



The Nexus Between Smart Energy Street Lighting and Informal Small Traders' Location and Operation in Migori Town, Kenya

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ABSTRACT

Smart energy street lighting influences spatial location of informal business enterprises in urban areas. This is mostly attributed to the positive contribution that lighting has on the small traders' sales and security when night falls, yet they must remain on the streets to keep selling to clients who pass by from work and those who prefer shopping in the night when the hustle and bustle of urban streets has cooled off due to people retiring to their homes. The Objective of the study was to determine the influence of smart energy street lighting grid systems on the spatial location and operation of informal sector trading activities in Migori town. The research was guided by the Technology Acceptance Model, Spatial Interaction and Spatial Network theories. The research adopted convergent parallel research design. Out of a population of approximately 5,000 full-time informal sector traders operating in Migori town, 1,010 involved themselves in the selected categories of commodities, which included beauty, salon and barber shops, cloth and footwear, building and construction materials, metal and carpentry, vehicle parts and mechanics, small food kiosks, local transport services, household goods and foodstuff retailers. Guided by Yamane (1967) formula, a sample size of 287 informal sector traders was used for the study. Area and random sampling methods were used to reach target respondents amongst the total number of traders. Purposive sampling was used to identify the key informants, who were, the Market Manager, Town Physical Planner and Informal Sector traders' representatives. Voluntary sampling was used to reach buyers. Primary data was collected by use of questionnaires, key informant interviews and Focus Group Discussions. Secondary data was collected through reviewing County Integrated Development plans, policy and planning reports. Qualitative data was analyzed by creating relevant themes and patterns. Quantitative data was analyzed using descriptive and inferential statistics so as to determine the association between adoption of smart urban street lighting and urban spatial development. This study revealed that smart energy Street Lighting technology is playing an important role in the distribution and location of the informal business activities in the urban set-up. However, its potential has not been fully leveraged to create the basis for its integration into the urban spatial development of Migori town. This study recommends that the County government of Migori fully creates an enabling environment that is supportive its integration into urban spatial planning and development.

Keywords: Smart Energy Street Lighting; Informal small traders; Traders' location and operation; Migori town

BACKGROUND

The informal trade sector came to the limelight following the International Labour Organization (ILO, 1972) study report on employment, income, and equality in Kenya. The report revealed that the informal trade sector comprises profitable and efficient business ventures with the capacity to create employment opportunities hence reduce poverty. The informal trade sector businesses include those in the service and production industries (Melisa, G., & Raphaela, K. (2020); Paiva, S. et al (2021)). In the past, the formal sector received much attention from planners, while the informal trade sector was considered temporary in developing economies (Taylor, 2020). However, this urban fine-grained economy has persistently grown, becoming part of the urbanization process in developing countries. Today, city authorities have realized that attempts to eliminate or restrain this sector's activities to realize an organized, clean city are futile undertakings. In fact,



the informal trade sector is now seen as resilient and contributes positively to the economies of most cities, especially in the developing world (World Bank, 2019)

Globally, the informal trade sector is a widespread phenomenon in most cities and towns. Approximately 2 billion people, constituting 61% of the world's urban population, are employed in the informal trade sector in developing countries (ILO, 2018). Currently, the development and regulation of this sector has indeed become a critical policy issue for national governments and international agencies worldwide (Broadway, E. 2017). The main challenge associated with planning for the informal sector is providing appropriate spaces for its operation (ILO, 2018). Consequently, governments have taken different approaches to solving this issue.

The last 10 to 15 years have seen governments embrace smart urban technology with the intention of improving efficiency in the management of urban trading activities (Tranos & Loannides, 2021). In Africa, the informal trade sector is ubiquitous. Recent research by Melisa and Raphaela (2020) shows that this sector forms 80.9%, a sizeable component of urban economies. To further integrate this sector into spatial development, some governments have adopted the use of smart urban street lighting to serve the traders. In Kenya, the informal trade sector has been around for a long time and is fairly large and dynamic. It employed 14.5 million people - over 80% of the total number of employed people. The government has recognized that the informal trade sector contributes to the Gross Domestic Product hence has embraced smart urban technology in its commerce.

Since devolution was adopted in Kenya following the enactment of Kenya's new constitution (2010), authority and some resources were transferred from the central government to local municipalities to make them more efficient and to improve the implementation of their policies for poverty alleviation and enhance the quality of service delivery. Hence, county governments were required to manage their local governance affairs. Aligned with Kenya's Vision 2030 and the Kenya Constitution (2010), county governments are mandated to formulate their Integrated Strategic Urban Development Plans (ISUDP)

Some researchers, such as Krishna, (2020) and UNCTAD (2019), studied the impact of smart urban technology on urban governance and management. They found that although some types of smart urban technology, such as street lighting remained invisible, their impact on service delivery to traders cannot be denied. The current study sought to examine the influence of Smart street lighting on urban- space -use as it provides an opportunity to support transformative spatial changes.

METHODOLOGY

The study adopted the Convergent Parallel research design, whereby a concurrent embedded mixed method was used, with a dominant descriptive-correlational quantitative component. Under this, both quantitative and qualitative data were collected simultaneously. However, the former was embedded within the latter as a supportive component. Quantitative data formed the primary methodology, while the qualitative dataset was added to provide additional insights or context. The advantage of this design is its complementarity, enhanced validity, and clarity of findings. The findings were then integrated by merging and interpreting both datasets to gain insights for deeper understanding (Creswell, 2015).

The design was used to characterize the prevalence of adoption of smart urban street lighting technology in informal sector traders' activities by focusing on understanding the current status of utilization (frequency) and its influence on urban spatial development of Migori Town. Data were collected on the adoption attitudes, perceptions, experiences, and behaviors of the target population regarding adoption of smart urban street lighting technology and how it was influencing their businesses and business distribution and location decisions.

