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Research Article:

Comparative Analysis of Peak Hour Factors for Four Major Collector Roads in Sulaymaniyah City, Iraq

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Abstract

This study presents a comparative analysis of Peak Hour Factors (PHF) for four major collector roads in Sulaymaniyah City, Iraq. Traffic volume data were collected using video recording techniques and processed at 15-minute intervals over a 24-hour period. The Peak Hour Factor was calculated for each site to assess the uniformity of traffic demand during peak periods. The results reveal notable variations in PHF values among the selected roads, indicating differences in within an hour demand concentration that were not directly proportional to peak-hour traffic volume. PHF values ranged from 0.849 to 0.986, with both extremes recorded at Twimalik during the morning period in opposite directions of travel: inbound direction showed the greatest within-hour concentration, while outbound direction showed the most even within-hour distribution. Kaniba exhibited consistently high PHF values (0.924–0.969) despite carrying the largest peak-hour volumes (up to 1,807 veh/h per direction). The lowest PHF coincided with the lowest observed volume, indicating that a low PHF does not necessarily correspond to a high hourly traffic demand. The largest differences occurred between the two directions of the same corridor rather than between corridors, with Twimalik ranging from 0.849 to 0.986 across its four directional observations. The observed PHF values were generally within ranges reported in comparable studies, although such comparisons are used only as contextual references rather than as classifications of traffic performance. The findings provide a descriptive basis for identifying periods and directions with greater within-hour demand concentration and for guiding future detailed operational investigations. Because PHF enters capacity analysis as a demand adjustment factor ($v = V/PHF$), the reported values also indicate the extent to which the design flow rate exceeds the average hourly volume at each site. The study contributes the first documented directional 15-minute traffic dataset covering a full 24-hour period for these corridors, providing a quantitative baseline for future surveys and identifying the periods and directions in which detailed operational investigation would be most productive. Because the data were collected on a single weekday during the summer holiday period, the values reported characterize the survey day.

1. Introduction

Urban traffic congestion has become a major challenge in rapidly growing cities, particularly in developing regions where infrastructure expansion often lags behind increasing vehicle ownership [1]. One of the key indicators used to describe short-term variations in traffic demand is the Peak Hour Factor (PHF), which reflects the variation of traffic demand within the peak hour [2].Major collector roads play a crucial role in urban mobility by collecting traffic from local streets and neighborhoods and distributing it to the arterial network, while also providing direct access to adjacent activity centers [3]. Because collectors combine a mobility function with frequent access points and frontage activity, their traffic demand may show considerable temporal variation throughout the day [4]. Understanding these short-term variations is important because hourly traffic totals alone may not fully represent how demand is distributed within the peak hour [5]. Peak Hour Factor is widely used in traffic engineering to measure the uniformity of traffic demand within the peak hour [6]. A lower PHF indicates that demand is more concentrated within one or more of the 15-minute intervals of the selected hour [7]. On the other hand, higher PHF values represent a more even distribution of traffic demand across the four 15-minute intervals [8].Urban transport systems are highly sensitive to demand fluctuations, and inadequate infrastructure planning can result in severe congestion and inefficiencies [1]. Therefore, examining the temporal distribution of peak-period demand can provide additional information beyond total hourly traffic volume[9].Moreover, peak-hour traffic demand can differ both in magnitude and in its distribution within the hour [10]. PHF provides a simple means of distinguishing between relatively uniform hourly demand and demand that is concentrated within shorter intervals. However, PHF by itself does not directly measure congestion, speed, delay, capacity, or level of service; it describes only how the hourly demand is distributed among the four 15-minute intervals of the selected hour [2,9,21]. In addition, the temporal signature of traffic demand on an urban road may be influenced by the land uses it serves [12]. Commuter-dominated corridors may exhibit concentrated demand in the morning and evening, while corridors fronted by retail, dining, and healthcare activities may exhibit different temporal demand patterns [13]. Understanding this relationship can provide useful context when interpreting differences in PHF among urban corridors [14]. Published traffic studies in Sulaymaniyah City have addressed topics such as traffic safety and driver behavior [15], while PHF-specific evidence remains limited. Therefore, this study aims to help fill this gap by analyzing and comparing PHF values for selected major collector roads, while also exploring whether the observed patterns are qualitatively consistent with differences in the adjacent land-use context.

1.1 Objectives

The main objective of this study is to analyze and compare Peak Hour Factors (PHF) for selected major collector roads in Sulaymaniyah City using high-resolution traffic data. The specific objectives are:

- To quantify 24-hour temporal variation of traffic volumes using 15-minute interval data for each direction of the four study corridors.
- To calculate and compare directional Peak Hour Factors (PHF) and Peak Hour Volumes (PHV) across the corridors and between the morning (AM) and afternoon/evening (PM) analysis periods.
- To explore whether the observed differences in PHF are qualitatively consistent with the adjacent land-use context of each corridor, recognizing that land use was not quantified in this study.
- To compare the observed PHF values with published PHF ranges and selected design guidance for contextual interpretation [16, 19].

2. Literature Review

Peak Hour Factor (PHF) has been well established as an important indicator to quantify the temporal variation in traffic during the peak hour. It is a measure of the uniformity of traffic demand during the peak hour and it is widely applied in traffic engineering analyses to describe how hourly traffic volume is distributed among shorter intervals. Lower PHF values indicate that a greater proportion of the hourly traffic demand is concentrated within one or more short intervals, whereas higher PHF values indicate a more uniform distribution throughout the hour [7]. The Highway Capacity Manual [16] includes PHF values for use in traffic analysis when appropriate field measurements are unavailable; however, these values should be interpreted according to the relevant facility and analysis context. Previous studies have shown that hourly traffic volume alone does not describe how demand is distributed within the hour. PHF provides additional information by indicating whether the hourly demand is relatively uniform across the four 15-minute intervals or concentrated within shorter portions of the hour. Empirical studies have also shown that PHF can vary by time period, day, traffic volume, and site characteristics; therefore, a single PHF value should not necessarily be assumed to represent all conditions at a site [2,9]. The range of PHF values reported in previous studies illustrates substantial variation across traffic contexts. At unsignalized intersections in Najaf, Iraq, PHF values ranged from about 0.85 to above 0.95 [19]. For urban roads in Cimahi City, Hendrawan reported PHF values from 0.79 to 0.98, with an average of about 0.91 [7]. Bassan reported model-based PHF ranges of approximately 0.91–0.98 for urban arterials [11], while a mixed-traffic urban-road study determined PHF from 15-minute video observations [18]. Lan and Abia also demonstrated that PHF varies across traffic conditions and developed PHF guidance for capacity analysis using field observations [21]. The Highway Capacity Manual provides additional PHF guidance for use where appropriate field measurements are unavailable [16]. In the HCM, PHF is applied as a demand adjustment that converts a peak-hour volume into the equivalent flow rate for the busiest 15 minutes ($v = V/PHF$), and the manual reports default values rather than performance thresholds; the present study therefore treats published PHF figures as typical reported ranges and not as standards. These external values are used in the present study only as contextual references rather than as thresholds for classifying congestion or operational performance. Roadside friction adds to the complexity of traffic flow in urban settings. On-street parking, loading and unloading, vehicle turnarounds, pedestrian movements, and access activity can influence traffic characteristics along urban roads [4,17]. Studies in developing-city and heterogeneous-traffic contexts also show that roadside activity, mixed traffic, and constrained urban road space can affect observed traffic conditions [4,17,20]. The surrounding land-use context may further influence travel behavior and the timing of traffic demand [12–14]. These findings provide contextual support for exploring whether differences in PHF among the study corridors are qualitatively consistent with differences in surrounding roadside activity and land-use characteristics. Empirical PHF studies remain relatively limited for medium-sized cities, where traffic-demand patterns may differ from those observed in larger metropolitan areas. In particular, locally documented traffic datasets using directional 15-minute counts over a complete 24-hour observation period are limited for Sulaymaniyah City. In this context, the present study has two related goals. First, it compares PHF values observed on the four Sulaymaniyah corridors with published PHF ranges from comparable studies and selected design guidance to provide contextual interpretation of the local observations. Second, it explores whether differences in the temporal distribution of peak-hour demand are qualitatively consistent with the adjacent land-use context of the study corridors. With only four corridors in the sample, no statistical association between land use and PHF can be tested; the land-use discussion is therefore presented as a qualitative observation and a hypothesis for future work rather than as a result of this study. PHF is therefore used primarily as a descriptive measure of within-hour demand concentration, while external PHF values and land use characteristics are considered only as contextual information for interpreting the observed patterns. Previous PHF studies also show that the selected method of peak-hour identification can influence the resulting values. In particular, fixed-hour and moving-hour approaches may yield different PHF estimates, especially where demand fluctuates sharply within the day [7]. PHF may also vary by travel direction, site characteristics, and from one observation day to another [2,9,21]. Directional asymmetry is of particular relevance to corridor studies. Design practice already treats the two directions of a facility separately through the directional distribution factor, since the peak direction and the off-peak direction of the same corridor commonly serve different trip purposes at the same time of day [16]. The same logic applies to the within-hour distribution: because PHF is computed from the counts of a single movement, the two directions of one corridor can return substantially different values in the same hour, and reporting a single corridor-level PHF may conceal this. For this reason, the present study reports PHF separately for each direction and period rather than aggregating across directions. These issues are particularly relevant under heterogeneous urban traffic conditions, where short-term demand concentration may differ substantially between approaches, directions, and periods. Accordingly, the present study interprets PHF as a descriptive measure of within-hour demand concentration on the survey day rather than as a fixed operational characteristic of a corridor.

