: Spatial interaction theory serves as a foundational framework for understanding the flow and patterns of transport movements within urban and rural areas. Hence, the objective of this paper was to evaluate the spatial patterns of travel behavior among residents in Sango-Ota, Ogun State, Nigeria, by assessing the factors influencing mobility, including socio-economic characteristics, land use distribution, and population density using primary data collected via structured questionnaires administered to 357 households across different residential zones. Data obtained show that majority of trips (54.4%) are work – related, with average trip lengths between 5.1 and 10 km. A significant statistical variation exists in daily trip frequency among different spatial structures ($F = 22.082$, $p = 0.000$). Findings indicate that urbanization has led to increased travel demands and changing mobility patterns, necessitating targeted transportation policies. The study underscores the importance of integrating urban planning with transportation strategies to improve mobility in rapidly growing urban areas.

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Spatial interaction theory serves as a foundational framework for comprehending the flow and patterns of transport movements within urban areas (Liu, *et.al.*, 2019). Transport flows, including the movement of people, goods, and information, exhibit variations in scale, direction, and content based on the modes of transportation utilized. These interactions are not uniform but are shaped by diverse factors, such as land use distribution, socio-economic characteristics, population density, and land-use densities in residential areas (Ojekunle, 2016). Despite concerted efforts to grasp the dynamics of urban travel behaviour, the complexities of spatial patterns persist, particularly in developing nations such as Nigeria. This necessitates further exploration to establish definitive trip generation patterns linked to diverse land uses. Clifton and Handy (2021) succinctly capture this situation, highlighting how the understanding of urban travel behaviour constantly expands, revealing new intricacies and posing fresh challenges to transportation planners and managers. The interplay between transportation systems and travel behavior is complex, particularly in urban environments experiencing rapid growth and change.

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In Sango-Ota, Nigeria, the dynamics of mobility are influenced by a myriad of factors, including the spatial distribution of activities, socioeconomic characteristics, and residential location. As highlighted by Clifton and Handy (2021), understanding the spatial patterns of transport movements is crucial for effective urban planning. This study investigates the factors that shape residents' travel behavior and the spatial patterns of activities that influence these behaviors. By analyzing the relationships between economic, educational, administrative, and social activities, the research aims to uncover the underlying patterns that dictate how residents navigate their urban environment. Understanding these relationships is crucial for urban planners and policymakers who seek to create sustainable and efficient transportation solutions that accommodate the evolving needs of Sango-Ota's population (Muili, 2013; Sodiya, 2020). This rapid urban expansion has brought about various socio-economic changes and challenges, particularly in the realm of transportation and mobility. As the population of Sango-Ota continues increases, the demand for efficient and accessible transportation systems has become more pronounced (Sodiya, 2020). However, the existing transportation infrastructure in the area often struggles to cope with the growing needs of residents, leading to issues such as traffic congestion, inadequate public transit services, and limited mobility options. Analysing the mobility of resident within and around the area, researchers and policymakers can identify patterns, trends, and bottlenecks in mobility, as well as assess the effectiveness of existing transportation systems.Mobility behaviour is influenced by various socio-economic factors, including income levels, employment opportunities, land use patterns, and access to transportation facilities. Therefore, a comprehensive understanding of these factors is essential for developing targeted interventions and policies aimed at improving mobility outcomes and enhancing overall quality of life for residents. Against this background, this study examines the spatial analysis of mobility behaviour of residents by highlighting the urbanization trends, transportation challenges, and the importance of understanding mobility behaviour in Sango-Ota, Nigeria with a view of observing the variations in trip behaviour across varying residential densities. The objectives are to assess the spatial pattern of residents' travel pattern in the study area, to analyze the relationship between spatial structures and trip modes among residents in Sango-Ota and to examine the factors that influence the travel behaviour of the residents in the study area.