The research was conducted by survey method through administration of questionnaires, observation, and interviews. The quantitative data provided the primary basis for testing the hypotheses and identifying statistical patterns, while the qualitative data offered explanatory insights that enriched the interpretation of survey findings. This ensured a comprehensive understanding of both the measurable impacts and the



underlying contextual factors influencing business behavior in smart urban environments. Further, respondents for focus group discussions and key informants were identified for the study with the aim of enabling the researcher to probe further for clarification. The units of analysis were informal trade activities.

The Study Population

The target population comprised selected categories of informal sector traders, market manager, town planner, town manager, town administrator, and street traders' association officials. The interest of this study was the traders who operated informal enterprises and were settled in particular locations of their choice within town. A pre-visit undertaken by the researcher at the County Government of Migori (CGM) town manager's office revealed that approximately 6,000 regular informal sector traders operated in different parts of the town. According to the records for the year 2024, it was established that out of this number of informal sector traders, there were approximately 1,800 informal sector traders who dealt in the sale of goods and services selected for this study.

The other respondents were the buyers who were conveniently sampled to share their experience and perception of zoning areas for informal sector trading activities with respect to street lighting. The Migori County officials (Town Physical Planner, Town Administrator, County Market Manager, and officials from the Kenya National Association of Street Vendors [KENASVIT]) were purposively selected to shed light on the influence of adoption of smart street lighting technology in management and governance of urban spaces.

Sampling Procedure

Out of the total population of informal sector traders, 1,010 traders dealt in the type of merchandise selected for study. Some of these traders were operating out of designated areas while others operated within designated areas. With the assistance of the market manager, areas of high and low concentration of informal sector traders were identified. Both probability and non-probability sampling techniques were used for selecting the samples. *In probability sampling*, stratified sampling method was used to categorize informal traders based on gender, the type of merchandise they sold, and area sampling (within and out of designated markets). This was necessary to obtain varied responses and experiences from different categories of traders and in different locations within town. *Simple random sampling* was used to pick informal sector traders as respondents from identified locations of high and low concentrations. Each trader was picked by chance from the traders' register to ensure fair representation of the population under study. The random selection was done using a sampling frame constructed from the market administrator's register of traders who operate in selected areas of high concentration.

Convenience sampling were used to obtain customers who buy from these informal sector traders. This is sampling that is dependent on the ease of access to subjects of study. In addition, *purposive sampling* was used to select County Government of Kenya officials, that is, County Market Manager, Town Planner, Town Administrator, and two informal sector traders' association officials as key informants. The essence of purposive sampling was to deliberately obtain relevant information from relevant informants. It was believed that those informants had in-depth understanding of the influence of smart urban street lighting technology use in trading activities and planning.

In addition, Focus Group Discussions (FGDs) for informal sector traders were organized. *Voluntary sampling method* was used to sample informal sector traders for the FGDs. Nine Focus Group Discussions (one FGD for each area) were organized, with a sample of 10 participants for each FGD being invited to take part. The FGDs comprised traders and buyers who were willing to participate. FGDs enabled confirmation of validity of responses through corroboration.

Target population and Sample Frame.

From the pre-visit to the County Manager's office, it was established that there were approximately 5,000 informal sector traders spread out in the town. According to the County Market Manager, approximately 1,881 traders operated within the designated County market structure while 3,119 traders operated out of designated

market structures. Out of the total, the target population of informal sector traders who dealt in the type of merchandise selected for study in the targeted areas was 1,010, spread out in nine selected locations of high concentration. These *Jua Kali* traders dealt in scrap metal and furniture, cloth sellers, footwear sellers, salons and barbers, local transport services, motor vehicle mechanics and spare parts, foodstuff sellers, cooked foods sellers, and building and construction material sellers. The sample size was determined using the Yamane (1967) formula, as it is simple in its application and can be used in cases of large populations.

Formula:

$$n = N / [1 + N(e)^2]$$

Where:

- n = sample size
- N = population size
- e = level of precision or margin of error at 5% (standard value of 0.05)

Therefore:

Therefore,

$$\begin{aligned} n &= 1010 / [1 + 1010(0.05)(0.05)] \\ &= 287 \text{ informal sector traders} \end{aligned}$$

The study used a sample of 287 informal sector traders from the target population obtained from the identified areas of high concentration. The sample was based on the proportionate distribution of these traders in town as illustrated on Table 1.

Proportion calculation:

$$\text{Proportion} = n/N \times 100$$

For instance, the proportion for Kenya Industrial Estates (KIE) informal sector traders was:

$$\text{Proportion} = 237/1010 \times 100 = 23.5\%$$

Sample size for each location:

$$\text{Sample size (KIE)} = (P/100) \times 287 = (23.5/100) \times 287 = 67 \text{ informal sector traders}$$

Sample number of males and females for each area:

$$\begin{aligned} \text{Males} &= 226/237 \times 67 \\ &= 64 \text{ male informal sector traders} \end{aligned}$$

$$\begin{aligned} \text{Females} &= 11/237 \times 67 \\ &= 3 \text{ female informal sector traders} \end{aligned}$$

Stratification according to gender was necessary to understand heterogeneity and technology adoption distribution among the study population. It helped in generalisability and validity of the study as well as avoiding under-coverage biases. Therefore, the study sample was distributed as follows:

Table 1: Sample Frame for the Informal Small traders Traders

Type of Business	Location						Sample		
		Male	Female	TOTAL	Percentage (%)	Male	Female	TOTAL	
Jua Kali artisans	Main Bus Park	226	11	237	23.30%	64	3	67	
(metal scrappers&									
Carpenters)									
Clothes & footwear	Oruba street	50	71	121	12%	14	18	32	
Assorted Household/electrical goods	Kuja Lane	49	62	111	11%	12	20	32	
Salons & Barbers	Central County Market	6	6	12	0.01%	1	2	3	
Local Transport	Ombo street	249	3	252	25.70%	70	4	74	
Mechanics& spares sellers	Kenya-Sirare border Highway	100	3	103	10.40%	28	2	30	
Foodstuff wholesalers	CBD Round-about area	21	110	131	13.20%	7	31	38	
Building & Construction	Nyasare street	18	3	21	0.02%	5	2	7	
Cooked Food/	Taxi Stage	7	15	22	0.02.78%	2	4	6	
Hotels/kiosks									
TOTAL		726	284	1010	100%	198	89	287	