3. Methodology

This study was conducted on the four major collector roads in Sulaymaniyah city, which are four lane divided roads and separated by the raised median, these roads are: Kaniba, Hawari Taza, Azadi and Twimalik. Traffic data were collected using video recording techniques over a 24-hour period on Tuesday, 8 July 2025.

3.1 Data Collection

Traffic volumes were recorded continuously and extracted at 15-minute intervals for each direction of travel (eastbound and westbound) separately. A total of 96 hours of video data was obtained from four study sites (24 hours per site). The vehicles were classified into six types: passenger cars, buses, trucks, vans, motorcycles/bicycles and auto-rickshaws, popularly known as tuk-tuks.

Counts were extracted for all 96 fifteen-minute intervals of the full 24-hour recording period, and the complete 24-hour record is used for the volume profiles reported in Section 4. For the purpose of comparing a morning with an afternoon peak, two analysis windows were defined within that record: an AM window of 06:00–12:00 and a PM window of 12:00–20:00. Within each window, the peak hour for each direction was identified using a moving (sliding) hour approach, in which every sequence of four consecutive 15-minute intervals was evaluated and the sequence with the highest total volume was selected [7]. The peak hour is therefore not constrained to begin on the clock hour, which is why several of the reported peak hours begin at a quarter, half or three-quarter hour. Restricting the search to these windows did not exclude any site's busiest hour: for all eight corridor directions, the highest-volume hour of the entire 24-hour record fell inside the relevant window. Because at some sites the selected AM peak fell at the end of the AM window and the selected PM peak in the early afternoon, the labels AM and PM denote the analysis window rather than a commuter peak. Due to the mixed traffic conditions and driver behavior in these local areas, raw vehicle counts were directly used for baseline traffic volume analysis, without converting to passenger car units (PCUs). Because PHF is a ratio of two volumes drawn from the same traffic stream within the same hour, it is largely insensitive to the choice of PCU factors provided that vehicle composition remains approximately stable across the four 15-minute intervals; composition was checked and found not to vary systematically within the selected peak hours. Data collection was performed with high definition traffic monitoring cameras (HDTCs) installed on electrical poles on the roadside at an average of 5.5 m for full and unobstructed coverage of all travel lanes. The traffic survey was conducted in bright and sunny conditions to minimize any anomalies in the environment and in visibility that may have affected the normal speed of the vehicles or the utilization of the lanes. The main geometric and physical features of the four study corridors are summarized in Table 1.

3.2 Peak Hour Factor Calculation

The Peak Hour Factor (PHF) was calculated using the standard formula given in Eq. (1) [16]:

$$\mathrm{PHF} = \frac{V}{(4 \times V_{15})} \qquad (1)$$

where V is the total traffic volume during the peak hour (veh/h) and V_{15} is the volume of the busiest 15-minute interval within that hour (veh/15 min). Here V15 denotes the highest of the four 15-minute counts making up the selected hour. PHF is dimensionless and ranges from 0.25 (all traffic concentrated in a single 15-minute interval) to 1.00 (perfectly uniform flow). PHF values are reported to three decimal places because the observed values occupy a narrow band (0.849–0.986) in which rounding to two decimals would merge genuine directional and period differences; differences smaller than about 0.002 are not interpreted.

3.3 Data Processing and Analysis

Volumes extracted from the video recordings were aggregated at a resolution of 15 minutes in order to capture the temporal variation of traffic demand. This way, peak periods can be identified consistently, and Peak Hour Factor (PHF) can be calculated with accuracy. The 15-minute interval allows short-term variations within the peak hour to be examined in detail, and is the interval on which the PHF definition is based.Furthermore, comparative analysis was done between the selected roads to assess differences in PHF and peak-hour volume by corridor, direction, and analysis period. Video-based data collection is a reliable, accurate way to record traffic flow characteristics over a long time. This way, there is less chance for human error, and traffic data can be processed in great detail afterwards.

4. Study Corridors and Adjacent Land Use

The four study corridors also have significant variations in the extent and type of surrounding development that may be associated with differences in trip generation and the temporal pattern of traffic demand. The Kaniba Road area is in a densely developed urban area. Continuous mixed commercial uses predominate its frontage, such as grocery stores, fast food restaurants, restaurants, general retail stores, and hospitals. These activities provide a mixed land-use context that may be associated with traffic demand occurring across different periods of the day. The main function of Twimalik Road is a health cluster comprising several private clinics and a private hospital. This concentration of healthcare activities provides a distinct land-use context in which trip timing may be influenced by consultation and appointment periods. In contrast, the outbound lanes connect the corridor toward the central city and bazaar area, which contains substantial commercial activity. Hawari Taza Road and Azadi Road are used for a variety of commercial purposes such as fast-food stalls, restaurants, flower shops, local food markets, etc. These surrounding activities provide a mixed commercial land-use context that may contribute to temporal differences in travel demand during the day and evening periods. Table2 summarizes the dominant adjacent land use characteristics of the four corridors, while Figure 2 shows the schematic frontage composition. The overall study area and selected corridors are indicated, with their outbound/inbound directions, in Figure 1-A and Figure 1-B, respectively.

5. Results

Traffic Volume data were collected for four main collector roads in Sulaymaniyah City : Hawari Taza, Kaniba, Azadi ,and Twimalik, The analysis used 15 minute interval counts across 24 hours and compared the Peak Hour Volume and Peak Hour Factor between the study sites to examine differences in traffic-demand magnitude and within-hour temporal distribution. The survey was carried out using video-based traffic counting at the Hawari Taza, Kaniba, Azadi and Twimalik locations on 8 July 2025. The 24 hour directional volume for each site is reported in Table 3 and Figure 3 compares the two-way hourly volume profiles of the four corridors. Kaniba carried by far the heaviest demand (49,426 veh/day, two-way), followed by Hawari Taza (30,210), Azadi (27,517), and Twimalik (25,262). Figure 3 shows distinct daily traffic volume profiles among the four corridors. Kaniba maintained the highest two-way traffic volume for much of the observation period and developed a relatively broad daytime plateau. Hawari Taza and Azadi showed lower but noticeable increases during the daytime and evening periods, while Twimalik recorded the lowest total daily traffic volume among the four corridors. These profiles describe the observed temporal variation in traffic demand on the survey day; possible relationships with adjacent land use are considered separately in the Discussion.

4.1 Hawari Taza

In the case of Hawari Taza, there was a moderate variation in the PHF values in both directions during the peak period. For the inbound direction the morning peak hour had a PHF of 0.962, while the evening peak had a PHF of 0.905. The outbound PHF's were 0.954 in the morning and 0.933 in the evening. Table 4 shows the higher PHFs for both directions in the morning, suggesting that traffic demand was more evenly distributed among the four 15 minutes intervals, while the lower evening PHFs suggested that traffic demand became more concentrated within part of the selected peak hour. This morning/evening peak split may be associated with the land use context and direction of commuter flow. Morning traffic is likely to be more work-oriented, while PM-period traffic may include a broader mixture of returning home, retail and other local trips. The observed PHF variation indicates that the temporal distribution of demand was different between the morning and evening periods, independently of the total hourly volume. Figure 4 shows the temporal variations in the directional traffic volume throughout the observation day. Inbound traffic increases during the morning period, while outbound traffic increases gradually toward a broader afternoon plateau. This pattern may be qualitatively consistent with a combination of commuting and surrounding commercial activity. However, trip purposes were not directly measured in this research.