According to Donegan *et. al.*, (2017), people's travel pattern was designated by Pickup and Town in 1983 as 'an outcome of the balance between the activity choices and constraints that face each individual. Stead and Marshall (2011) pointed out that travel pattern typically speaks to individual's travel characteristics in terms of mode choice (e.g. commuting, shopping or leisure). Unlike travel patterns studies, travel pattern research usually seeks to find justifications and explanation of people's travel-related options; i.e. how and why rather than frequency of travel. People's travel pattern is typically designated by a number of travel outcome such as trip frequency, mode share, journey length and time of day (Meurs and Van Wee,2013). Travel outcomes such as transport energy consumption and $C0_2$ emissions have been recently also used as composite metrics (Headier *et al.,* 2019). The spatial distribution in daily activities and increasing rate of car ownership are central to increase in travelled distances and car dependency. Consequently, it has become important to consider the resulting travel-related externalities. Researchers pointed out that adequate understanding of people's travel pattern could significantly contribute in helping to mitigate these issues (Llera*et al.,* 2012) and(Meurs and Van Wee, 2013). Transportation is a crucial sector supporting people's activities, enabling them to meet their needs related to social and economic interactions. Individuals engage in diverse activities across different locations, driven by biological needs, social obligations, and personal desires, encompassing work, education, recreation, and social interactions (Vilhelmson, 2017, in Lars Eriksson, 2019). As time progresses, people's activities become more intricate, leading to a heightened demand for mobility.Over the past few decades, the landscape of travel modes has evolved from limited options to a diverse range that caters for different preferences and needs. This variety includes travel modes ranging from the most economical to the most luxurious, with varying service standards from common to exclusive quality. This diversity empowers individuals to choose the most suitable travel mode for each activity, whether through private transportation or public transportation (Erikson, 2018). With the rise in people's incomes, many individuals can now afford to purchase private vehicles such as cars. Cars are preferred for their speed, comfort, convenience, carrying capacity, and the privacy they offer. Owning a car, significantly enhances freedom in performing activities across different locations, including work, shopping, and leisure pursuits. The ownership of a car is often associated with status, and driving is seen as a means to gain recognition (Eriksson, 2018). However, with the car being at home, other members

of the household now have access to the car and many change their activity patterns, possibly leading to increased mobility (Ettema and Timmermans, 2017). Having a car at home not only grant the owner increased mobility but also provides access to other household members. This accessibility may lead to changes in activity patterns within the household, contributing to increased overall mobility. Understanding the dynamics of travel modes, particularly the role of cars, is essential for comprehending how individuals navigate and conduct their activities in the contemporary world (Jakobsson, 2014) and (Ettema and Timmermans, 2017).Steg, *et.al.*, (2011) asserted that mode is a mean of transport that makes an object become mobile in certain movement path, and are operated in that path. Transport is facility to help people or a group of people to reach many places. According toShen,*et. al*., (2016), there are few factors affecting mode choice, and they are divided into three groups: Road user characteristics, e.g. car ownership, driving license ownership, household structures, income and density of residential, movement characteristics e.g. trip purpose, time travel, travel distance and Transportation mode facilities, consisting of two categories, i.e. quantitative factors e.g. travel time inside the vehicle, waiting time and walking time and cost and Qualitative factors, e.g. comfort and leisure, availability and orderly and safety.A mode of transport is a situation that makes use of a particular type of vehicle, infrastructure and operation. Each mode has its advantages and was chosen for a trip on the basis of cost, capability route and speed. Understanding mode choice is important since it affects how efficiently we can travel; how much urban space is devoted to transportation functions as well as the range of alternatives available to the traveler (Convery and Williams, 2019). Hence, the objective of this paper was to evaluate the spatial patterns of travel behaviour among residents in Sango – Ota, Ogun State, Nigeria.

MATERIALS AND METHODS

Study Area: Sango Ota, located in Ogun State, is an ancient Yoruba Awori town with roots traced back to the late 15th and early 16th centuries.

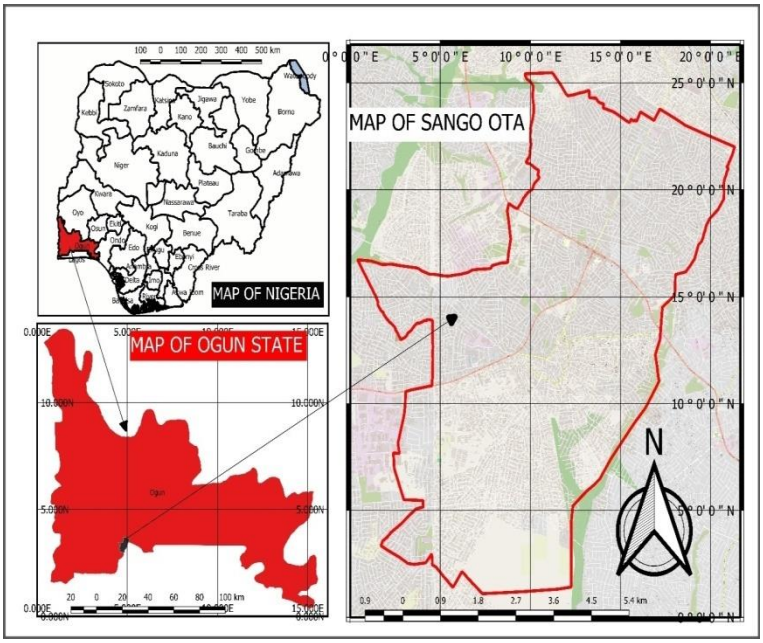

Fig 1: Sango Ota, Within the Context of Ogun State and Nigeria
Source: Geographic Information System (GIS), 2023