Source: Field Data, 2026

The traders who sold their merchandise within designated areas, that is, County markets (salons and barbers, foodstuff sellers, and Jua Kali artisans) were:

$$404/1010 \times 287 = 115 \text{ informal small traders}$$

Those who worked from out of designated areas included second-hand clothes and footwear sellers, transport operators, mechanics and spare parts sellers, building and construction material sellers, and cooked foods sellers:

$$606/1010 \times 287 = 172 \text{ informal small traders}$$

These traders were randomly selected from registers held by their representatives from each zone.

Data Analysis

The analysis involved a two-step approach. The primary (quantitative) data were analyzed first to address the main research questions, while the qualitative data, as a secondary dataset provided additional deeper insight, context, or explanation. Thus, in the first step, the dominant dataset (quantitative data) was subjected to respective statistical analysis. Descriptive statistics were used to establish the main characteristics of the study variables and summarize the data. Inferential statistics were used to examine the associations and relationships between the variables under study. The second step involved analysis of the embedded dataset (qualitative data) for themes and patterns. The use of embedded mixed research methods design enabled the researcher to gain comprehensive understanding by leveraging both the depth of qualitative data and the breadth of quantitative data in analysis of the collected data. Thus, it allowed for the measurement of outcomes while at the same time capturing respondents' experiences and perspectives in relation to the phenomenon under study.



The hypothesis tested was that smart urban street lighting significantly influenced where traders operated and how long they extended business hours into the night. Descriptive statistics such as frequencies, percentages, and means summarized reliance levels, proximity distributions, and perceptions. Chi-square tests examined associations between smart lighting usage and spatial location, as well as proximity and perceptions of influence. Cramér's V was used to test for strength of association between the influence of smart urban street lighting on the spatial location of informal sector businesses in the town. These inferential results were to confirm that smart street lighting plays a significant role in shaping both spatial distribution and temporal business operations hence supporting the hypothesis or not (See Table 2).

Table 2: Analysis Framework

Objective	Hypothesis (H0)	Independent Variable (IV)	Dependent Variable (DV)	Data Type / Measure	Descriptive Statistics	Inferential Statistics
Establish the influence of smart energy street lighting grid systems on the spatial location of informal sector trading activities in Migori town	H04: Smart energy street lighting grid systems does not significantly influence the spatial location and operational patterns of informal sector traders in Migori town	Smart energy street lighting grid systems (reliance, proximity, usage, perceptions)	Spatial location of informal businesses (CBD vs periphery; designated vs undesignated), operational hours into the night	Nominal (location: CBD/periphery, designated/undesignated); Ordinal (perceptions Likert scale); Ratio (distance in meters, number of hours extended)	Frequencies, percentages, cross-tabulations,	Chi-square tests (association between lighting use and location; usage vs hours extended)
						Cramer's V test for strength of association proximity categories
						Binary Logistic Regression (to predict likelihood of location based on adoption of smart lighting

Narrative and thematic analyses were conducted for further explanation and contextualization of facts pertaining to the adoption and influence of smart urban street lighting technology on the spatial development of the town. They were used to elicit, analyze, and describe the subjective meanings and interpretation of the experience of the informal sector traders.

Narrative analysis focused on using the experiences shared by people. It involved observations from the field survey, interviews, and focus group discussions obtained verbatim, recorded throughout the process of doing the research, transcribed, and analyzed. The method was appropriate for analyzing the differences in cases and describing the dynamics of individual narratives in their unique context.

Thematic analysis was used to analyze the documented data in form of texts and questionnaire response transcripts collected from the field.

RESULTS AND DISCUSSION

Reliance on Smart Energy Lights in Areas of Operation

To understand the impact of smart energy lighting on the spatial distribution of informal small traders, respondents were first asked if they relied on smart energy lights in their areas of operation. The findings are summarized in Table 3.

Table 3: Traders reliance on Smart Energy Lights in Areas of Operation

Response	Frequency	Percent (%)	t-value	Sig. (2-tailed)	Mean Difference
Yes	233	81.2	-78.399	0	-1.8119
No	54	18.8			
Total	287	100			

Source: Field Data, 2026

The majority (81.2%) of the respondents reported that they relied on smart energy street lighting systems in their areas of operation, while 18.8% indicated that they did not. A one-sample t-test was conducted to determine whether the reported reliance on street lighting was statistically significant. The one-sample t-test result ($t = -78.399$, $p = .000$) with a mean difference of -1.812 indicated a statistically significant preference ($p < .05$), confirming widespread reliance on smart street lighting among informal traders in Migori town environments. These results suggest that smart energy lighting systems play a crucial role in supporting informal trade activities, particularly in extending operational hours into the evening and enhancing security in trading areas. Traders likely perceive well-lit environments as safer for both vendors and customers, which can increase customer footfall and boost sales. Moreover, the strong dependence on smart energy lights highlights the importance of integrating energy infrastructure into urban planning to promote inclusive economic activities. For the minority who do not rely on these lights, possible reasons could include operating during daytime only, being in areas without proper installation, or personal safety concerns even with lighting.

