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Sound Pressure Profiles in Wholesale Fruit and Vegetable Markets in Kathmandu Valley, Nepal

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Abstract

Wholesale fruit and vegetable markets are busy urban workplaces where vehicles, loading activities, bargaining, horn use, and crowd movement can create continuous noise. This study assessed the environmental noise in two of the major wholesale produce markets of Kathmandu Valley, i.e. Kalimati and Balkhu, during the principal trading periods of the day. Noise levels were recorded at both markets throughout seven consecutive days using class 2 integrating sound meter. On each day, a 60-minute reading were taken during three primary trading periods: morning (05:00-07:00), midday (12:00-14:00), and evening (16:00-18:00). Noise meter was set to A-weighting and logged sound levels at 1-minute intervals where on each session, the hourly equivalent continuous sound level (LAeq,1h) and percentile levels (L10, L50, and L90) were calculated. Results were then compared with Nepal's National Sound Quality Standard (NSQS) daytime commercial area limit of 65 dB(A). Kalimati and Balkhu's morning noise levels were the highest and similar to each other (76 .59 and 76.63 dB(A), decrease in midday and differed considerably (67.35 and 60.14 dB(A)) and evening levels intensified in both market (71 .53 and 70.20 dB(A)) respectively. All the day, Kalimati surpassed 65dB(A) in every inspected period whereas Balkhu crossed guideline in the morning and evening but not at midday. Percentile metrics showed frequent peak events (morning L10 approximately 79-80 dB(A)) while background level (morning L90 approximately 71-72 dB(A)). Under an illustrative vendor activity pattern (3 h morning, 2 h midday, and 3 h evening), estimated LEX, 8h for Kalimati and Balkhu were 73.8 dB(A) and 73.3 dB(A) respectively.

The finding support practical recommendations such as delivery management, horn control, improved loading circulation, and adaptations for small scale stalls. These measures should be presented as recommendation rather than the tested intervention.

Keywords: Noise, Informal-sector workers, Percentile level, Wholesale produce markets

Introduction

Environmental noise is increasingly recognized as a public-health problem in rapidly growing cities (European Environment Agency, 2025). It is often discussed in relation to hearing, but also the evidence shows chronic exposure cause sleep disturbance, annoyance, cognitive impacts, and stress-related cardiovascular risks (Basner et al., 2014; Münzel et al., 2014; Stansfeld & Matheson, 2003). In rapidly motorizing cities, traffic noise often dominates the urban sound environment and remains difficult to manage (Goines & Hagler, 2007; King & Murphy, 2016; World Health Organization Regional Office for Europe, 2018).

In South Asian cities, dense mixed land use, road congestion, informal trading, and frequent horn use, can intensify an exposure in the public spaces (Vijay et al., 2015; Yadav et al., 2025). Wholesale produce markets bring vehicles, handcarts, unloading work, vendor-customer interaction, and pedestrian movement into the same confined space for many hours. Vendors, porters, loaders, drivers, and market staff may face repeated exposure, while customers and nearby residents may experience shorter but recurring exposure during peak trading hours (Bhowmik, 2005; International Labour Organization, 2018; Roever& Skinner, 2016). Market noise has also an immediate functional effect: raising in the background noise levels can mask speech, increase listening effort, and may encourage louder speech, which can further elevate the sound environment (World Health Organization, 1999).

Previous market soundscape studies suggest that market activity and layout can affect both sound levels and perceived comfort. That makes direct measurement in wholesale markets worthwhile (Meng et al., 2017). Kathmandu Valley has expanded rapidly (Thapa & Murayama, 2010), and previous Nepali studies report elevated traffic and occupational noise along major corridors and among high-exposure groups (Chhetri et al., 2019; Shrestha et al., 2011; Singh et al., 2022). However, market microenvironments where workplace and community exposures overlap remain under documented. Nepal's National Sound Quality Standard (NSQS) specifies ambient noise-limits, including 65 dB(A) for commercial areas during daytime and 55 dB(A) at night (Government of Nepal, 2012). Despite Kathmandu's documented urban noise challenges, routine monitoring and operational guidance for informal market governance remain limited (Chauhan et al., 2021). This study describes short-term noise patterns in two major wholesale markets in Kathmandu Valley (Kalimati and Balkhu) using hourly equivalent levels (LAeq,1h) and distributional descriptors (L10, L50, L90) This study also used to the observed peak-event and background-noise patterns, summarized through LAeq,1h, L10, L90, and L10–L90, draft a practical mitigation matrix spanning source, pathway, and receiver controls, including textile-based and health-education measures that may be feasible in informal market settings.