4.2 Kaniba

Among the four corridors, Kaniba showed the most uniform within-hour distribution of demand. During inbound, the morning PHF was 0.969 and the evening PHF was 0.924. For the outbound direction, the morning PHF was 0.940 while for the evening direction it was 0.957. The values are relatively high and show all four observations to be at or above 0.92, indicating a fairly even distribution of traffic in the selected peak periods. High PHFs at Kaniba indicate that traffic volumes are relatively evenly distributed throughout the 15 minutes intervals within the hour. Kaniba site showed less localized concentration of cars when compared with other sites, which could be due to differences in access and trip making patterns. However, these factors were not directly observed in this study. Of particular interest, this uniformity – the narrowest PHF range of the study, and the highest minimum value (0.924–0.969) – was obtained despite Kaniba having the highest recorded peak-hour traffic volumes (up to 1,807 veh/h per direction), highlighting that within an hour demand uniformity is not necessarily the result of low demand. For Kaniba, the traffic distribution is relatively uniform, and the traffic flow is relatively consistent in its distribution, both up and down curves steeply increasing at 07:00–08:00 and then maintaining a relatively high daytime plateau before declining during the evening. (Figure 5).

4.3 Azadi

The variation in PHF was greater for Azadi than for Kaniba and Hawari Taza, and was the only corridor with more than one directional value below 0.92, recording three of its four values (0.885, 0.891 and 0.909) below that level. For the inbound direction, the morning PHF was 0.891 and the evening PHF increased to 0.973. for the outbound direction, The morning PHF was 0.909, while the evening PHF dropped to 0.885—the lowest evening PHF observed among the four corridors. The pattern indicates clear differences in the within hour distribution of traffic demand between directions and analysis periods at Azadi. The low morning PHF inbound suggests that inbound traffic demand was relatively concentrated within part of the selected peak hour. The timing of the observed peaks may be qualitatively consistent with the commercial and dining activities located along the corridor. However, individual trip purposes were not directly measured. The low evening outbound PHF (0.885) indicates that outbound demand was also concentrated within a relatively short portion of the selected evening peak hour. The difference in the two directions shows that the temporal distribution of demand was direction dependent during the observation day. On the whole, Azadi exhibited greater variation in PHF across directions and periods than Kaniba and Hawari Taza. It is clear from Figure 6 that traffic volume at Azadi varies throughout the observation day, with different temporal patterns between the inbound and outbound directions. These changes illustrate the variation in traffic demand over time rather than differences in operational traffic conditions.

4.4 Twimalik

Twimalik recorded both the minimum and maximum PHF values observed in the study during the morning period, but in opposite directions. The inbound morning PHF was 0.849, the lowest value observed among the sixteen directional peak-period cases, while the inbound evening PHF was 0.973. The highest outbound was in the morning time, 0.986 (09:30–10:30), while the evening time PHF was 0.941. The very low inbound PHF at the morning period suggests a relatively high concentration of traffic demand within part of the selected hour, while the high PHF of the outbound morning observation indicates that the traffic demand was distributed much more evenly in the opposite direction. The resulting strong directional asymmetry shows that the temporal distribution of demand differed considerably between the two directions during the morning period. The low inbound morning PHF may be qualitatively consistent with concentrated arrivals associated with the corridor's healthcare activity, while the higher outbound morning PHF indicates a more even distribution of traffic demand within the selected hour. Among all sixteen observations, Twimalik showed the widest contrast in PHF between directions during the morning period. Notably, the lowest PHF of 0.849 occurred at the same time as the lowest peak-hour volume in the study, 530 veh/h during the inbound 11:00–12:00 period. This demonstrates that a low PHF does not necessarily correspond to a high hourly traffic volume. The observed pattern may be related to the timing of local trip-generating activities, but this relationship was not quantitatively tested in the present study. Figure 7 shows the traffic flow at Twimalik, the profile of which is clearly skewed with sharp peaks around midday in the inbound direction, and a very uniform outbound profile throughout the morning, indicating a greater within-hour concentration of demand in the inbound direction and a more even temporal distribution in the outbound direction during the observed morning period.

4.5 Comparative Analysis of PHF

A comparison across all four roads shows clear differences in the temporal distribution of peak hour demand. The observed differences are consistent with previous studies showing that PHF can vary significantly even at the same site because of peak period, traffic volume, and local conditions [2]. The observed variations may also be associated with differences in surrounding activities and travel patterns; however, these factors were not quantitatively tested in the present study. Therefore, the PHF results for Sulaymaniyah indicate differences in how peak-hour traffic demand was distributed across time and direction on the survey day. Figure 8 presents all sixteen directional PHF values by corridor, direction, and period, allowing direct comparison of the observed within-hour demand distribution among the four corridors. Figure 9 shows the corresponding peak-hour volumes. Table 8 summarizes the observed PHF range for each corridor. The corridor-mean PHF value – the arithmetic mean of the four directional values (inbound and outbound, morning and evening) recorded at a site – ranged between 0.915 at Azadi and 0.948 at Kaniba and Twimalik had the widest range in PHF. The observed differences may be qualitatively consistent with differences in surrounding land-use activities and trip-generation patterns. However, land-use intensity, access density, and trip purpose were not quantitatively measured; therefore, these observations should be treated as exploratory rather than as evidence of a statistical relationship between land use and PHF. The comparison also shows that PHF and peak-hour volume describe different characteristics of traffic demand. Kaniba recorded the highest peak-hour volumes while maintaining relatively high PHF values, whereas the lowest PHF of 0.849 occurred at Twimalik during a comparatively low-volume peak hour of 530 veh/h. This indicates that the magnitude of hourly demand does not necessarily determine how uniformly that demand is distributed within the hour. PHF should therefore be interpreted as an indicator of within-hour demand concentration rather than as a direct measure of congestion, delay, capacity, or level of service.