These findings emphasize that expanding smart street lighting coverage can further strengthen informal trading activities and contribute to safer, more vibrant urban spaces. The finding that 81.2% of informal traders rely on smart energy lights aligns with empirical literature highlighting the pivotal role of street lighting in enabling safer and extended trading hours. Gitonga and Njeru (2017) observed that smart lighting contributed significantly to improved urban safety and business viability under Vision 2030. Lucia et al. (2015) and Krishna (2020) also confirmed that smart lighting minimized energy costs while ensuring operational efficiency, which facilitated night commerce. Moreover, Wambugu (2014) emphasized that smart lighting systems increased urban inclusion in Nairobi City.

Table 4: The Influence of Smart Energy Street Lighting Grid Systems On The Spatial Location Of Informal Sector Trading Activities.

	CBD			Periphery		
Usage Category	CBD – Designated (n=53)	CBD – Undesignated (n=62)	CBD Total (n=115)	Periphery – Designated (n=72)	Periphery – Undesignated (n=100)	Periphery Total (n=172)
Yes	38 (71.7%)	57 (91.9%)	95 (82.6%)	53 (73.6%)	85 (85.0%)	138 (80.2%)
No	15 (28.3%)	5 (8.1%)	20 (17.4%)	19 (26.4%)	15 (15.0%)	34 (19.8%)
Total	53 (100%)	62 (100%)	115 (100%)	72 (100%)	100 (100%)	172 (100%)

Source: Field Data, 2026

The findings on the use of smart energy street lighting systems revealed widespread adoption across business locations, though with significant differences between designated and undesignated areas. In the CBD, 71.7% of designated businesses reported using smart lighting compared to an even higher 91.9% of undesignated businesses. Non-use was more common among designated businesses at 28.3%, while only 8.1% of undesignated respondents reported not relying on the lighting system. This indicates that while the majority in both CBD categories benefit from smart street lighting, reliance is substantially greater in undesignated areas, reflecting stronger dependence on public infrastructure for safety and visibility.

A similar trend is observed in the periphery. Here, 73.6% of designated businesses reported using smart lighting, compared to 85.0% of undesignated businesses. Non-use was higher among designated respondents (26.4%) than undesignated ones (15.0%). This again underscores that informal businesses in undesignated zones are more inclined to adopt smart energy lighting, possibly because such infrastructure directly enhances their evening and night-time trading activities, which may not be as strongly supported in designated zones.

Overall, the results demonstrate that use of smart energy street lighting is higher in undesignated areas, both in the CBD and the periphery, compared to designated ones. This suggests that informal sector businesses outside formalized trading zones rely more heavily on the benefits of enhanced visibility and security provided by smart energy grids. In contrast, designated areas may depend less on such systems, possibly because of alternative infrastructural provisions within planned trading environments.

Further, a Chi square test was performed to establish association between street lighting systems and the location of informal sector trading activities in the town.

Table 5: Chi Square Test on Smart Energy Street Lighting Grid Systems on The Spatial Location of Informal Sector Trading Activities.

		CBD	Periphery
Use of smart energy lights	Chi-square	8.146	3.423
	df	1	1
	Sig.	.004*	0.064

The Chi-square test for the CBD is significant ($\chi^2 = 8.146$, $p = 0.004$), meaning there is a statistically significant association between site of working (designated vs. undesignated) and use of smart energy lights in the CBD. Informal traders are significantly more likely to adopt energy-saving lighting than formal ones. For the Periphery ($\chi^2 = 3.423$, $p = 0.064$), the association is not statistically significant at the 5% level, though it is borderline. This indicates that while the trend (higher adoption among undesignated) is visible, it is not strong enough to be statistically confirmed.

Proximity of Informal Businesses to the Nearest Street Lighting System

To assess how smart street lighting influences informal traders' location choices, respondents were asked to indicate the proximity of their businesses to the nearest lighting infrastructure. The responses were categorized by distance brackets, and a one-sample t-test was conducted to examine whether the distribution significantly favored closer proximity. The findings are indicated in Table 6 .

Table 6: Proximity of Informal Businesses to the Nearest Street Lighting System

Distance from Lighting	Frequency	Percent (%)	t-value	Sig. (2-tailed)	Mean Difference
Over 90 meters	55	19.2	-7.896	0	-0.4913
61–90 meters	99	34.5			
31–60 meters	65	22.6			



0–30 meters	68	23.7			
Total	287	100			

Source: Field Data, 2026

The results show that 34.5% of respondents reported that their businesses are located 61–90 meters from the nearest street lighting system, 23.7% are within 0–30 meters, and 22.6% are within 31–60 meters. A smaller proportion (19.2%) operate more than 90 meters away from street lights. The one-sample t-test result ($t = -7.896$, $p = .000$) with a mean difference of -0.491 indicates that the distribution is statistically significant ($p < .05$), confirming that most informal traders position themselves relatively close to street lighting infrastructure. These findings suggest that traders prefer to operate within areas with good lighting coverage, likely due to enhanced security, extended operational hours, and improved visibility that attract more customers.

The strong preference for locations within 90 meters of lighting systems underscores the critical role that smart urban lighting infrastructure plays in influencing spatial distribution and business site choices among informal traders. For the 19.2% operating beyond 90 meters, possible reasons could include overcrowding near lighting systems, higher space costs in better-lit zones, or availability of cheaper spaces farther away.

The preference of traders to locate their businesses within 90 meters of smart lighting systems underscores the spatial influence of lighting. This observation is consistent with Krishna (2020), who found that smart lighting encourages spatial organization by providing safe, accessible environments. Phil (2020) further argues that effective lighting enhances urban space quality, leading to denser informal trading clusters. Additionally, Kaplan & Chalfin (2021) posits that solar-powered smart lights reduce operational costs and improve spatial accessibility for traders. The study affirms that proximity to lighting plays a central role in determining trader location, reflecting a growing recognition of infrastructure's role in informal sector development.

Duration of Business Operations beyond nightfall

To assess the extent to which smart energy lighting infrastructure supported extended trading hours, respondents were asked to indicate how long they typically continued business operations beyond 1800hrs.