Founded by Aworis originating from Ile-Ife, the town's progenitor, Olofin, and his followers embarked on a journey from Ile-Ife, eventually settled in the present site of Ota after the ship they were following sank.Olofin's descendants, Osolo and EleidiAtalabi, established themselves in different quarters of Sango Ota, Otun and Osi, respectivelywhile the third quarter, Ijana, was populated by people of Oyo, Ishaga, and Egun extraction. Sango Ota's strategic location made it a haven for powerful warriors, defending the town against external aggressions. Sango Otacurrently serving as the headquarters of Ado-Odo-Ota Local Government Area has played a prominent role in the

administrative, cultural, and economic development of its region over an extended period. Geographically, Sango Ota is positioned between latitude 6°42' - 6°50' North of the Equator; and Longitude 3°8' - 5°15' East of the Greenwich Meridian covering a total land area of 1,263 square kilometers as presented on Figure1.The terrain of Sango Ota comprises 1,010.4 square kilometers of plain land and approximately 252.6 square kilometers of challenging terrain, including 16% riverine and 4% hilly regions. Notably, Sango Ota has steadily grown to become the largest industrial town in Ogun State, a feat largely attributed to its proximity to Lagos, as it is situated near the boundary with Lagos State, Nigeria.

Data Collection: Primary data was the main data used in the study. The primary data is from original source and it constitutes the bulk of data required for the study. The secondary source of data utilized for the study includes information which were be adapted from textbooks, journals, and online media. Others are information on the population figure of Sango Ota which was adapted from the Nigerian Population Commission (NPC) and Nigerian Bureau of Statistics (NBS). This was aimed at determining the population trend of the study area and in calculating the number of questionnaires to be administered in each of the local government areas. Maps of the study area were sourced from Google Earth Map and Geographic Information Software.The main instrument of data collection was the questionnaire. A questionnaire consists of a number of questions printed or typed in a definite order on a form or set of forms, Questionnaire for this study shall be structured into two parts, sections A and B. The first part considered the socio-economic characteristics of respondents. The second part of the questionnaire dealt with the travel and activity pattern of urban Residents.The information required covers the detailed characteristics of the household trips for different purposes and for different days of the week. The basic questions include the mode-choice, purpose of trip, time spent on the journey and trip length. All the possible trips were divided into five purposes. Namely, work, shopping, recreation, social and business trips.The questionnaire was administered on selected households in Sango Ota Area of Ogun state for a period of a week (Monday-Sunday). Thus, the Questionnaire serves as a self-administered travel diary and it was collected after seventh day of a week.

Table 1: The sampled Area in Sango Ota

S/N	Spatial Structure	Localities	Number of Selected Localities
1	Traditional Core Zone	Mefun, Palace road, Okeede, Abebi, Papa Aro, Ilo	6
2	Transitional Zone Zone	Ewupe, Iyana Ilogbo, Afobaje, IloAwela	4
3	Sub-urban Zone	Iyesi, Osuke	2

Source: Author's Conceptualization (2023)

Data Analysis: Descriptive statistics (which includes calculating average trip frequencies, trip purposes, and lengths, which provides a general overview of the travel behavior of residents) and ANOVA was used for the study

Sample Size: The sample size for the study was calculated using Yammane (1967) sample size formula 95% level of confidence and a confidence interval or margin error of 5%. Therefore, a total of three hundred and fifty-seven (357) copies of questionnaires were administered to households' heads across the three spatial structures as shown in Table 2.

Table 2: Number of Houses on the Selected Residential Location

Selected Localities (Core Zone)	No of Houses	Sample Size	Selected Localities (Intermediate Zone)	No of Houses	Sample Size	Selected Localities (Periphery Zone)	No of Houses	Sample Size
Mefun	170	18	Ewupe	382	42	Iyesi	356	26
Palace Road	314	33	Iyana Ilogbo	258	27	Osuke	582	42
Okede	298	33	Afobaje	276	30	-	-	-
Abebi	234	24	IloAwela	167	16	-	-	-
Papa Aro	298	33	-	-	-	-	-	-
Ilo	315	33	-	-	-	-	-	-
Total	1557	174	-	1083	115	-	938	68
Total: 174 + 115 + 68 = 357								

Source: Author's Conceptualization (2023)

RESULTS AND DISCUSSION

Trip Characteristics of Residents: This section discusses findings on residents' trip frequency, trip purpose and trip length. Furthermore, the results of analysis on weekly resident trip and Intra-Urban variation in residents trip frequency are reported.