5. Discussion

The observed PHF values across the four collector roads indicate that peak-hour traffic demand differed both in magnitude and in its temporal distribution within the selected hour. For example, Kaniba recorded relatively high PHF values despite carrying the highest peak-hour volumes, whereas Twimalik recorded the lowest PHF of 0.849 during a comparatively low-volume inbound morning period. This shows that peak-hour volume magnitude and within-hour demand concentration are distinct characteristics. The observed PHF range for each corridor is summarized in Figure 10 and each directional PHF value is plotted against the corresponding peak hour volume in Figure 11. The minimum and the maximum of each corridor correspond to the lowest and the highest values of the four directional PHF values (inbound and outbound during morning and evening peak hours) respectively, while the mean PHF (the diamond) is the average of the four values. Figure 11 also illustrates that higher peak-hour volume did not consistently correspond to lower PHF. Kaniba recorded the highest peak-hour volumes while maintaining relatively high PHF values, whereas the lowest PHF of 0.849 occurred at Twimalik with a peak-hour volume of only 530 veh/h. This comparison further demonstrates that PHF describes the temporal distribution of demand within an hour rather than the magnitude of hourly demand itself. The Sulaymaniyah corridors showed corridor-mean PHF values of 0.915 (Azadi), 0.937 (Twimalik), 0.939 (Hawari Taza) and 0.948 (Kaniba). These observed values were generally within ranges reported in previous PHF studies and design guidance [7,11,16,18,19,21]. They are also comparable with the most directly relevant Iraqi evidence from unsignalized intersections in Najaf, where PHF values ranged from about 0.85 to above 0.95 [19]. However, PHF is sensitive to site characteristics, traffic composition, analysis period, and traffic-control conditions [2,9,21]. Therefore, comparisons with external studies and design guidance are used only as contextual references and not as classifications of traffic performance. Twimalik's inbound morning PHF of 0.849 represents the greatest within-hour concentration observed in the present dataset. These patterns were qualitatively consistent with differences in the adjacent land-use context of the corridors (Section 3.4).The overlapping trip purposes of those who arrive at Kaniba's continuous mixed commercial frontage (shopping, dining, health, and commuting) may contribute to a more distributed pattern of arrivals within the hour. In contrast, the frontage of Twimalik, dominated by the healthcare sector, was associated on the survey day with the lowest PHF during the 11:00–12:00 inbound period, indicating greater within-hour concentration of traffic demand. By contrast, the outbound morning observation was more uniformly distributed, with a PHF of 0.986. Twimalik's inbound and outbound lanes exhibit a marked difference in the morning PHF, which may reflect differences in the trip purposes and activities served by the two directions. However, trip purpose, land-use intensity, and access characteristics were not quantitatively measured in this study. Therefore, these interpretations should be treated as exploratory and should not be considered evidence of a causal relationship between land use and PHF. Hawari Taza and Azadi also contain mixed retail and food-related frontage activities and showed intermediate PHF patterns across the observed periods. A consistent directional pattern is visible across the two corridors with the clearest land-use contrast. At Twimalik the outbound carriageway leads toward the city centre and the central bazaar and recorded the highest PHF in the study (0.986), while the inbound carriageway serves the healthcare cluster and recorded the lowest (0.849), both within the same morning period. At Kaniba the inbound carriageway likewise leads toward the city centre, and all four of its directional values were 0.924 or above. In both cases the movement oriented toward the city centre – which serves many overlapping trip purposes and destinations – showed the more even within-hour distribution, whereas the movement serving a single dominant activity showed the greater concentration. This is consistent with the expectation that a destination mix drawing on several trip purposes spreads arrivals across the hour, while a single activity with scheduled arrival times concentrates them. The pattern is offered as an observation from four corridors on one day, not as a tested relationship. Overall, the observed differences were qualitatively consistent with differences in surrounding activity patterns, although this relationship was not statistically tested. The difference in volume recorded during the morning and evening peaks indicates that traffic volumes varied across the observed periods of the day. Similarly, the PHF results show that the within-hour distribution of demand also varied between the morning and evening periods and between travel directions. The differences noted in the analysis of the Azadi further demonstrate that PHF can vary considerably within the same corridor by direction and time, further emphasizing the importance of more adaptable and flexible traffic management strategies, that are time sensitive. Figure 12 presents these morning-to-evening changes for each corridor and direction. It shows that the inbound direction changed more than the outbound direction at every site, and that the direction of change was not uniform: PHF fell from morning to evening at Kaniba and Hawari Taza but rose at Azadi and Twimalik. For the inbound direction, the change in PHF from morning to evening is shown in Figure 12 and is particularly noticeable at Azadi and Twimalik, where substantial differences were observed between the morning and evening PHF values. PHF should be interpreted as a measure of how traffic demand is distributed within the selected hour. A lower PHF indicates that a larger share of the hourly traffic occurs during one or more 15-minute intervals, while a higher PHF indicates a more even distribution of traffic throughout the selected hour. However, PHF alone does not provide information about congestion, roadway capacity, delay, queue formation, speed, or level of service. Assessing these conditions would require additional traffic variables and analyses that were not included in the present study. The results of the study have practical implications for identifying periods and directions with greater within an hour concentration of traffic demand in Sulaymaniyah City. Sites that have lower PHF values should be considered for further detailed operational evaluation because they exhibit greater concentration of demand within the selected peak hour. PHF results can therefore be used as a screening tool to identify where more detailed analyses of speed, delay, capacity, queueing, access conditions, or traffic control may be useful before specific management measures are recommended. The results also illustrate the need for high-resolution traffic data in analyzing short-term variations in traffic demand, since hourly totals alone may not reveal how strongly demand is concentrated within shorter intervals. For Twimalik in particular, the low inbound morning PHF suggests that future investigations should examine the timing of local trip-generating activities and access conditions there first. The practical value of the analysis lies in this targeting: rather than surveying four corridors in full, a subsequent operational study can concentrate its resources on the movements and periods identified here as carrying the most concentrated demand. The dataset also supplies the directional PHF values required to convert peak-hour volumes into design flow rates on these corridors (v = V/PHF), which previously had to be assumed from published defaults. Several limitations should be acknowledged when interpreting these results. The analysis covers four selected corridors observed on a single 24-hour weekday (Tuesday, 8 July 2025) falling within the school summer holiday, so school-related morning travel is likely under-represented and the reported peak hours — particularly the late-morning peaks at Azadi and Twimalik — may differ from those of the academic season. Traffic composition, intersection control, roadside activity, weather, and incident effects were not explicitly modeled. In addition, the single-day observation does not capture day-to-day or seasonal variability, which has been shown to affect peak-hour traffic measures [2,9]. Therefore, the reported PHF values should be interpreted as characteristics of the survey day rather than as representative long-term values for the four corridors. Future work should extend the surveys across multiple weekdays and seasons, and quantify corridor land use — for example, frontage establishments per category per kilometers and access-point density — to test the land-use–PHF association statistically across a larger sample of corridors. Future studies may also incorporate operational measures such as speed, delay, queueing, and capacity where a broader assessment of roadway performance is required.

6. Conclusion

This study examined the Peak Hour Factor (PHF) for four major collector roads in Sulaymaniyah City using 15-minute traffic counts over a 24-hour period. The results showed clear differences in the temporal distribution of traffic demand among the study locations and between morning and evening peak periods. Although Kaniba had the highest traffic volumes, it exhibited relatively high PHF values ranging from 0.924 to 0.969 , and Twimalik had the most directionally concentrated traffic demand with a PHF of 0.849 inbound direction and 0.986 for outbound direction, showing a marked directional difference in within-hour demand concentration. The observed results were generally within the range reported in comparable PHF studies; however, such comparisons are used only as contextual references because PHF varies with site characteristics, analysis period, and local traffic conditions. Temporal demand patterns and directional traffic movements were associated with clear differences in PHF across the observed corridors. Kaniba exhibited relatively uniform within-hour demand despite carrying the highest traffic volumes, while Twimalik recorded the lowest PHF during a comparatively low-volume inbound morning peak. The results indicate that peak-hour volume magnitude and within-hour demand concentration are distinct characteristics. The observed patterns were qualitatively consistent with differences in the surrounding land use context; however, land use was not quantitatively measured, and no statistical or causal relationship was established. In conclusion, the study underscores the need to consider PHF as a useful metric to characterize the temporal distribution of peak-hour traffic demand and identify periods and directions with greater within-hour concentration. The findings can support the identification of locations and time periods where more detailed operational analysis may be warranted. Because the observations were obtained on a single weekday during the summer holiday period, the results should be interpreted as characteristics of the survey day and should not be generalized to long-term or seasonal traffic conditions.

References

[1] Bashingi, N., Mostafa, M., & Das, D. K. (2020). The state of congestion in the developing world; The case of Gaborone, Botswana. Transportation Research Procedia, 45, 434–442. https://doi.org/10.1016/j.trpro.2020.03.036

[2] Tarko, A. P., & Perez-Cartagena, R. I. (2005). Variability of peak hour factor at intersections. Transportation Research Record: Journal of the Transportation Research Board, 1920, 125–130. https://doi.org/10.3141/1920-15

[3] Iowa Statewide Urban Design and Specifications (SUDAS). (2018). Section 5B-1: Street classifications. SUDAS Design Manual, Institute for Transportation, Iowa State University.

[4] Salini, S., & Ashalatha, R. (2020). Analysis of traffic characteristics of urban roads under the influence of roadside frictions. Case Studies on Transport Policy, 8(1), 94–100. https://doi.org/10.1016/j.cstp.2018.06.008

[5] Findley, D. J., Cunningham, C. M., Brown, T. H., Jr., Cahill, L. M., Yang, G., & Huntsinger, L. F. (2022). Highway engineering: Planning, design, and operations (2nd ed.). Elsevier.

[6] Ciont, N., Cadar, R. D., Iliescu, M., & Laslău, D. A. (2015). Interactive application for the evaluation of the peak hour factor using weigh-in-motion traffic data. U.P.B. Scientific Bulletin, Series C, 77(1), 121–128.

[7] Hendrawan, H. (2020). Peak hour factor at urban road network system with fixed hourly interval and moving hourly interval: A case study at urban road in Cimahi City. Creative Research Journal, 6(1), 29–38. https://doi.org/10.34147/crj.v6i01.256

[8] Zárate Torres, B. A., & Segarra Morales, M. S. (2015). Variación temporal de los factores de hora pico y volumen horario en carreteras de dos carriles: Caso de estudio, vía Loja–Zamora. AXIOMA, 2(13), 25–32.