Table 7: Duration of Business Operations into the Night Beyond 1800hrs

Hours of Operation After 1800hrs	Frequency	Percent (%)	t-value	Sig. (2-tailed)	Mean Difference
0–1 hour	163	56.8	-26.994	0	-1.331
2–5 hours	56	19.5			
More than 5 hours	68	23.7			
Total	287	100			

Source: Field Data, 2026

The majority of respondents (56.8%) reported that they extend their business operations by an hour beyond 1800hrs, while 23.7% operate for more than 5 extra hours, and 19.5% extend for 2 to 5 hours. The one-sample t-test result ($t = -26.994$, $p = .000$) with a mean difference of -1.331 indicates that this distribution is statistically significant ($p < .05$). This suggests that, overall, most traders do not operate for long hours into the night, possibly reflecting caution around security, lighting availability, or limited customer demand after dark. However, the substantial proportion of traders (43.2%) who extend operations beyond 2 hours (combining those in 2–5 hours and more than 5 hours' categories) suggests that smart energy lighting does facilitate longer working hours for many. Traders who stay open longer may be leveraging enhanced lighting to serve evening customers, increase daily sales, and maximize profits. These findings underscore the need to improve and expand street lighting to encourage longer business hours safely, which can stimulate economic activity, create jobs, and support urban vibrancy in the town.



The finding that 43.2% of traders operate more than two hours into the night due to smart lighting aligns with literature showing that lighting extends business hours. Gitonga and Njeru (2017) assert that urban lighting investments under Vision 2030 facilitate night-time commerce. UNCTAD (2020) also emphasized that smart technologies, including lighting, increased operational flexibility for informal traders. Moreover, they argued that smart urban lighting technology empowered local economic participation by enabling longer business hours and safer environments. This supports the finding that smart lighting contributes to extended working hours, boosting local informal economies. Also, Wambugu (2004) noted that well-lit environments enhance night-time trade by improving security and customer flow. Maarten (2021) reinforced that smart lights supported 24-hour economies by reducing energy consumption and encouraging after-dark activities. Additionally, Phil (2020) recognized that strategic lighting improved public space functionality, fostering prolonged business operations. These sources supported the conclusion that lighting infrastructure played a transformative role in enabling longer and safer informal business activities, especially in growing urban centers like Migori.

A cross tabulation analysis was conducted to explore the relationship between the number of hours informal traders extend their operations beyond 6:00 pm and their perceptions of whether smart street lights influence their business location choices in Migori town. Traders' responses were categorized across five levels of agreement (Strongly Disagree to Strongly Agree), and compared across three business extension periods: 0–1 hour, 2–5 hours, and more than 5 hours.

Table 8: Cross tabulation Between Extended Night Hours and Perceived Influence of Smart Street Lighting on Business Location

Hours of Night Operation	Strongly Disagree	Disagree	Somehow Agree	Agree	Strongly Agree	Total (%)
0–1 hour	13 (8.0%)	56 (34.4%)	46 (28.2%)	31 (19.0%)	17 (10.4%)	163 (56.8%)
2–5 hours	7 (12.5%)	14 (25.0%)	14 (25.0%)	15 (26.8%)	6 (10.7%)	56 (19.5%)
More than 5 hours	4 (5.9%)	13 (19.1%)	26 (38.2%)	22 (32.4%)	3 (4.4%)	68 (23.7%)
Total	24 (8.4%)	83 (28.9%)	86 (30.0%)	68 (23.7%)	26 (9.1%)	287 (100.0%)
Test		Value	df	Asymptotic Sig. (2-sided)		
Pearson Chi-Square		44.086	8	0.030 *		

Source: Field Data, 2026

A Chi square test was conducted to determine association between extended night hours and perceived influence of smart street lighting on business location. The analysis revealed a Pearson Chi-Square value of 44.086 with 8 degrees of freedom, and a p-value of 0.030, indicating that this association is statistically significant at the 0.05 level. This suggests that traders' decisions on where to locate their businesses are meaningfully linked to how long they remain open at night, which is likely influenced by the presence and reliability of smart lighting systems. From the cross-tabulation, traders who operate their businesses for longer hours (especially "More than 5 hours" or "2-5 hours" beyond 1800hrs) tended to report higher agreement levels that smart street lighting affects their spatial choices. Specifically, 38.2% of traders who operate more than 5 hours into the night "Somehow agree" and 32.4% "Agree" that lighting influences business location. In contrast, those operating for only 0-1 hour showed higher percentages in the "Disagree" and "Somehow. These results underscore the crucial role of urban lighting infrastructure in enabling night-time economic activities. The presence of smart street lighting not only improves security and visibility but also empowers traders to extend business hours, thereby influencing their decision on where to locate for optimal benefit.

The statistically significant link between extended trading hours and belief in lighting's influence on business location ($p = .030$) supports earlier findings by Gitonga and Njeru (2017), who stated that smart energy



infrastructure empowers traders to operate into the night. UNCTAD (2020) also identified extended hours as a direct benefit of urban smart technologies, suggesting that such infrastructure helps redefine business scheduling and urban vibrancy. Ana & Sao (2017) emphasized that longer operating hours reflect enhanced environmental security, making traders more likely to align with lighting infrastructure. The positive association in this study reflects how urban lighting is both a physical and temporal enabler of informal trade activity.

A cross-tabulation analysis was carried out to examine the relationship between traders' proximity to urban street lighting systems and the number of hours they extend their business operations into the night (beyond 1800hrs). Four categories of proximity were analysed: above 90 meters, 61–90 meters, 31–60 meters, and 0–30 meters. Similarly, trading hours were grouped into: 0–1 hour, 2–5 hours, and more than 5 hours.