Weekly Trip Frequency of Residents: As revealed in Table 3, travel diary of 357 residents for seven days of the week in the three residential areas generated a total of 3,772 trips, with residents' daily average trip of 179.6 trips. Further analysis shows that person's daily average trip was 4.6 trips, while daily average household trip was 1.5. The person's average weekly trip generated was 32, while household's average weekly trip generated was 10.4. The results of household average trip generation are low when compare with that of individual. The results of household trip generation show that few individuals within a household generated trip, while others are either not making or generated few trips. The implication of the findings was that an individual in the study area has the tendency to generate 4.6 trips daily and 32 trips per week. However, a household has proclivity to generate 1.5 trips daily and 10.4 trips weekly. Further analysis reveals that a seven-day travel diary of 147 sampled residents in traditional Spatial Structure generated 1,557 trips, with resident's daily average trip of 222.4. It was found that a person's average daily was 4.4 and household daily average trip was estimated to be 1.5. In addition, resident's weekly average trip generated was 30.5, whereas household weekly average trip made was 10.5. From the findings, it could be inferred that a resident in traditional core zone has tendency to generate 4.4 trips per day and 30.5 trips per week. Moreover, a household in the zone has propensity to make 1.5 trips daily and 10.5 trips in a week. The findings show that number of a resident trip was higher than that of household. This was because an individual in a household generated more trips compare to household as a whole. Findings from Transitional zone, it was revealed that a seven-day travel diary of 102 residents made 1,046 trips, with residents' daily average trip of 149.4. Additionally, the daily average trip of a person was 4.3. A daily average household trip generated was 1.5. While the result of resident's weekly average trips generated was 30, the household weekly average trip made was 10.3. This implication of this findings was that resident from traditional zone has propensity to generate 4.3 trips per day and 30 trips in a week. While a household in the zone has probability of generating 1.5 trips daily and 10.3 trips in a week.

Table 3: Trip Generation of Residents

Spatial Structure	**Week days**	**Aggregated Daily Person Trips**	**Daily Average Person Trip**	**Daily Average Household Trip**
Traditional Core	Monday	262	5.1	1.8
	Tuesday	237	4.7	1.6
	Wednesday	211	4.1	1.4
	Thursday	221	4.3	1.5
	Friday	239	4.7	1.6
	Saturday	180	3.5	1.2
	Sunday	207	4.1	1.4
	Total Weekly Trips	1,557	30.5	10.5
	Average Daily Trip	222.4	4.4	1.5
Transitional Zone	Monday	150	4.3	1.5
	Tuesday	149	4.3	1.5
	Wednesday	156	4.5	1.5
	Thursday	151	4.3	1.5
	Friday	153	4.4	1.5
	Saturday	146	4.2	1.4
	Sunday	141	4.0	1.4
	Total Weekly Trips	1,046	30	10.3
	Average Daily Trip	149.4	4.3	1.5
Sub-urban	Monday	187	5.7	1.7
	Tuesday	176	5.3	1.6
	Wednesday	173	5.2	1.5
	Thursday	187	5.7	1.7
	Friday	185	5.6	1.6
	Saturday	133	4.0	1.2
	Sunday	128	3.9	1.1
	Total Weekly Trips	1,169	35.4	10.4
	Average Daily Trip	167	5.1	1.5
Ground Total Weekly Trips		**3,772**	**32**	**10.4**
Ground Average Daily Trip		**179.6**	**4.6**	**1.5**

Source: Author's Field Survey (2023)

Moreover, results of analysis from sub-urban Spatial Structure show that a seven-day travel diary of 113 residents generated 1,169 trips, with residents' daily average trip of 167. A daily average trip generated by a resident and a household in the study area was 5.1 and 1.5 trips respectively. In similar vein, a resident's and household weekly average trip generated was 35.4 and 10.4 trips respectively. It was evident from the findings that a resident in sub-urban zone generated 5.1 trips daily and 35.4 trips weekly, while a household made 1.5 trips per day and 10.4 trips in a week.

Intra-Urban Variation in Residents Trip Frequency: Information presented on Table 4 shows the residents' trip frequency in each day of the week and spatial structures. The seven-day travel diary of 362 residents surveyed in the study area generated a total of 3,772 trips. 41.3% of the trips were generated by the residents in the traditional zone. While 27.7% of the trips were made by residents in Transitional zone, about one third (31%) were generated by the residents in sub-urban spatial structure. The study shows that an average of 222 trips were generated by residents in the traditional area, a daily average of 149 trips were made by residents in transitional zone, while 167 trips were generated by residents in sub-urban area. Furthermore, average daily trip per household was 10.6, 10.3 and 10.4 in the traditional, transitional zone and sub-urban zones respectively. The average daily trip per person in traditional area was 4.3. While respective average daily trip per person in transitional zone and sub-urban zones was 2.9 and 0.3. From the foregoing, it implies that respondents from traditional zone generated more trips than those in transitional and sub-urban zones. In the same vein, individual in traditional area made more daily trip than individual respondents from other zones. The reasons behind the higher trip generation in the traditional zone compared to Transitional and sub-urban zones could be rooted in several factors. The traditional zone might have a higher concentration of commercial and retail activities, leading to increased movement for shopping or market purposes. Additionally, it might host more public amenities, resulting in higher mobility for activities such as religious events or cultural gatherings. The area might also have a higher population density, contributing to increased travel needs. The implications of these results are significant for urban planning and transportation management. Understanding the differential trip generation across Spatial Structures was crucial for designing transportation infrastructure, allocating resources for public amenities, and implementing zoning regulations. Policymakers and urban planners can use this information to tailor transportation strategies, optimize public services, and develop efficient land-use plans that cater to the diverse travel patterns in different spatial structures.