Materials and Methods

Study Area

Kalimati and Balkhu are among the main wholesale fruit and vegetable in Kathmandu Valley. Kalimati wholesale market is the largest wholesale market in the Kathmandu valley. This market has high vendor density and center urban location. The layout is congested with tightly packed stalls and shops and surrounding roads often experience heavy traffic (Kalimati Fruits and Vegetable Market Development Board). Balkhu wholesale market is one of the major market located near the ring road corridor along the bank of bagmati river (Giri, 2023). The two markets therefore represent contrasting market-road interfaces: a centrally embedded terminal market at Kalimati and a major wholesale location with strong corridor at Balkhu. Their locations are shown in Figure 1.

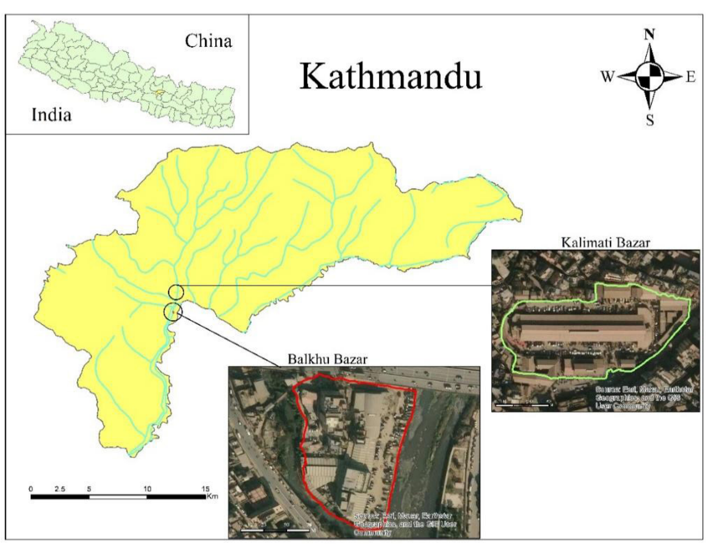

Figure 1. *Location of Kalimati and Balkhu Wholesale Markets in Kathmandu Valley, Nepal*

Short-term noise monitoring was conducted for seven consecutive days at Kalimati and Balkhu markets. On each day, one 60-minute measurement session was conducted within each of three operating periods: morning (05:00-07:00), midday (12:00-14:00), and evening (16:00-18:00). This design produced 21 hourly sessions per market and 42 hourly sessions in total.

Measurements were taken with a PCE-322A integrating sound level meter (PCE Instruments), operated as a Class-2 instrument. The meter was set to A-weighting and logged sound levels at 1-minute intervals. During each session, it was placed approximately 1.5 m above ground in a representative open area of the market and, where the field setting allowed, away from large reflecting surfaces. Monitoring was restricted to dry weather and avoided rainfall or visibly strong wind. The field procedure followed general environmental-noise measurement principles, but the standards citation should be corrected to ISO 1996-2 and the relevant IEC 61672 sound-level meter standards (International Electrotechnical Commission, 2013; International Organization for Standardization, 2017).

For each 60-minute session, the primary indicator was LAeq,1h, the equivalent continuous A-weighted sound level over one hour. Percentile levels (L10, L50, and L90) were also derived from the 1-minute sound-level distributions. L10 was used to describe the louder events that occurred during each session, L50 represented the median level, and L90 represented the background or sound-floor condition. The L10-L90 difference was used as a simple indicator of intermittency in an activity- and traffic-influenced sound environment (Murphy & King, 2022).

A simple intermittency screen was calculated as L10-L90. Regulatory screening used the NSQS commercial area daytime guideline of 65 dB(A); because the early morning window partially overlaps the NSQS night limit (55 dB(A)), comparisons to 65 dB(A) should be interpreted as conservative (Government of Nepal, 2012).

Analyses were performed on day-level session summaries (n=7 days per market × period). Descriptive statistics are reported as mean ± SD and min-max. Between-market contrasts within each period were tested with Welch's two-sample t-test (two-sided $\alpha = 0.05$), which is appropriate when equal variances cannot be assumed (Delacre et al., 2017). To contextualize potential work-shift exposure, an illustrative 8-h equivalent level (LEX,8h) was calculated by energy-averaging mean LAeq,1h values under a plausible vendor time activity pattern of 3 h morning, 2 h midday, and 3 h evening.