Table 9: Relationship Between Traders' Proximity to Urban Street Lighting Systems and the Number of Hours They Extend their Business Operations into The Night

Proximity to Urban Street Lighting System	0–1 hrs	2–5 hrs	>5 hrs	Total (N)	% of Total
Above 90 m	55 (100.0%)	0 (0.0%)	0 (0.0%)	55	19.20%
61–90 m	76 (76.8%)	23 (23.2%)	0 (0.0%)	99	34.50%
31–60 m	18 (27.7%)	21 (32.3%)	26 (40.0%)	65	22.60%
0–30 m	14 (20.6%)	12 (17.6%)	42 (61.8%)	68	23.70%
Total	163 (56.8%)	56 (19.5%)	68 (23.7%)	287	100.00%
Test	Value	df	Sig. (2-sided)		
Pearson Chi-Square	152.81	6	.000 ***		

Source: Field Data, 2026

The findings revealed a clear pattern linking closer proximity to street lighting with longer operational hours. Among traders located beyond 90 meters from lighting systems, 100% operate for only 0–1 hour beyond 1800hrs, suggesting strong limitations likely due to low visibility and safety concerns. In the 61–90 meter category, most traders (76.8%) also operate for 0–1 hour, while 23.2% extend operations to 2–5 hours; none operate beyond 5 hours. A more diverse pattern emerges for traders 31–60 meters from lighting: 27.7% operate for only 0–1 hour, 32.3% extend to 2–5 hours, and a notable 40% operate for more than 5 hours. This indicates that moderately close lighting begins to enable extended economic activity. The trend is most pronounced for traders closest to lighting systems (0–30 meters). Here, 61.8% operate for more than 5 hours into the night, while only 20.6% work for 0–1 hour and 17.6% for 2–5 hours.

The Chi-Square test was used to determine whether there is a significant association between the proximity of traders to urban street lighting systems and the hours they extend business operations into the night in Kakamega town. The test returned a Pearson Chi-Square value of 152.810, with 6 degrees of freedom and a p-value of 0.000. The extremely low p-value (below 0.05) indicates that the relationship is statistically significant, meaning the observed distribution is unlikely to have occurred by chance.

The cross-tabulation analysis revealed a strong relationship between proximity to lighting and extended operation hours, with 61.8% of traders within 0–30 meters working beyond five hours. This supports Maartel (2021), who demonstrated that proximity to smart lighting promotes longer activity hours due to enhanced security and visibility. Similarly, Gitonga and Njeru (2017) showed that Kenya's urban smart lighting projects aim to support vibrant, safe, late-night economic environments. Krishna (2020) added that closer access to lighting enables both traders and customers to engage confidently at night. This finding confirms that smart lighting is not only spatially influential but also critical for temporal economic extension in the informal sector.

Perceptions on the Influence of Smart Urban Lighting on Business Operations

To assess the broader perceptions regarding the impact of smart lighting systems, traders were asked to indicate their level of agreement with several key statements related to business location, safety, operation time, and mobility. Responses were analyzed using a one-sample t-test to determine the statistical significance of observed perceptions.

Table 10: Perceptions on the Influence of Smart Energy Street Lighting on Business Operations

Statement	5	4	3	2	1	t-value	Sig. (2-tailed)	Mean Difference
Influences densities of businesses in some urban spaces	4.5	36.2	33.8	25.1	0.3	3.76	0	0.19512
Increases frequency of movements at night	8.7	43.9	42.2	5.2		13.093	0	0.56098
Extends time for business	29.3	51.2	18.1	1.4		25.349	0	1.08362
Improves security for businesses	34.1	55.4	1.5			33.503	0	1.23693

Source: Field Data, 2026

The results show that 36.2% of respondents agreed and 4.5% strongly agreed that smart energy street lights influence the densities of businesses in certain urban spaces, while 33.8% somehow agreed. On the other hand, 25.1% disagreed and only 0.3% strongly disagreed. The one-sample t-test result ($t = 3.760$, $p = .000$) with a mean difference of 0.195 confirms a statistically significant perception. These results indicate that many traders believe well-lit areas attract higher business clustering because they provide safety, visibility, and longer operational hours. However, the quarter who disagreed suggests that for some traders, other factors like rent or customer flow may still outweigh lighting in deciding location.

The majority of respondents agreed (43.9%) or strongly agreed (8.7%) that smart street lights increase their frequency of movements at night, while 42.2% somehow agreed and only 5.2% disagreed. The t-test result ($t = 13.093$, $p = .000$) with a mean difference of 0.561 shows strong statistical significance. This suggests that lighting infrastructure encourages safer and more confident movement for both traders and customers, enabling extended service delivery and boosting nighttime economic activity. The perception highlights the critical role of lighting in supporting a vibrant evening economy and urban social life.

More than half of respondents agreed (51.2%) and 29.3% strongly agreed that smart lighting helps extend business operating hours, while 18.1% somehow agreed and only 1.4% disagreed. The t-test ($t = 25.349$, $p = .000$) with a mean difference of 1.084 reveals very strong statistical significance. This clearly shows that traders view smart street lighting as a practical enabler of longer trading time, enhancing their ability to maximize daily earnings and serve late customers. This finding underlines how lighting infrastructure directly supports informal sector growth by enabling safer and longer working hours.

Finally, the vast majority of respondents agreed (55.4%) or strongly agreed (34.1%) that smart street lights improve security for businesses, while only 10.5% somehow agreed and none disagreed. The t-test result ($t = 33.503$, $p = .000$) with a mean difference of 1.237 demonstrates the highest level of consensus among all statements. This strong agreement underscores that traders highly value lighting as a critical safety measure, reducing crime risk, deterring vandalism, and creating a more secure environment for operations. This perception supports the prioritization of smart lighting in urban policy to foster safe, inclusive, and resilient informal trading spaces.

The sampled buyers were also asked whether they consider the new smart lighting system as promoting informal sector activities in Migori town. This question sought to assess customer perspectives on how



improved lighting infrastructure influences the vibrancy, safety, and spatial dynamics of informal business operations during evening hours.