[9] Hellinga, B., & Abdy, Z. (2008). Signalized intersection analysis and design: Implications of day-to-day variability in peak-hour volumes on delay. Journal of Transportation Engineering, 134(7), 307–318. https://doi.org/10.1061/(ASCE)0733-947X(2008)134:7(307)

[10] Ma, F., Xu, J., Gao, C., & Bi, Y. (2022). Study on the distribution of the suburban expressway hourly traffic volume and modification of the design hourly volume under the background of the tourism economy—Analysis on design factors of

normalized congestion in suburban expressway. Sustainability, 14(17), 10775. https://doi.org/10.3390/su141710775
[11] Bassan, S. (2013). Modeling of peak hour factor on highways and arterials. KSCE Journal of Civil Engineering, 17(1), 224–232. https://doi.org/10.1007/s12205-013-1551-y
[12] Zegras, P. C. (2004). Influence of land use on travel behavior in Santiago, Chile. Transportation Research Record: Journal of the Transportation Research Board, 1898, 175–182. https://doi.org/10.3141/1898-21
[13] Ewing, R., & Cervero, R. (2010). Travel and the built environment: A meta-analysis. Journal of the American Planning Association, 76(3), 265–294. https://doi.org/10.1080/01944361003766766
[14] Zhang, T., Sun, L., Yao, L., & Rong, J. (2017). Impact analysis of land use on traffic congestion using real-time traffic and POI. Journal of Advanced Transportation, 2017, Article 7164790. https://doi.org/10.1155/2017/7164790
[15] Muhamad, B., Karim, H. K., & Ahmed, H. U. (2020). Effects of traffic violation and demographic characteristics on traffic safety in Sulaymaniyah City. Sulaimani Journal for Engineering Sciences, 7(3), 197–205. https://doi.org/10.17656/sjes.10142
[16]Transportation Research Board. (2022). Highway Capacity Manual: A guide for multimodal mobility analysis (7th ed.). National Academies of Sciences, Engineering, and Medicine.
[17] Gulivindala, P., & Mehar, A. (2018). Analysis of side friction on urban arterials. Transport and Telecommunication Journal, 19(1), 21–30. https://doi.org/10.2478/ttj-2018-0003
[18] Ayeni, T. S., & Iyeke, S. D. (2024). Determination of traffic characteristics for an urban road under mixed traffic conditions. Journal of the Nigerian Association of Mathematical Physics, 67(1), 1–8. https://doi.org/10.60787/jnamp-v67i1-336
[19] Turki, I. M., & Shubber, K. H. H. (2024). Hourly traffic flow variation at unsignalized intersection in Najaf city. AIP Conference Proceedings, 3092(1), 070003. https://doi.org/10.1063/5.0199763
[20]Hanumappa, D., Mulangi, R. H., & Kudachimath, N. S. (2018). Traffic characteristics evaluation and traffic management measures: A case study of Dharwad City. The Open Transportation Journal, 12, 258–272. https://doi.org/10.2174/1874447801812010258
[21] Lan, C.-J., & Abia, S. D. (2011). Determining peak hour factors for capacity analysis. Journal of Transportation Engineering, 137(8), 520–526. https://doi.org/10.1061/(ASCE)TE.1943-5436.0000241

التحليل المقارن لمعاملات ساعة الذروة لأربعة طرق تجميعية رئيسية في مدينة السليمانية، العراق

الملخص

تُعدّ التغيرات الزمنية في الطلب المروري من الخصائص المهمة للحركة المرورية في المناطق الحضرية، ولا سيما خلال فترات الذروة. تقدم هذه الدراسة تحليلاً مقارناً لمعامل ساعة الذروة (Peak Hour Factor – PHF)لأربعة طرق تجميعية رئيسية في مدينة السليمانية، العراق. وتهدف إلى تحديد الاختلافات في التوزيع الزمني للطلب المروري خلال ساعة الذروة بين الطرق والاتجاهات وفترات التحليل المختلفة، مع استكشاف هذه الأنماط في ضوء طبيعة استعمالات الأراضي المحيطة .تم الحصول على بيانات أحجام المرور من خلال تسجيلات فيديو امتدت على مدار ٢٤ ساعة، ومعالجتها على فترات زمنية مقدارها ١٥ دقيقة. وتراوحت قيم معامل ساعة الذروة بين ٠.٨٤٩ و٠.٩٨٦، حيث سُجلت كلتا القيمتين في طريق توي مالك خلال الفترة الصباحية ولكن في اتجاهين متعاكسين؛ إذ أظهر الاتجاه الداخل أعلى درجة من تركز الطلب المروري خلال الساعة، بينما أظهر الاتجاه الخارج التوزيع الأكثر انتظاماً. كما سجل طريق كانيبة قيماً مرتفعة نسبياً لمعامل ساعة الذروة تراوحت بين ٠.٩٢٤ و٠.٩٦٩، على الرغم من تسجيله أعلى أحجام مرورية خلال ساعة الذروة، والتي بلغت ١,٨٠٧ مركبة/ساعة لكل اتجاه. وتزامنت أدنى قيمة لمعامل ساعة الذروة مع أقل حجم مروري خلال ساعة الذروة، مما يوضح أن حجم الطلب المروري خلال الساعة ودرجة تركزه داخل الساعة يمثلان خصيصتين مختلفتين .ويتم تفسير نتائج معامل ساعة الذروة في هذه الدراسة بوصفها مؤشراً على توزيع الطلب المروري داخل الساعة، وليس كمقياس مباشر للازدحام أو السعة أو التأخير أو السرعة أو مستوى الخدمة. كما تم تناول الاختلافات في استعمالات الأراضي بصورة وصفية واستكشافية دون إثبات علاقة سببية. وتوفر الدراسة قاعدة بيانات مرورية اتجاهية بفواصل زمنية مقدارها ١٥ دقيقة للطرق الأربعة، بما يساعد على تحديد الفترات والاتجاهات التي قد تتطلب دراسات تشغيلية أكثر تفصيلاً مستقبلاً. ونظراً إلى أن البيانات جُمعت خلال يوم واحد من أيام الأسبوع وفي فترة العطلة الصيفية، فإن النتائج تمثل ظروف يوم المسح ولا ينبغي تعميمها على الظروف المرورية طويلة الأمد.

الكلمات المفتاحية:

معامل ساعة الذروة(PHF) ، حجم المرور، الطرق التجميعية، التوزيع الزمني للطلب المروري، السليمانية، استعمالات الأراضي، الحركة المرورية الاتجاهية.

Table 1. Geometric and Operational Characteristics of the Study Corridors

Corridor	Lane Width (m)	Median Type	On-Street Parking (Yes/No)
Kaniba	3.6	Raised	Yes
Hawari Taza	3.4	Raised	Yes
Azadi	2.5-3.6*	Raised	Yes
Twimalik	2.75	Raised	Yes

*Note: Unlike the other roads, the cross-section of Azadi Road fluctuates significantly due to horizontal curves and changing roadway geometry throughout the segment; therefore, its lane width is expressed as a range.

Table 2. Dominant adjacent land use of the study corridors

Corridor	Dominant frontage land use
Kaniba	Mixed commercial, retail, dining, and healthcare activities distributed along the corridor
Hawari Taza	Mixed commercial and food-related activities along the corridor
Azadi	Mixed commercial (fast food, restaurants, flower shops, local food markets)
Twimalik	Healthcare-dominated with private clinics and hospital