Table 2 presents an evidence-informed decision-support matrix rather than a validated or experimentally evaluated intervention model. The mitigation matrix was built from the observed noise patterns, from standard source-path-receiver control logic, and from a practical assessment of what might be feasible in informal market settings; was feasible in informal market settings; it distinguished peak-event prominence-reflected in higher L10 values and wider L10-L90 spreads from background-noise elevation, reflected in higher L90 values, while also considering period-specific NSQS exceedance. Second, control-point classification was applied by grouping candidate controls according to the primary point of action; source, path, or receiver consistent with established noise-control principles that prioritize source reduction where feasible, followed by interruption of transmission pathways and, lastly, protection of exposed individuals (National Institute for Occupational Safety and Health [NIOSH], 1998). Third, context-feasibility screening was used to retain only those measures considered practically feasible for informal market settings, based on author judgment regarding governance suitability, likely resource needs, and minimal disruption to trade flow. In this study, Home Science-based mitigation options refers to interventions that fall within the practical scope of Home Science/Home Economics, particularly improvement of everyday living environments through material use, household- and community-scale environmental modification, and health education for behavior change. Accordingly, the Home Science-based options in Table 2 were limited to feasible stall or user-level measures such as textile-based sound-absorbing materials, layout-sensitive micro-environment improvement, and awareness-oriented protective practices, rather than major civil or engineering reconstruction (International Federation for Home Economics [IFHE], 2008).

Results and Discussion

Table 1 summarizes hourly equivalent levels (LAeq,1h) and percentile descriptors (L10, L50, L90) by market and operational period (n=7 days per cell). Morning LAeq,1h was high and nearly identical at Kalimati and Balkhu (76.59 ± 1.14 and 76.63 ± 0.76 dB(A), respectively), with modest day-to-day variability. Midday LAeq,1h differentiated the sites: Kalimati remained elevated (67.35 ± 0.93dB(A)), whereas Balkhu dropped to 60.14 ± 1.34dB(A). Evening LAeq,1h again rose in both markets (71.53 ± 0.89dB(A) in Kalimati; 70.20 ± 0.69dB(A) in Balkhu).

Table 1. *Hourly equivalent noise levels and percentile indices by market and operational period (1-h session per day per period; n = 7 day-level observations per cell))*

Market	Period	LAeq,1h mean ± SD (dB(A))	Min–Max (dB(A))	L10 mean (dB(A))	L50 mean (dB(A))	L90 mean (dB(A))
Kalimati	Morning	76.59 ± 1.14	75.04–78.62	79.99	75.23	71.07
Kalimati	Midday	67.35 ± 0.93	66.22–69.04	70.40	66.79	62.23
Kalimati	Evening	71.53 ± 0.89	70.49–72.50	74.20	70.70	67.60
Balkhu	Morning	76.63 ± 0.76	75.63–77.62	79.33	75.83	71.71
Balkhu	Midday	60.14 ± 1.34	57.36–61.45	63.50	58.71	54.84
Balkhu	Evening	70.20 ± 0.69	69.12–71.04	72.79	69.57	66.69

Both marketplaces had highest noise level during the early morning time, whereas there was clear distinction between both locations around midday. Although the overall soundscape level remained high in Kalimati during the specified period, the relatively low noise during the midday hours in Balkhu implies that the activities in the market place dropped for a short while. Wholesale transactions involving arrival and departure of goods occur in earlier morning, so, the noise spike during early mornings that supports wholesale market functions (Japan International Cooperation Agency, 2001). According to studies on traffic noise, vehicles, varying speeds, and honking can result in a noise spike in busy urban cities (Vijay et al., 2015). However, due to the failure to incorporate traffic volume, the act of honking, and the act of loading, any conclusions that are made concerning the source are valid interpretations and not source identifications