Table 11: Perception of Smart Lighting Promoting Informal Sector Activities (Customer Perspective)

Response Category	Frequency	Percent (%)	t	Sig. (2-tailed)	Mean Difference
Somehow Agree (U)	8	20	59.327	0	3.8
Agree (A)	32	80			
Total	40	100			

Source: Field Data, 2026

The results show that a large majority of customers (80.0%) agreed that the new smart energy street lighting system promotes informal sector activities in Migori town, while 20.0% somehow agreed. Notably, no respondents disagreed or strongly disagreed. The t-test result ($t = 59.327$, $p = .000$) with a mean difference of 3.800 confirms strong statistical significance. This indicates that customers perceive the new lighting as significantly supporting informal trade, likely by enhancing safety, extending operating hours, and increasing accessibility at night. The overwhelmingly positive perception suggests strong community approval and validates investments in smart lighting infrastructure to stimulate local economic activity.

The findings show strong trader agreement that smart lighting improves security, extends hours, and increases movement echoing Gitonga and Njeru (2017), who emphasized that urban lighting supports Kenya's Vision 2030 goals by enhancing safety and enabling night economies. These perceptions confirm that lighting is not merely functional but strategic in shaping how and where urban informal trade activities flourish at night.

Respondents' Agreement That Smart Lighting Influences Business Location

To further assess the spatial effects of smart urban lighting, respondents were asked to indicate their agreement with the statement that smart lighting systems influenced where informal businesses chose to locate. The results offered strong insights into perceived spatial dynamics shaped by lighting infrastructure.

Table 12: Respondents' Agreement That Smart Lighting Influences Business Location

Response Category	Frequency	Percent	t-value	Sig. (2-tailed)	Mean Difference
Strongly Disagree (SD)	12	4.20%	13.468	0	0.89547
Disagree (D)	20	7.00%			
Somehow Agree (U)	66	23.00%			
Agree (A)	77	26.80%			
Strongly Agree (SA)	112	39.00%			
Total	287	100%			

Source: Field Data, 2026

The results show that the majority of respondents strongly agreed (39.0%) or agreed (26.8%) that the smart urban lighting system influences the spatial location of businesses, while 23.0% somehow agreed. In contrast, only 7.0% disagreed and 4.2% strongly disagreed. The one-sample t-test result ($t = 13.468$, $p = .000$) with a mean difference of 0.895 indicates a statistically significant consensus ($p < .05$). These findings suggest that traders perceive smart lighting as a key factor in choosing where to operate within urban spaces. Lighting systems likely attract traders to certain locations because they improve safety, visibility, and customer presence during evening hours. Areas with reliable lighting become preferred business zones, creating informal commercial clusters and reshaping urban spatial patterns. Meanwhile, the small group that disagreed may prioritize other locational factors such as rent costs, space availability, or proximity to specific customer bases.

over lighting considerations. Overall, this result highlights the critical importance of integrating smart lighting into urban planning as a tool for shaping equitable and vibrant trading environments, ensuring that all areas are attractive, safe, and accessible to support diverse business activities.

The sampled buyers were also asked whether they believe that the new smart lighting system influences the location of businesses in Migori town. This question aimed to evaluate customer perceptions on how improved lighting conditions affect where informal sector enterprises choose to operate, especially in relation to safety and visibility.

Table 13: Influence of New Lighting System on Business Location (Customer Perspective)

Response Category	Frequency	Percent (%)	t	Sig. (2-tailed)	Mean Difference
Somehow Agree (U)	18	45	44.563	0	3.55
Agree (A)	22	55			
Total	40	100			

Source: Field Data, 2026

Over half of customers (55.0%) agreed and 45.0% somehow agreed that the new lighting system influences where businesses are located in town. Again, no respondents disagreed or strongly disagreed. The t-test result ($t = 44.563$, $p = .000$) with a mean difference of 3.550 indicates strong statistical significance. This suggests that customers recognize lighting as a key factor influencing traders' locational choices, drawing them toward well-lit, safer, and more visible areas. Such perceptions highlight the importance of integrating lighting into urban planning to encourage organized business clustering, enhance safety, and support the dynamic growth of informal trading zones.

The finding that 65.8% of respondents agreed or strongly agreed that smart lighting influenced business location confirms the literature's emphasis on lighting as a spatial determinant. Wambugu (2014) observed that street lighting underpins both economic inclusion and spatial reconfiguration in urban areas. Krishna (2020) highlighted that smart lighting reduced energy while enhancing locational efficiency for traders and customers alike. Maartel (2021) further emphasized lighting's role in reshaping night-time economies and creating spatial advantages for informal enterprises. These alignments confirm that smart lighting infrastructure is a crucial variable in shaping business geography, with traders clustering in well-lit areas to maximize security, visibility, and operational time.

The Pearson Chi-Square test statistic was 47.978 with 12 degrees of freedom, and a p-value of 0.016. This result is statistically significant at the 0.05 level, indicating that there is a significant association between the traders' distance to smart street lighting and their perceived influence of these lights on business location choices. This finding implies that as traders vary in proximity to the lighting grid system, their views on the role of smart lighting in influencing where they choose to operate also significantly change. Traders located closer to lighting infrastructure may perceive stronger advantages in terms of security, customer attraction, and extended business hours, leading to a higher likelihood of agreeing that lighting shapes their location decisions. On the other hand, those farther from these lights may perceive fewer benefits and thus express more neutral or disagreeing views.

This finding that proximity significantly influenced perception of lighting's role in business location ($p = .016$) aligns with the assertions of Marianne (2021), who noted that the perceived benefits of smart lights diminish with distance, especially beyond 90 meters. Lucia et al. (2015) similarly found that the closer businesses are to lighting infrastructure, the more they report advantages such as increased safety and customer volume. Phil (2020) adds that quality lighting enhances space inclusivity, but spatial inequalities in access can reproduce locational disadvantage. Thus, this association highlights the critical importance of equitable lighting distribution to ensure all traders can benefit from enhanced night-time operations.