Figure 1-A. Study area: Selected Corridors in Sulaymaniyah City

Figure 1-B. Selected Corridors Detailing Outbound and Inbound Directions

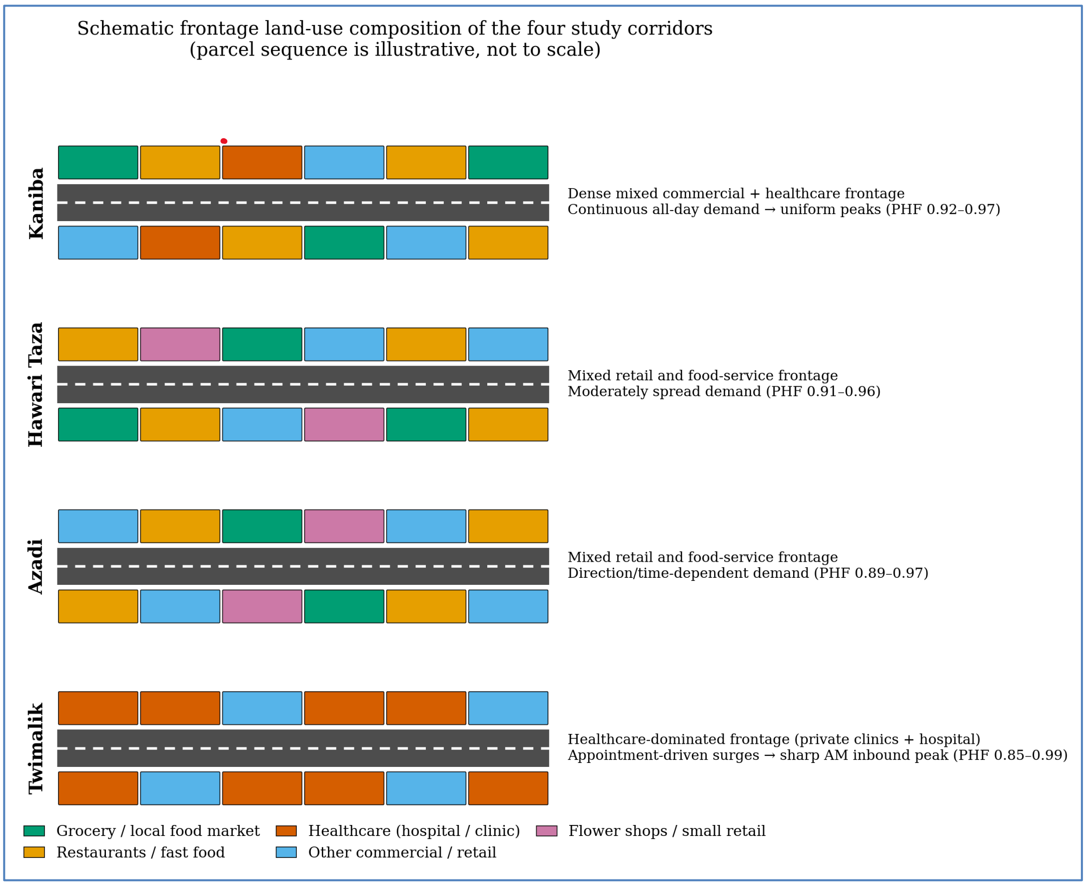

Figure 2. Schematic frontage land-use composition of the four study corridors (parcel sequence illustrative, not to scale)

Table 3. 24-hour directional traffic volumes on the survey day (veh/day)

Corridor	Inbound	Outbound	Two-way total
Kaniba	26,399	23,027	49,426
Hawari Taza	16,378	13,832	30,210
Azadi	13,912	13,605	27,517
Twimalik	11,047	14,215	25,262

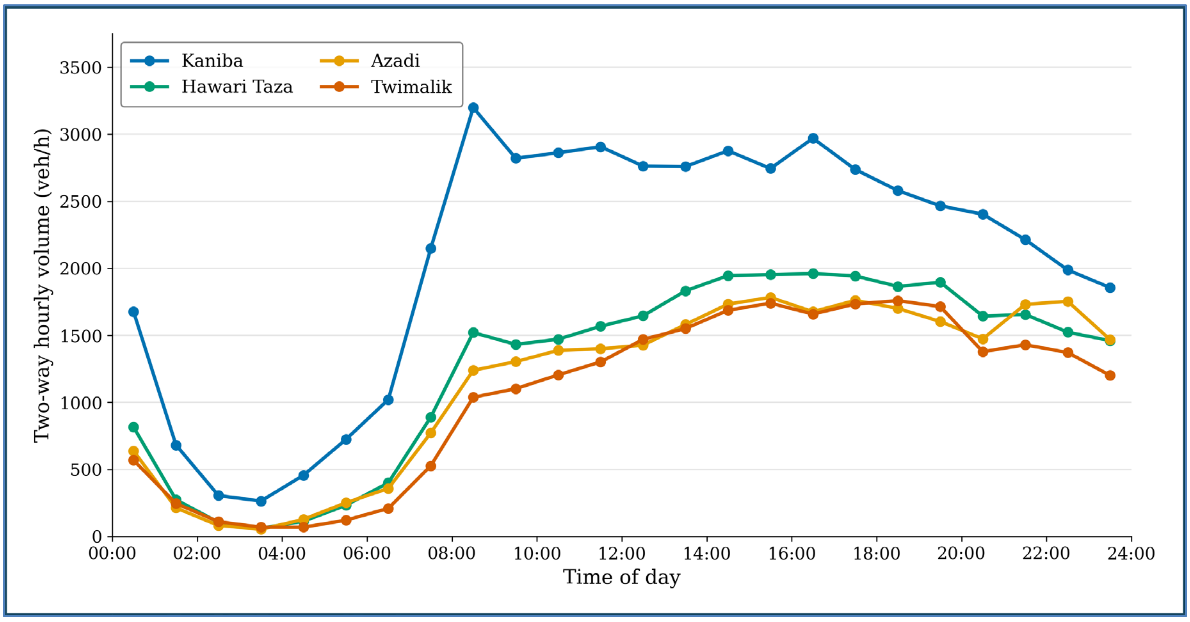

Figure 3. Two-way hourly traffic volume profiles of the four corridors

Table 4. Peak Hour Volume (PHV) and Peak Hour Factor (PHF) for Hawari Taza

Direction	Period	Peak hour	PHV (veh/h)	Peak 15-min vol. (veh)	PHF
Inbound (to Hawari Taza)	Morning	08:00 – 09:00	877	228	0.962
	Evening	16:30 – 17:30	1165	322	0.905
Outbound (from Hawari Taza)	Morning	11:00 – 12:00	733	192	0.954
	Evening	14:15 – 15:15	1004	269	0.933

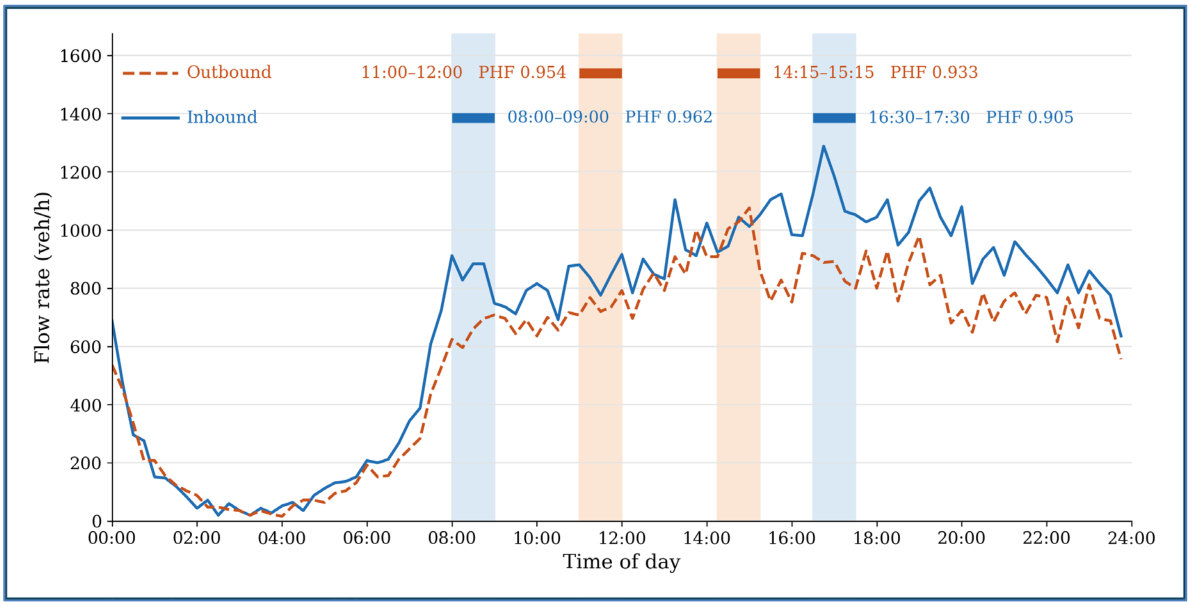

Figure 4. Directional flow-rate profile (15-min intervals) with identified peak hours – Hawari Taza

Table 5. Peak Hour Volume (PHV) and Peak Hour Factor (PHF) for Kaniba

Direction	Period	Peak hour	PHV (veh/h)	Peak 15-min vol. (veh)	PHF
Inbound (to Kaniba)	Morning	08:00–09:00	1807	466	0.969
	Evening	16:15–17:15	1686	456	0.924
Outbound (from Kaniba)	Morning	07:45–08:45	1422	378	0.940
	Evening	16:00–17:00	1336	349	0.957

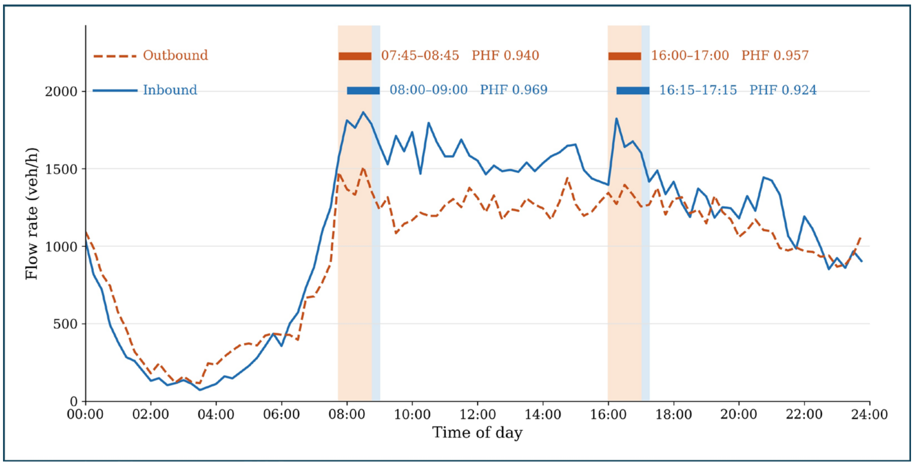

Figure 5. Directional flow-rate profile (15-min intervals) with identified peak hours – Kaniba