Table 4: Spatial Structure Trip Frequency and Days of Week

Spatial Structures	Mon	Tue	Wed	Thurs	Fri	Sat	Sun	Total	%
Traditional Core	262	237	211	221	239	180	207	1,557	41.3
Transitional Zone	150	149	156	151	153	146	141	1,046	27.7
Sub-urban	187	176	173	187	185	133	128	1,169	31.0
Total	599	562	540	559	577	459	476	3,772	100
Z score	1.15238	.44343	.02190	.38595	.73084	-1.53012	-1.20439		

Source: Author's Field Survey (2023)

Spatio-Temporal Variation in Residents Trip Frequency: Findings on the spatio-temporal variation reveal that daily trip pattern varies by day in the three spatial structures. As shown in Figure 2, the trip frequency is highest on Monday in the traditional and suburban zones, while the highest trip frequency was obtained on Wednesday traditional zone. The least trip was generated on Saturday in traditional zone. However, the least trip was observed to be made on Sunday in transitional and sub-urban zones. It was noteworthy that respondents generated relatively low trip on Sunday in the three spatial structures. The need for Z-scores analysis of the spatio-temporal variation was predicated on the fact that it will provide better insight into deviation of daily trip from the mean. The daily distributions in each spatial structure were subjected to standard scores (Z-scores) as presented on Table 5. The results are as shown in the table. Findings show a divergent pattern of daily trip frequency in the three spatial structures. The trips generated in traditional core area were relatively high on Monday, Tuesday and Friday, but comparatively low on Wednesday, Thursday, Saturday and Sunday. The surge in trips recorded on Mondays aligns with the conventional start of the workweek, being the first official working day. This trend was economically significant, as it corresponds to the return to work for most individuals engaged in both public and private sector jobs. Hence, the increased mobility observed on Mondays can be attributed to the workforce commuting to their respective workplaces, reflecting the necessity of travel associated with the start of the workweek. The notable increase in trip frequency on Fridays correlates with this being the last working day before the weekend. It's a common phenomenon for individuals to prepare for the weekend ahead, potentially resulting in more frequent trips. People may undertake additional outings or errands in anticipation of the upcoming leisure time, contributing to the heightened mobility observed on Fridays. These travel patterns on Mondays and Fridays underscore the influence of the workweek cycle on residents' travel behaviour. They reflect the structured routine of weekdays and the transition from work-oriented activities to the anticipation of leisure and relaxation during the weekend. Understanding these fluctuations in travel activity concerning the workweek's commencement and conclusion was crucial for urban planners and transportation authorities to ensure adequate

infrastructural support and services to accommodate these peak travel periods. The results of trip frequency in Transitional zone reveal that the trips generated were comparatively high on Wednesday, Friday, Thursday and Monday. However, it was relatively low on Tuesday, Saturday and Sunday. The low trip frequency observed especially on Saturday and Sunday might be as a result of the fact that the days fall within weekend when some residents do not go to work. The findings from the trip frequency analysis within the Transitional zone demonstrate varying levels of mobility across different days of the week. Particularly, there's a noticeable surge in trip generation on Wednesday, Friday, Thursday, and Monday, indicating heightened travel activity during these days. Conversely, the trip frequency is notably lower on Tuesday, Saturday, and Sunday.

The observed decline in trip frequency during weekends, particularly on Saturday and Sunday, aligns with the conventional notion of these days representing the weekend when a significant proportion of residents are typically not engaged in work-related activities. During weekends, individuals often have fewer work commitments or professional obligations, leading to decreased mobility as compared to weekdays. This decline in trips during weekends suggests a shift in residents' behaviour, where the need for travel, especially for work-related purposes, diminishes, allowing for reduced travel activity. Understanding these patterns provides insight into the temporal variations in travel behaviour within the transitional zone, reflecting the influence of weekdays and weekends on residents' mobility and trip-making tendencies.

The disparities in trip frequencies could be attributed to distinct residential characteristics across zones. For instance, sub-urban areas may exhibit different travel patterns due to the prevalence of residential neighborhoods with fewer commercial hubs, impacting the necessity and frequency of trips. Socioeconomic differences might also contribute, with varying occupational distributions or socioeconomic statuses impacting residents' travel needs and patterns. Discrepancies in transportation infrastructure and accessibility to transit options could further shape the travel behaviour observed in different zones. Additionally, the mix of land use, including the availability of amenities, might influence the purpose and frequency of trips among residents.

