The Impact of the Absence of Organized Rest and Service Areas (RSA) on Highway Safety and Mobility in Nigeria: A Review

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ABSTRACT

Rest and Service Areas (RSAs) are a critical component of modern highway systems, designed to mitigate driver fatigue, provide emergency support, and enhance both traffic flow and logistics efficiency. In Nigeria, where road transport dominates passenger and freight movements, the systematic development of RSAs remains extremely limited. Consequently, motorists and freight operators depend on informal roadside stops that often lack safety, sanitation, and parking infrastructure, thereby increasing vulnerability to fatigue related crashes and operational inefficiencies. This study examines the implications of the absence of organized RSAs on Nigeria's major transport corridors through an integrative literature review supported by empirical analysis of highway operations. It synthesizes global best practices on RSA typology, spacing, and facility standards, and adapts these to Nigeria's 80-100 km/h design speed corridors. Findings reveal that the scarcity of formal RSAs contributes to elevated fatigue risk, unsafe stopping behaviour, and diminished emergency response capacity. The paper proposes a context specific RSA classification system and design standards encompassing functional typologies, geometric criteria, and minimum service requirements. It further outlines actionable policy instruments such as Public-Private-Partnerships (PPP), regulatory integration within national road safety strategies, and spatial demand modelling to guide nationwide RSA implementation. If adopted, these measures are projected to significantly reduce fatigue related collisions, improve corridor reliability, and generate local socioeconomic and environmental benefits, thereby aligning Nigeria's highway network with global standards of safe and sustainable mobility.

Keywords: Driver Fatigue; Highway Safety; Mobility; Nigeria; Rest and Service Areas; Road Infrastructure

BACKGROUND

Globally, road infrastructure remains a critical enabler of socioeconomic growth and territorial integration. It provides the framework for mobility, trade, and access to essential services, forming a vital component of national development strategies (Armstrong, Aboah; Blessing, Agyei Kyem; Eugene, Kofi Okrah Denteh; Joshua, Kofi Asamoah; Kenneth, 2024). The quality and availability of supporting roadside facilities such as rest areas, fuel stations, and service points are essential determinants of road efficiency and user safety. As travelling by car continues to dominate global transport modes, modern highways require adequate rest and service areas to minimize fatigue related crashes, support long distance freight movement, and enhance overall travel experience (Kolodinskaja, and Bertulienė, 2020). Developed economies have institutionalized these facilities as integral parts of highway infrastructure planning, recognizing their contribution to improved road safety, mobility efficiency, and driver welfare.

In Europe and other advanced regions, highway rest and service areas (RSAs) are strategically integrated within transport corridors to ensure safe, comfortable, and efficient travel. For instance, road transport accounts for over 75% of passenger and freight movement across the European Union, necessitating the provision of organized RSAs at regular (Pérez-Acebo, Romo-Martín & Findley, 2022). These facilities not only mitigate fatigue related accidents but also stimulate local economies by creating commercial opportunities along transport routes. Similarly, in emerging economies, rest areas form part of comprehensive corridor management frameworks that enhance connectivity and logistics competitiveness. FTI Consulting (2024) emphasizes that well developed transport corridors are more than mere road networks they act as economic catalysts that drive urban growth, trade expansion, and regional integration.

However, many developing countries, including Nigeria, have not adequately incorporated organized rest and service areas into their highway development frameworks. Despite the recognized role of road transport as the backbone of national mobility systems, most intercity highways in Nigeria lack properly designed rest stops or driver support facilities. This gap undermines both safety and efficiency, as drivers often resort to informal roadside halts that pose security, health, and traffic risks. The Nigerian road transport system carries over 90% of the nation's passengers and freight Yero, Ahmed, and Hainin, (2015), yet suffers from inadequate ancillary infrastructure such as parking bays, weighbridges, and rest areas. Consequently, fatigue induced crashes, uncontrolled roadside trading, and congestion along major corridors remain persistent threats to road safety and operational performance.