Table 6. Peak Hour Volume (PHV) and Peak Hour Factor (PHF) for Azadi

Direction	Period	Peak hour	PHV (veh/h)	Peak 15-min vol. (veh)	PHF
Inbound (to Azadi)	Morning	10:00 – 11:00	752	211	0.891
	Evening	14:45 – 15:45	934	240	0.973
Outbound (from Azadi)	Morning	11:00 – 12:00	691	190	0.909
	Evening	16:30 – 17:30	949	268	0.885

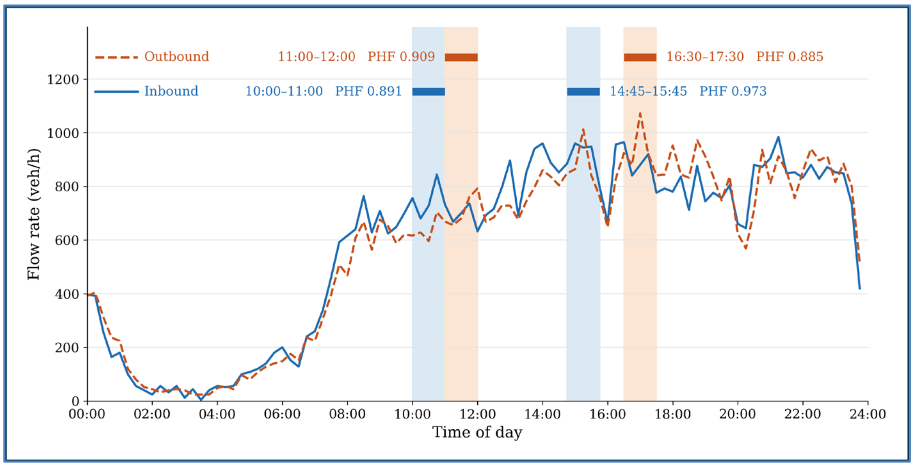

Figure 6. Directional flow-rate profile (15-min intervals) with identified peak hours – Azadi

Table 7. Peak Hour Volume (PHV) and Peak Hour Factor (PHF) for Twimalik

Direction	Period	Peak hour	PHV (veh/h)	Peak 15-min vol. (veh)	PHF
Inbound (to Twimalik)	Morning	11:00 – 12:00	530	156	0.849
	Evening	19:00 – 20:00	950	244	0.973
Outbound (from Twimalik)	Morning	09:30 – 10:30	781	198	0.986
	Evening	14:30 – 15:30	1031	274	0.941

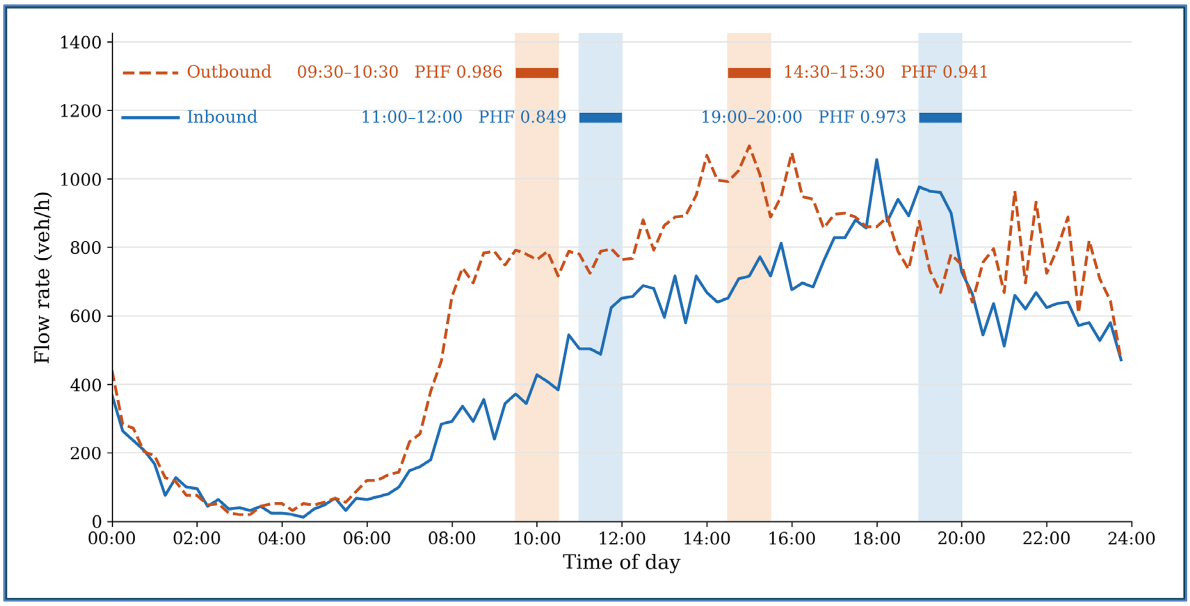

Figure 7. Directional flow-rate profile (15-min intervals) with identified peak hours – Twimalik

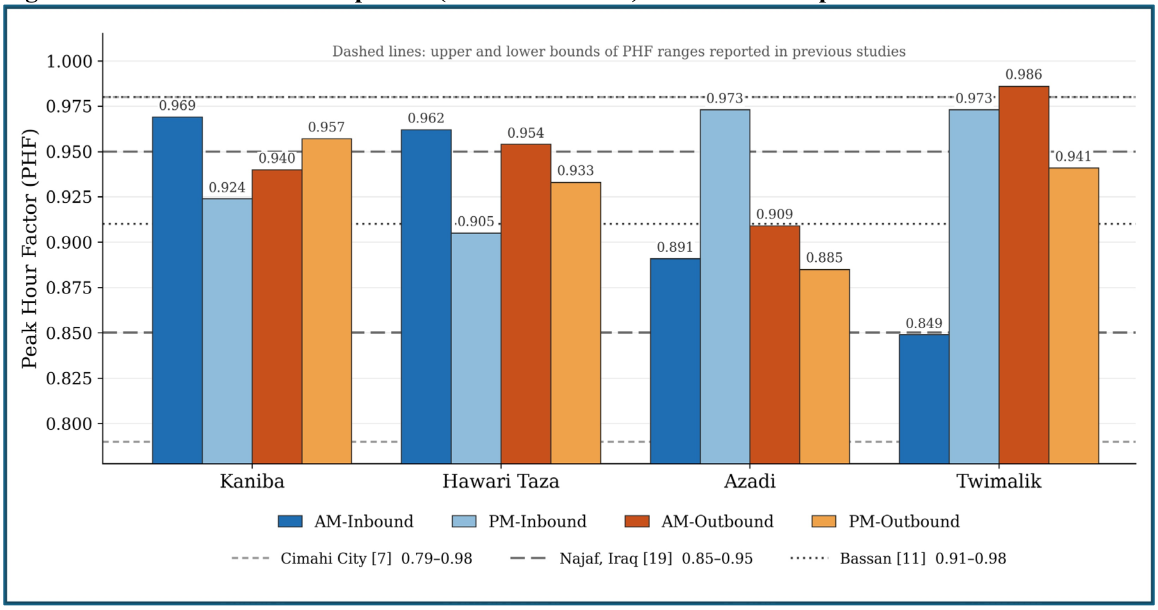

Figure 8. Directional Peak Hour Factors by corridor and peak period. The dashed lines mark the upper and lower bounds of PHF ranges reported in previous studies (Najaf, Iraq [19]; Cimahi City [7]; Bassan's urban arterial models [11]), included for context only and not as thresholds for assessing operational performance.