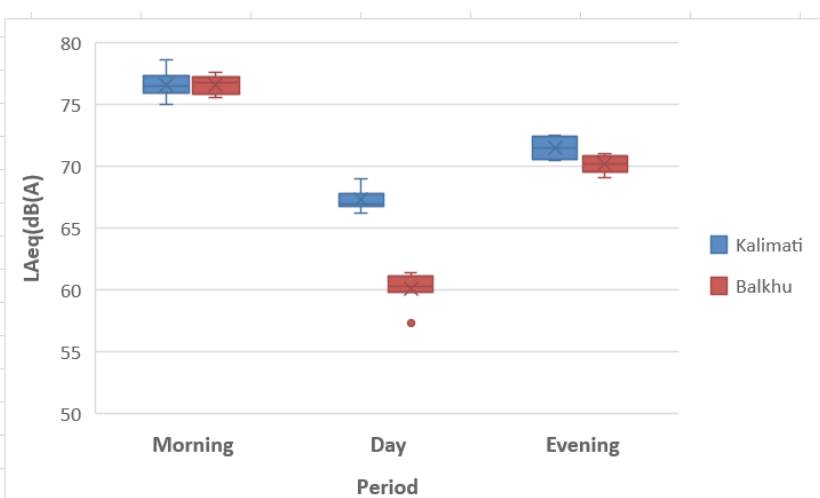

Figure 2. *Distributions of day-level LAeq,1h by market and period (n = 7 day-level observations per cell)*

Using the NSQS daytime commercial guideline of 65 dB(A), on each day, Kalimati exceeded the benchmark in all monitored periods (morning, midday, and evening: 100%). Balkhu exceeded 65 dB(A) on all monitored days in the morning and evening but recorded 0% exceedance at midday as all seven midday LAeq, 1h values were below 65 dB(A) (Figure 3).

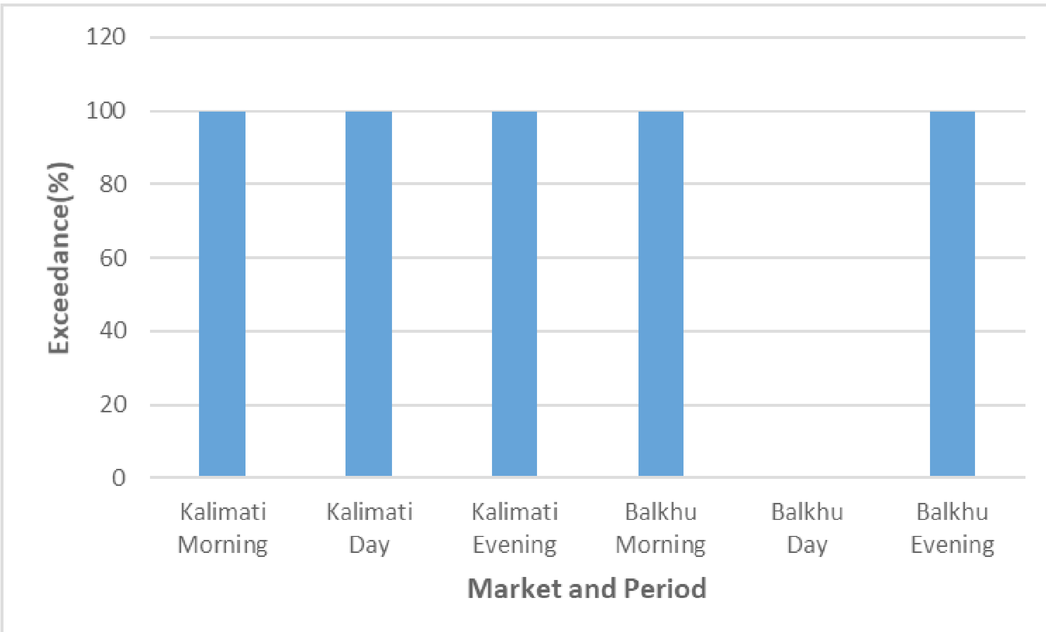

Figure 3. *Proportion of monitored days exceeding 65 dB(A) (NSQS daytime commercial guideline) by market and period.*

Welch's t tests on day-level LAeq,1h indicated negligible between-market difference in the morning (mean difference = -0.04 dB(A), 95% CI [-1.19, 1.11], p = .94). At midday, Kalimati was louder than that of Balkhu (mean difference = 7.21 dB(A), 95% CI [5.85, 8.57], p < .001), corresponding to approx. 5.3 times higher sound energy. In the evening, Kalimati's noise is slightly higher than Balkhu (mean difference = 1.33 dB(A), 95% CI [0.40, 2.26], p = .009).

Percentile provide the complementary insight of temporal structure of the market sound level. In both market, morning L10 was around 79-80 dB (A), while morning L90 was around 71-72 dB (A) indicating repeated loud occurrences with a high background noise level. The midday contrast was pronounced: Balkhu showed a markedly lower median (L50 = 58.71 dB(A)) and background (L90 = 54.84 dB(A)) than Kalimati (L50 = 66.79 dB(A); L90 = 62.23 dB(A)). Again in the evening, in both market noise level is elevated (Table 1).