In this context, assessing the impact of the absence of organized Rest and Service Areas (RSAs) on highway safety and mobility in Nigeria becomes crucial. The country's reliance on road transport, coupled with rapid population growth and increased freight activity, has intensified the strain on existing highway infrastructure (Afolayan, Easa, Abiola, Alayaki, & Folorunso, 2022; Elijah & Rabi Menmak, 2021). The lack of well-structured RSAs compromises driver welfare, traffic flow, and logistics efficiency, leading to safety hazards and economic losses. Therefore, this study aims to evaluate how the non-provision of organized rest and service areas affects safety outcomes and mobility patterns on Nigerian highways, providing evidence based insights for policy formulation and infrastructure planning.

METHODOLOGY

Research Design and Approach

This study adopted an integrative review design to synthesize multidisciplinary evidence on Rest and Service Areas (RSAs) and their implications for highway safety and mobility. The integrative review was selected because it enables the combination of diverse evidence types including empirical crash studies, engineering standards, behavioural research, and policy documents into a unified analytical framework. This approach aligns with Torraco's (2005) definition of integrative reviews as a method for generating new perspectives through the systematic integration of heterogeneous literature. The design also reflects the recommendations of Russell (2015), who emphasizes that integrative reviews are well suited for applied fields requiring cross-disciplinary understanding, and Hopia et al. (2016), who underscore the importance of methodological transparency and structured synthesis. In addition, the use of an integrative review draws from Snyder's (2019) argument that such reviews are essential when addressing contemporary and rapidly evolving policy problems, such as the lack of RSAs in developing-country highway systems.

Literature Search and Selection

The literature search followed a structured and transparent procedure consistent with integrative review standards. Searches were conducted across Scopus, Web of Science, ScienceDirect, PubMed, and Google Scholar, supported by official datasets from the Federal Road Safety Corps (FRSC) and the National Bureau of Statistics (NBS). Search queries included "rest area," "highway service area," "driver fatigue," "road safety facilities," "parking and rest stops," and "Nigeria road safety." Publications from 2010 to 2024 were prioritized to ensure contemporary relevance, although earlier foundational works were included where necessary for conceptual clarity. Studies were selected based on relevance to RSA design, spacing, behavioural implications, or safety outcomes, and preference was given to peer-reviewed articles, technical manuals, and government reports that demonstrated methodological rigour. In line with the guidance of Hopia et al. (2016) and Russell

(2015), documents with weak methodological transparency or insufficient relevance to RSA-related themes were excluded to maintain the credibility and analytic depth of the review.

Data Sources and Synthesis

The synthesis incorporated global empirical studies on fatigue-related crashes, international RSA design and spacing guidelines, and Nigeria-specific institutional reports and field observations. This diverse evidence base was analysed using an iterative and interpretive process consistent with Torraco's (2005) framework for integrative synthesis. Material was first examined to identify key thematic categories, including driver behaviour, traffic-flow dynamics, RSA infrastructure design, and policy frameworks. These themes were then compared across global and Nigerian contexts to identify areas of convergence and divergence, following the triangulation principles emphasized by Russell (2015). The synthesis proceeded by integrating these strands of evidence to infer how the absence of organized RSAs contributes to fatigue accumulation, risky stopping behaviour, traffic disruptions, and systemic inefficiencies. Snyder's (2019) emphasis on context-sensitive integration guided the analysis, ensuring that global best practices were interpreted in light of Nigeria's infrastructural and institutional realities.

Analytical Framework

The analysis was guided by a multi-level causal framework that connects RSA availability to safety and mobility outcomes at the driver, traffic-flow, and system levels. At the driver level, insufficient rest opportunities contribute to fatigue, microsleep, and impaired decision-making all established precursors of high-severity crashes. At the traffic-flow level, the absence of designated rest facilities encourages unsafe roadside stopping, abrupt speed changes, and lane-changing conflicts that degrade operational efficiency. At the system level, the lack of adequate RSA infrastructure diminishes emergency response capability, reduces corridor reliability, and limits the economic performance of major highways. This framework is consistent with the type of cross-scalar explanatory models encouraged in high-quality integrative reviews, as outlined by Torraco (2005) and reinforced by Snyder (2019), who highlights the need for multi-dimensional analytical grounding when synthesizing complex infrastructure challenges.