Comparing Agreeing on Influence of Smart Energy Lighting among Users and Non-Users

A Mann-Whitney U test was conducted to compare perceptions on the influence of smart energy street lights between businesses that rely on these lights and those that do not.

Table 14: Mann-Whitney U Test Comparing Agreement on Influence of Smart Energy Lighting Between Users and Non-Users

Statement	Use of Smart Energy Lights	N	Mean Rank	Sum of Ranks	U	Z	Sig. (2-tailed)
Influences business densities	Yes	233	152.11	35,441.00	4,402.00	-3.628	.000 ***
	No	54	109.02	5,887.00			
Increases frequency of night movement	Yes	233	153.33	35,727.00	4,116.00	-4.319	.000 ***
	No	54	103.72	5,601.00			
Extends time for business	Yes	233	154.78	36,063.50	3,779.50	-5.003	.000 ***
	No	54	97.49	5,264.50			
Improves security for businesses	Yes	233	155.9	36,325.50	3,517.50	-5.682	.000 ***
	No	54	92.64	5,002.50			

Source: Field Data, 2026

Results showed significant differences in median agreement scores across all four influence statements. Businesses that use smart lights reported higher agreement that lights influence business densities ($U = 4402$, $Z = -3.628$, $p < .001$), increase frequency of night movements ($U = 4116$, $Z = -4.319$, $p < .001$), help extend business hours ($U = 3779.5$, $Z = -5.003$, $p < .001$), and improve security ($U = 3517.5$, $Z = -5.682$, $p < .001$). The mean rank for businesses relying on smart lights was consistently higher across all measures (ranging from 152.11 to 155.90) compared to non-users (ranging from 92.64 to 109.02), indicating stronger agreement on their benefits. These results suggest that reliance on smart energy lighting is associated with more positive perceptions of its effects on operational density, safety, and extended working hours. This underscores the role of infrastructure access in shaping trader attitudes and business patterns, highlighting how integrated urban lighting strategies can actively support vibrant night-time economies and safer, more flexible business environments. The study results are in agreement with those of Maarten (2021) stated that improvements in street lighting affect routine activities during nighttime hour. Brighter street lighting leads individuals to feel safer and poor lighting does not change people's willingness to spend time outdoors or to engage in behaviors which mitigate risk. Street lights are widely thought to be an effective tool in reducing crime and have therefore become a ubiquitous type of investment in environmental design.

The Mann-Whitney U test revealed that traders who use smart energy lights strongly agreed that lighting improves densities, movement, security, and extended hours, more so than non-users. This resonates with Jacob and Aaron (2021), who noted that better-lit environments increase outdoor activity and reduce risk perceptions. Gitonga and Njeru (2017) supported this by showing that lighting access enhances night-time business viability. Krishna (2020) found that perception of safety and utility increases sharply among users of smart lighting. The finding highlights that actual use of smart infrastructure intensifies awareness of its spatial and economic benefits, making lighting a lived enabler of informal sector growth. Also Maarten (2021), in their study findings, stated that improvements in street lighting affect routine activities during nighttime hour. Brighter street lighting leads individuals to feel safer and poor lighting does not change people's willingness to spend time outdoors or to engage in behaviors which mitigate risk. Street lights are widely thought to be an effective tool in reducing crime and have therefore become a ubiquitous type of investment in environmental design.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study revealed that the adoption of smart energy street lighting significantly determined the spatial patterns of informal sector small traders in Migori town. The majority of traders situated both at the CBD and suburbs reported reliance on smart street lighting, with 82.6% in the CBD and 80.2% in the periphery indicating use of the technology. This reliance was statistically significant ($t = -78.399$, $p = .000$). Extended trading hours were strongly associated with lighting access 23.7% of traders reported operating beyond 5 hours past 6:00 PM, while 34.1% operated between 2–5 hours. A Spearman correlation ($\rho = 0.665$, $p < .001$) revealed a strong positive relationship between proximity to lighting and belief in its spatial influence. Traders closer to lights (within 0–30 meters) had the longest operational hours, with 61.8% working more than 5 hours into the night. This shows that improved lighting infrastructure encourages businesses to cluster in illuminated zones, reducing security risks and extending operational hours, especially in high-traffic evening and night periods. The availability of lighting thus enhances vibrancy in informal trade corridors and makes such spaces more attractive for commercial engagement.

Location preferences among traders are clearly shaped by the distance from streetlights. The highest business clustering was found between 0–30 meters and 31–60 meters from lighting systems, where 23.7% and 22.6% of traders were respectively located. A chi-square test ($\chi^2 = 152.810$, $p < .001$) confirmed a statistically significant association between proximity to lights and extended business hours. Further, logistic regression showed that traders within 31–60 meters of lighting were nearly twice as likely ($B = 0.982$, $p = .003$) to believe lighting influences spatial location. Only 19.2% of traders operated beyond 90 meters from lighting, and all of them closed within 1 hour after 6:00 PM. This spatial clustering around well-lit zones shows lighting not only supports business safety but also serves as a locational magnet in the informal economy.

The findings also demonstrated that smart energy lighting not only supports security but also reshapes urban spatial utilization by informal traders. Informal businesses in illuminated zones were more likely to report increased customer interactions and higher evening sales than those in poorly lit areas. The technology reduces vulnerability to crime and provides safer operating conditions, thereby drawing more traders toward designated locations equipped with lighting. This spatial shift creates pressure on CBD spaces where lighting investment is concentrated, while periphery areas without consistent lighting record lower levels of evening trading. The disparity highlights the role of urban infrastructure in redistributing economic activity within the town. This study recommends that the County government of Migori fully creates an enabling environment that is supportive its integration into urban spatial planning and development.

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