Understanding these variations holds significant implications for urban planners and policymakers. It emphasizes the need for tailored transportation and land use planning strategies specific to each zone. Areas with higher trip frequencies may require improved transportation infrastructure to mitigate congestion and enhance connectivity. Implementing policies like zoning regulations to encourage mixed-use developments or strategically locating amenities could optimize travel patterns and reduce unnecessary trips across zones. Addressing these implications has the potential to lead to more efficient urban planning, improved transportation systems, reduced traffic congestion, and ultimately, enhanced livability within spatial structures.

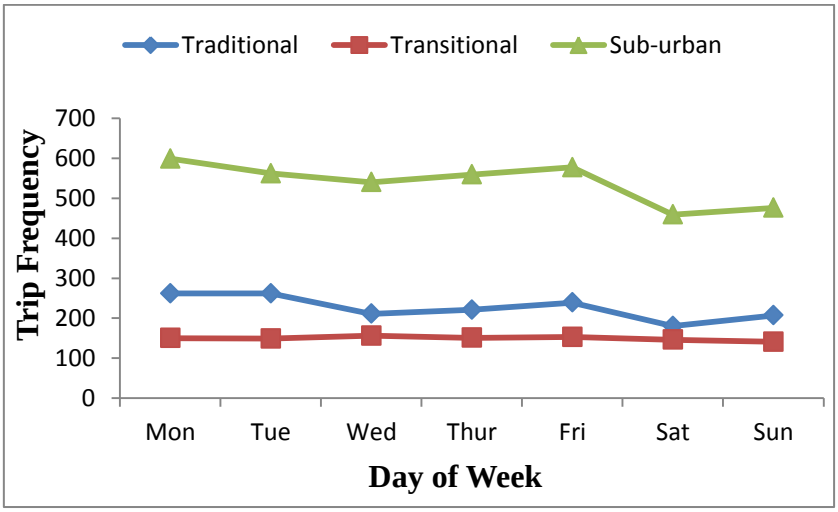

Fig 2: Daily Trip Pattern by Spatial Structure
Source: Author's Field Work (2023)

Table 5: Z-scores: Daily Trip Variation by Spatial Structures

Day	Traditional Zone		Transitional Zone		Sub-urban Zone	
	Trip Frequency	Z-score	Trip Frequency	Z-score	Trip Frequency	Z-score
Monday	262	1.49145	150	.11758	187	.78266
Tuesday	237	.54920	149	-.08818	176	.35220
Wednesday	211	-.43075	156	1.35216	173	.23480
Thursday	221	-.05384	151	.32334	187	.78266
Friday	239	.62458	153	.73487	185	.70439
Saturday	180	-1.59914	146	-.70548	133	-1.33052
Sunday	207	-.58151	141	-1.73429	128	-1.52619
Total	1,557		1,046		1,169	

Source: Author's Field Work (2023)

Residents' Trip Purpose: Findings on purpose of embarking on trips by the residents are shown in Table 6. Out of 1,026 trips made by residents within the 7 days of the week, 558 were generated to work. This translates to an aggregate daily person trip of 79.7, with a daily average person trip of 1.5 and daily average household trip of 4.7. It could be inferred that weekly a total of 558 trips were made to places of work. While a total of 79.7 trips were generated to places of work per day, a respondent made 1.5 trips to place of work daily. A household generated 4.7 trips to places of work per day. In order of magnitude, trips to recreational centres and social activities ranked second with 176 aggregated person's trips per week. While total daily person's trips were 25.1, daily average person's trips were 0.5 and 1.5 daily average household trips were generated. Trips to religious centers ranked third. The aggregated weekly persons' trips to religious areas were 112. It was found that aggregated daily person's trip was 16. While daily average person's trip was 0.3, average household trip per day was 0.9. Other trip purposes were market/shopping and educational centers. While aggregated trips to market/shopping were 94, the one generated to educational facilities was 86, which happened to be the least.

Table 6: Trip Purpose of Residents

Trip Purpose	Aggregated Weekly Persons' Trip	Aggregated Daily Person's Trip	Daily Average Person's Trip	Daily Average Household Trip
Work	558	79.7	1.5	4.7
Recreation/Social	176	25.1	0.5	1.5
Market/Shopping	94	13.4	0.3	0.8
Education	86	12.3	0.2	0.7
Religious	112	16.0	0.3	0.9

Source: Author's Field Survey (2023)

Trip Length of Residents: The results of residents' trip length show that trips between 5.1 and 10 km were mostly generated as shown in Table 7. In a week, 475 of such trips were made; on daily basis, 67.9 trips were made. An average of 1.3 (5.1- 10 km) trips were made by an individual per day, while a household generated 4.0 of such trip per day. The trips length of between 1-5 km were second highest generated. The aggregated weekly person trip was 137. While aggregated daily person trip was 19.6, whereas average trip generated by a person was 0.4. The average daily household trip generated was 0.2. The trip length of 10.1 – 15 km ranked third based on frequency of trip generation. The total weekly person trip was 68. The aggregated daily person's trip, daily average person's trip and daily average household trip are 9.7, 0.2 and 0.6 respectively. On the basis of frequency, least trip length generated by the residents was distance less than 1 km. The aggregated weekly person's trip for this trip length was 18. While aggregated daily person's trip was 2.6, the daily average person trip was 0.05 and daily average household trip was 0.2 (Table 8).