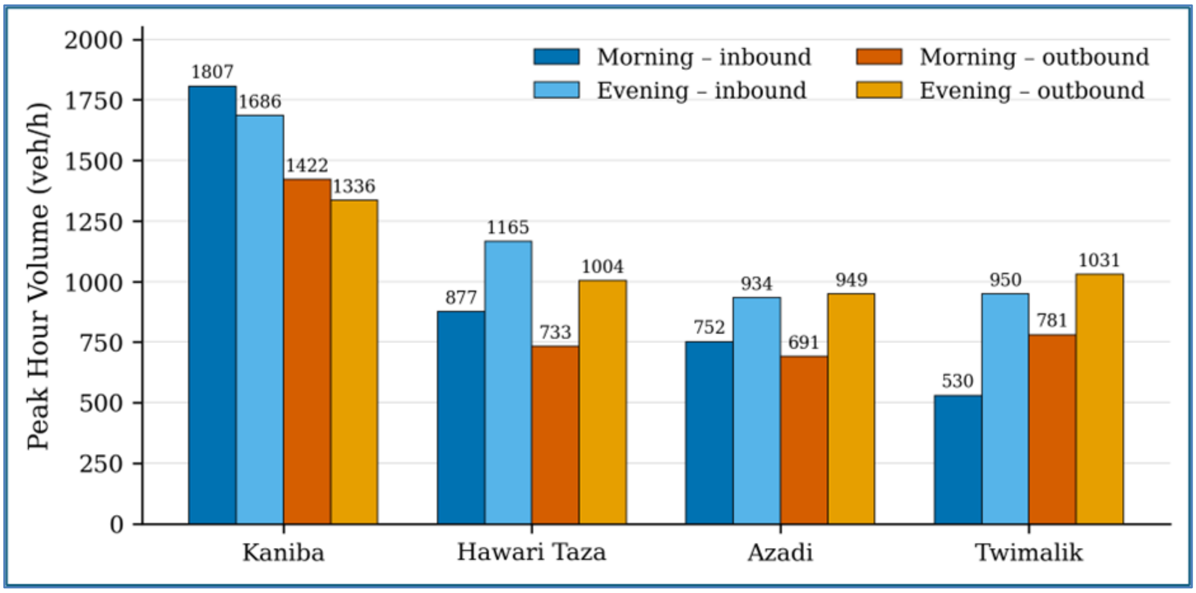

Figure 9. Directional Peak Hour Volumes by corridor and peak period

Table 8. Summary of observed PHF ranges by corridor

Location	PHF range
Kaniba	0.924 – 0.969
Hawari Taza	0.905 – 0.962
Azadi	0.885 – 0.973
Twimalik	0.849 – 0.986

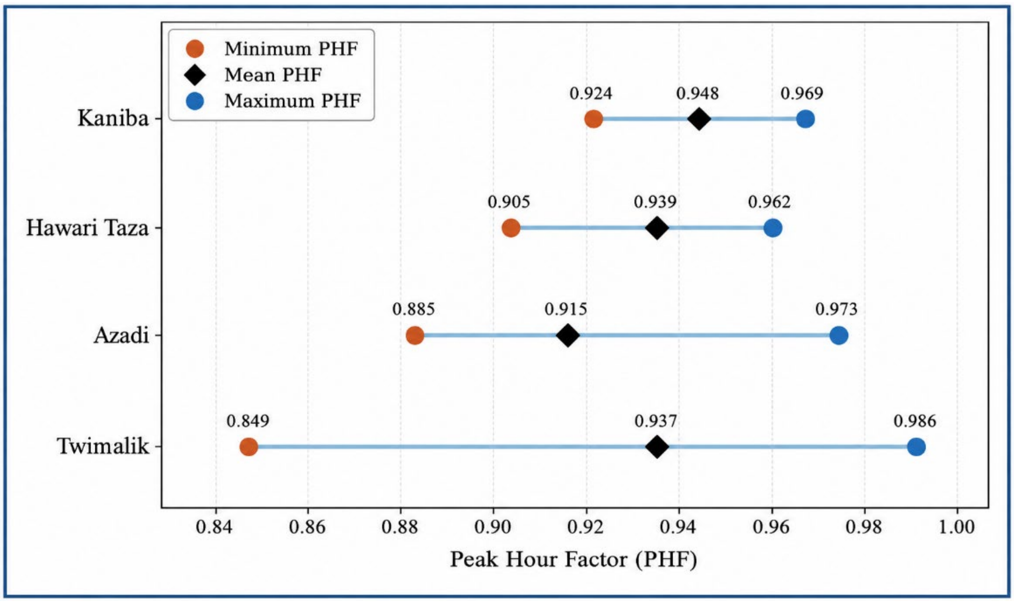

Figure 10. Range of directional PHF values by corridor. The diamond marks the mean of each corridor's four directional PHF values.

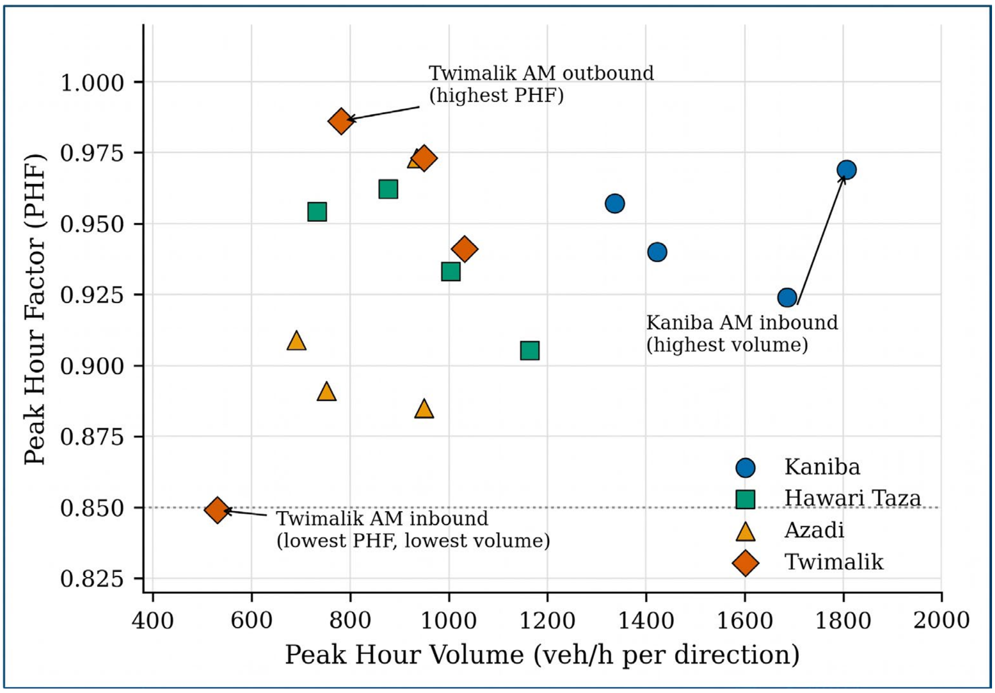

Figure 11. Relationship between directional PHF and Peak Hour Volume

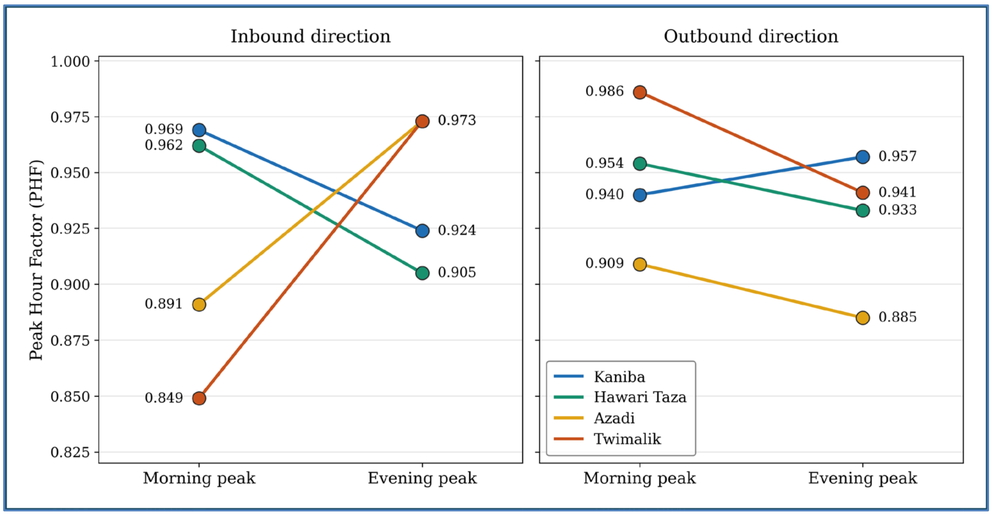

Figure 12. Morning-to-evening change in directional PHF by corridor