The difference between the L10 and L90 values ranged from 6.10 dB to 8.92 dB for each combination of the market periods (Figure 4). The higher values indicate more pronounced peak event such as horns, loud voices, loading and unloading of goods relative to the background noise (Can et al., 2008; Gilani & Mir, 2021).

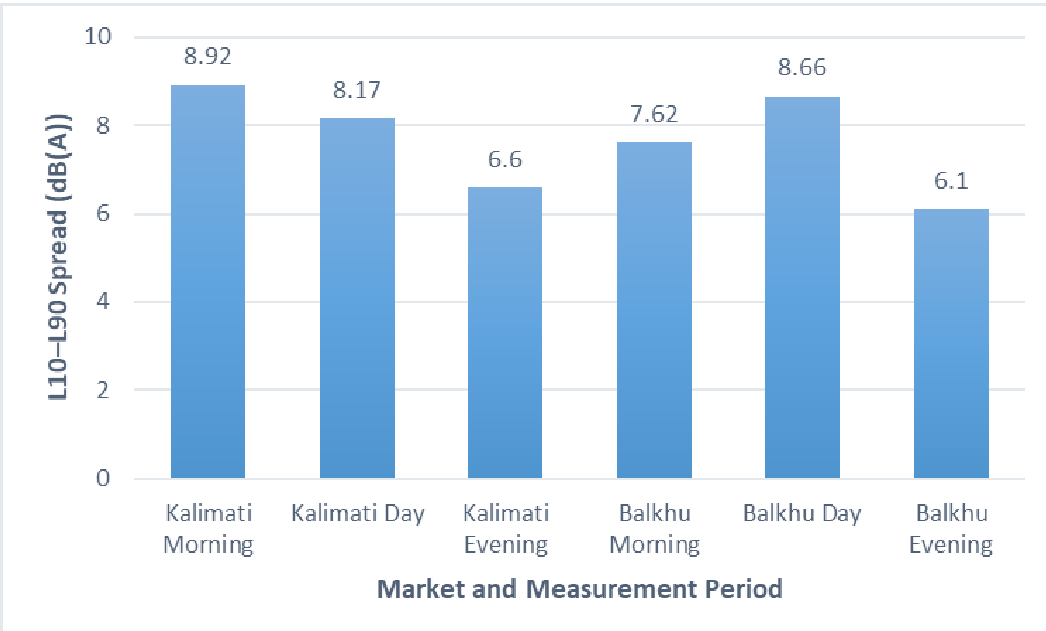

Figure 4. *Noise intermittency expressed as L10–L90 by market and period*

Consistent with event-based noise research, noise that contains many events can be found to be less pleasant compared to one that is constant and has a similar LAeq value but hampers communication, rest, or work (Wunderli et al., 2016; World Health Organization Regional Office for Europe, 2018).

Under the illustrative time activity pattern (3 h morning, 2 h midday, 3 h evening), mentioned above, the LEX,8h value estimated for Kalimati and Balkhu was 73.8 dB(A) and 73.3 dB(A), respectively. The previously mentioned calculation provides a value that is significantly less than both the industry's risk level for hearing loss and Nepal's acceptable workplace noise level (Center for Public Health and Environmental Development, 2023; National Institute for Occupational Safety and Health, 1998) but remain above the community noise guidance to minimize annoyance and sleep disturbance (Miedema & Oudshoorn, 2001; World Health Organization, 1999; World Health Organization Regional Office for Europe, 2018).

According to Babisch et al. (2005), Basner et al. (2014), Dratva et al. (2011), Miedema & Oudshoorn (2001), Muzet (2007), the World Health Organization (1999), the World Health Organization Regional Office for Europe (2018), and other studies showed chronic exposure for high ambient noise level may contribute listening effort, reduce speech intelligibility, fatigue, and stress-mediated cardiometabolic risk (Babisch et al., 2005; Basner et al., 2014; Dratva et al., 2011; Münzel et al., 2014; Muzet, 2007). However, there is practical constraints for the enforcement and occupational health surveillance in market governamce in Nepal's informal economy (International Labour Organization, 2018). The observed exposure profile supports the relevance of a national safe work environment (Government of Nepal, 2017). Prohibition of horn usage and stop and go vehicle movement activities may reduce the peak noise events whereas background noise can be reduced by improved circulation and clearer separation of loading areas from dense pedestrian zones. This aligns with noise control principles of sources, path, and receivers, and operational transport measure outlined by the National Institute for Occupational Safety and Health (1998) and Brown & Van Kamp (2017).