Intra-Urban Variation in Residents' Trip Length: Findings on intra-urban variation in trip length of residents are as shown in Table 9. It was found that the predominant trip length in traditional zone was between 5.1 and 10 km. It constitutes 44.1% of the total trips embarked on by the residents in the area. The least (3.0%) distance covered by the residents was trip length that was above 20 km. The reason for this outcome might be attributed to the fact that the zone was probably dominated by children and elderly who could not travel long distances. It was discovered that trip frequency decreases with trip lengths in the traditional zone. The same trend was observed in Transitional zone, where the trip length of 5.1 to 10 km accounts for the majority (57.1%). Findings on trip length from sub-urban zone are quite different from the other two zones. The highest trip frequency was trip length that was above 20 km. It constitutes 23.6% of the total trips generated in the area. The trip frequency was observed to increase with trip length in sub-urban zone.

Table 7: Residents' Trip Length

Trip Length	Aggregated Weekly Person Trip	Aggregated Daily Person Trip	Average Daily Person Trip	Average Daily Household Trip
Less than 1 km	18	2.6	0.05	0.2
1 – 5 km	137	19.6	0.4	1.2
5.1 – 10 km	475	67.9	1.3	4.0
10.1 – 15 km	68	9.7	0.2	0.6
15.1 – 20 km	51	7.3	0.1	0.4
Above 20 km	63	9.0	0.2	0.5

Source: Author's Field Survey (2023)

Table 8: Trip Length by Mode of Trip

Trip Length	Bus (%)	Tricycle (%)	Motorcycle (%)	Car (%)	Walking (%)	Total (%)
Less than 1 km	0.0	50.0	0.0	0.0	50.0	100
1 – 5 km	20.0	10.0	0.0	65.0	5.0	100
5.1 – 10 km	1.4	58.0	13.0	27.5	0.0	100
10.1 – 15 km	22.2	44.4	11.1	22.2	0.0	100
15.1 – 20 km	50.0	0.0	0.0	50.0	0.0	100
Above 20 km	81.8	0.0	0.0	18.2	0.0	100

Source: Author's Field Survey (2023)

Table 9: Trip Length by Spatial Structures

Spatial Structure	< 1 km (%)	1-5 km (%)	5.1-10 km (%)	10.1-15 km (%)	15.1-20 km (%)	Above 20 km (%)	Total (%)
Traditional	4.0	23.5	44.1	15.7	9.8	3.0	100
Transitional Zone	12.0	2.9	57.1	8.6	11.4	8.0	100
Sub-urban	10.8	12.2	14.8	16.1	22.5	23.6	100

Source: Author's Field Work (2023)

Relationship between Spatial Structures and Trip Modes among Residents in Sango-Ota, Nigeria: Furthermore, determining the weight of each Spatial Structure on different variables of trip characteristics requires ANOVA analysis (Table 10). It can be established from the table that only trip length was significantly linked to Spatial Structures, other two variables do not significantly relate with Spatial Structure. It can therefore be concluded that spatial structures are determinants of trip length in the study area. The earlier study by Shen et al., (2016) corroborates the current finding.

Table 10: ANOVA: Spatial Structure and Trip Characteristics

Trip characteristics	Source of Variation	Sum of Squares	df	Mean Square	F	P-value
Trip mode	Between Groups	13.989	1	13.989	2.962	.089
	Within Groups	118.500	88	1.347		
	Total	122.489	89			
Trip purpose	Between Groups	4.869	1	4.869	.749	.389
	Within Groups	572.420	88	6.505		
	Total	577.289	89			
Trip length	Between Groups	20.340	1	20.340	14.448	.000
	Within Groups	123.883	88	1.408		
	Total	144.222	89			

Source: Author's Field Work (2023)

Factors Influencing Residents' Travel Behavior: Attempt at investigating predictors of residents travel behaviour, nine independent variables were subjected to analysis. The variables include: residential location, gender, income, occupation, and age. Others are car ownership, trip purpose and trip length. When the travel behaviour of the residents was correlated with the independent variables, the results are as shown in Table11. There was a positive correlation (.559) between residents' travel behaviour and residential location. It implies that residents in low density have propensity to travel more compared to their counterparts in other residential densities. Residents' travel behavior correlated positively with the female gender (.792). The implication of this was that female gender tends to travel more than the male in the study area. There was a strong and positive relationship between income and residents travel behaviour (.950). This was an indication that residents with higher income have likelihood of traveling more than those that earn low income. Correlation between occupation and residents' travel behaviourwas strong and positive (.863). This implies that residents in occupation that requires specialized skills and better paid travel more than those in occupation with little or no skill. Age of the residents and travel behaviour has a strong and negative correlation (-.899). This means that younger residents travelled more compared to the older residents. There was a strong and negative correlation between car ownership and residents' travel behaviour (-.661). This suggests that the frequency at which the residents with car(s) travel was less compared to those without car(s) in the study area. The trip purpose correlated positively with the residents' travel behaviour (.797). The trip purposes such as trip to work, market and religiouscenters, among others greatly influence the residents' travel frequency. There was an inverse relationship between the travel length and residents' travel behaviour (-.750). The longer the distance the less the number of the residents that travelled.