Traffic scheduling, dedicated loading areas, and improved internal circulation may reduce congestion near the market entrance and loading point that help in reduction the noise level (Alho et al., 2018; Dalla Chiara & Cheah, 2017; Fransoo et al., 2022). Horn use during the congestion may cause the noise, so avoiding horn during congestion can reduce the peak noise events (Kalaiselvi & Ramachandraiah, 2016; Nguyen et al., 2025; Vijay et al., 2015). Utilizing permeable textiles, natural fiber panels, curtains, or baffles made from upcycled materials may be useful to reduce the noise, provided they do not compromise ventilation or create fire and hygiene hazards (Allard & Atalla, 2009; Asdrubali et al., 2012; Cox & d'Antonio, 2016). The observed sound profiles points two priority control i.e peak noise event as well as persistent background noise especially in morning and evening period on both market and also in midday at Kalimati. These findings informed the mitigation matrix in Table 2.

Table 2. *Evidence-informed mitigation matrix for wholesale market noise, including Home Science-informed options (decision-support tool; not an evaluated intervention package).*

Intervention (example)	Primary control level (source/path/ receiver)	Home Science contribution	Lead implementer(s)	Indicative cost and implementation notes
No-horn rule (signage and enforcement)	Source	Culturally legible messaging for drivers and vendors; risk-communication materials	Municipality; traffic police; market committee	Low. Focus enforcement on peak windows; pair penalties with awareness campaigns and driver engagement (Chauhan et al., 2021; Nguyen et al., 2025).
Staggered deliveries and dedicated loading bays	Source + path	Layout planning to separate unloading from high-occupancy zones	Market management; transport unions	Low-medium. Reduces stop-and-go movement and horn use; requires coordination and space allocation (Dalla Chiara & Cheah, 2017; Kalaiselvi & Ramachandraiah, 2016).
One-way vehicle circulation inside market lanes	Source + path	Low-cost wayfinding and lane-marking design; pedestrian–cart separation	Municipality; market management	Low-medium. Feasible in narrow lanes but requires consistent wayfinding and compliance monitoring (Karimi et al., 2022; Kalaiselvi & Ramachandraiah, 2016)
Stall-level natural-fiber curtains or canopies (e.g., jute/cotton composites)	Path	Selection of porous textiles, patterning, and maintenance guidance; local production	Vendor cooperatives; Home Science units; market committee	Low-medium. Absorbs mid/high-frequency noise in semi-enclosed stalls; avoid blocking ventilation; ensure fire safety (Allard & Atalla, 2009; Asdrubali et al., 2012).
Acoustic wall hangings or ceiling baffles using upcycled textiles	Path	Upcycled textile design; cleaning protocols; basic acoustic placement guidance	Market committee; local artisans	Medium. Best suited for covered/ reverberant sections; requires secure mounting and periodic cleaning (Cox & D'Antonio, 2016).
Vendor training on hearing risk, communication strategies, and short "quiet breaks"	Receiver	Tailored health education modules integrated into market routines	Public health offices; NGOs; university units	Low. Reinforces adoption of other controls and improves self-protection practices (World Health Organization, 2021).
Provision of reusable earplugs during peak tasks (with fit training)	Receiver	User training for comfort and correct use; hygiene guidance	Market committee; NGOs	Low-medium. Useful during short high-exposure tasks; acceptance depends on comfort and communication needs (National Institute for Occupational Safety and Health, 1998).

Limitations

This study employed 1-hour sessions rather than the continuous 24-hour on a single representative measurement position within each market. Therefore, the results interpreted as a temporal screening profile than a comprehensive sound map. A delicate field calibrator was unavailable; so, the study based on recent factory calibration. Future research should consider long monitoring periods, multiple sampling points and also record the source activity such as vehicle counts and horn-event logging, to better identify noise drivers and evaluate the effectiveness of interventions.

Conclusions

Kalimati and Balkhu wholesale market were consistently noisy during all the seven monitoring days. Kalimati exceeded the NSQS daytime commercial guideline in all monitored period while Balkhu exceed NSQS daytime commercial guideline in morning and evening only. The illustrative LEX, 8h estimates (73-74 dB(A)) remained below the industrial hearing damage thresholds but above the community noise guidance value which may affect comfort, communication and overall environmental quality. Overall, the finding suggests that both wholesale market has the persistent noise concern. Therefore, mitigation measures should be framed as practical recommendation, not as a proven innervation, because the study documented noise patterns rather than testing control measure.

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