.Table 11: Correlation between Residents' Travel Behaviour and Predictors

Predictor	Travel behaviour	Residential location	Gender	Income	Occupation	Age	Car ownership	Trip purpose	Trip length
Travel behaviour	1.000								
Residential location	.559	1.000							
Gender	.792	.693	1.000						
Income	.950	.611	.850	1.000					
Occupation	.863	.335	.681	.869	1.000				
Age	-.899	.545	.704	.879	.878	1.000			
Car ownership	-.661	.831	.695	.692	.451	.688	1.000		
Trip purpose	.797	.205	.595	.805	.961	.802	.294	1.000	
Trip length	-.750	.145	.532	.760	.942	.774	.241	.969	1.000

Source: Author's Field Survey (2023)

Regression analysis was done on eight (8) variables that correlated with residents' travelbehaviour as shown in Table 12. The analysis shows that when residential location was input as a predictor of

residents' travel behaviour, which was considered as a simple correlation between residents' travel behaviour and residential location, the value of R obtained was 0.559. The value of $R^2$was 0.313, which reveals that residential location can account for 31.3% of variation in residents travel behaviour. This means that 68.7% of the variation in residents' travel behaviour remains unaccounted for. However, when the other seven predictors are included (gender, income, occupation, age, car ownership, trip purpose and trip length), this value increases to 0.924 or 92.4% of the variance in residents' travel behaviour, which was significant with F value of 3.528 and p < 0.5. if residential location account for 31.3%, then gender, income, occupation, age, car ownership, trip purpose and trip length must account for an additional 61.1%. This means that addition of the seven predictors increase the ability of the model to predict the variability of residents' travel behaviour. The eight variables analysed can be used to predict up to 92.4% of residents' travel behaviour in the study area. However, there was 7.6% of variation in travel behaviour of residents not accounted for. This might be subject of further study. The findings of this study are in tandem with the works of scholars such as Heye and Timpf (2013);Thamizh*et al.*, (2016); Sholderer, (2017) and Stern (2020). They discovered that socioeconomic and physical environmental characteristics of the residents such astrip length, trip purpose, income, sex, physical environment and car ownership as factors or predictors of residents' travel behaviour.

Table 12: Regression Analysis of Residents' Travel Behaviour

Model	R	A	B	C	Change Statistics					Durbin-Watson
					D	E	df1	df2	F	
1	.559[a]	.313	.307	1.01016	.313	53.254	1	117	.000	
2	.792[b]	.627	.620	.74770	.314	97.555	1	116	.000	
3	.950[c]	.903	.900	.38297	.276	327.162	1	115	.000	
4	.953[d]	.908	.905	.37374	.005	6.755	1	114	.011	
5	.960[e]	.921	.918	.34767	.013	18.736	1	113	.000	
6	.960[f]	.921	.917	.34896	.000	.162	1	112	.688	
7	.960[g]	.922	.917	.34981	.000	.461	1	111	.498	
8	.961[h]	.924	.919	.34589	.002	3.528	1	110	.063	.687

Where A = R Square, B = Adjusted R Square; C = Std. Error of the Estimate; D = R Square Change; E = F Change; F = Sig. F Change
Source: Author's Field Survey (2023)

Conclusion: The study "Spatial Patterns of Travel Behavior in Rapidly Urbanizing Areas: A Case Study of Sango-Ota" reveals critical insights into mobility patterns amid rapid urbanization. Using ANOVA and regression analysis, it identifies significant variations in trip generation based on residential density, indicating increased travel demands. Work-related trips dominate, comprising 54.4% of journeys, with average lengths of 5.1 to 10 kilometers. The findings highlight substantial statistical variations in daily trip frequency, with an F-value of 22.082 and a p-value of 0.000, reflecting the influence of geographical and socio-economic factors. Residents in traditional core areas generate more trips than those in transitional or suburban zones, attributed to higher concentrations of commercial activities. Given Sango-Ota's population growth, the study underscores the need for targeted transportation policies that integrate urban planning with mobility strategies, ultimately enhancing accessibility and quality of life for residents while providing valuable insights for urban transportation management.

Declaration of Conflict of Interest: The authors declare no conflict of interest

Data Availability Statement: Data are available upon request from the first author or corresponding author or the fourth author.

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