Limitations

This study relies primarily on secondary data, and although triangulated with FRSC and NBS institutional records, it did not incorporate large-scale field measurements, direct driver assessments, or pre/post RSA intervention data. As Hopia et al. (2016) emphasize, transparency about methodological constraints is essential in integrative reviews to contextualize the depth of inference. Thus, some conclusions necessarily rely on theory-driven interpretations and extrapolations from international evidence adapted to Nigerian conditions. Future work should incorporate empirical RSA pilot evaluations, behavioural fatigue monitoring, and traffic micro-simulation to validate and quantify the causal mechanisms proposed in this review, consistent with the future research directions encouraged by Snyder (2019) and Russell (2015).

LITERATURE REVIEW

Global Concept of Rest and Service Areas (RSAs)

Rest and Service Areas (RSAs) are purpose built roadside facilities that provide essential amenities such as restrooms, parking bays, dining services, fueling stations, and other traveler support services aimed at enhancing driver welfare and ensuring safe and efficient highway operations (Monh, Ahmad, Aminudin, Vighio, & Awang, 2025; Shrestha, 2023). Beyond offering convenience, RSAs function as integral safety interventions by redistributing stopping behavior from unsafe informal halts to designated, controlled locations where drivers can legally and safely rest, refuel, and access basic services. This deliberate design contributes to reducing the likelihood of unsafe roadside parking, particularly by freight vehicles, which can otherwise obstruct emergency lanes, reduce visibility, and increase collision risks (Budzyński & Cieśla, 2025). By incorporating predictable and regulated stopping points along transport corridors, RSAs promote consistent traffic flow, minimize unscheduled disruptions, and enhance the overall safety of both passenger and freight transport systems.

Global research and Point of Interest (POI) datasets have classified RSAs into four (4) major categories truck stops, fueling locations, general highway rest areas, and parking only zones each defined by its dominant service offerings and accessibility characteristics (Link & Plötz, 2024). Truck stops represent the most comprehensive facilities, providing refueling, truck specific maintenance services, showers, accommodations, and dining options accessible to the public. Fueling locations are primarily designed for refueling with limited supplementary services, while general rest areas typically offer parking spaces and basic amenities such as restaurants and restrooms but may lack truck specific services. Parking only locations, often situated near industrial or freight terminals primarily provide designated spaces for heavy vehicle parking with restricted access (Link & Plötz, 2024). These distinctions are crucial because the needs of long haul truck drivers (LHTDs) differ from those of short distance travelers, requiring that RSA design, capacity, and spacing align with driver work rest cycles and safety regulations (Lise, Garcia, Shattell & Kincl 2025). Where these facilities are absent or inadequate, drivers often resort to unsafe roadside halts, exposing themselves and other road users to heightened safety and health risks.

The absence or poor distribution of RSAs has been linked globally to increased fatigue related crashes and occupational health challenges among long distance drivers. Fatigue remains a major cause of road traffic crashes, as long monotonous drives diminish alertness and reaction time, making sleepiness a significant human factor in accidents (Ronen, OronGilad, & Gershon 2014). Studies estimate that between 10% and 20% of all truck and bus crashes in the United States involve fatigued drivers, with contributing factors including irregular work hours, medical conditions affecting sleep, and poor environmental conditions during night driving (Bunn, Slavova & Rock 2019). Long haul truck drivers, who constitute a significant portion of commercial freight operators, face particular vulnerability due to extended working hours and limited access to safe rest facilities, leading many to park on road shoulders or in unlit areas when formal rest areas are unavailable (Chen, Sieber, Collins, Hitchcock, Lincoln, Pratt, & Sweeney 202; Crizzle, Toxopeus & Malkin 2020; Lise et al., 2025). This unsafe practice elevates the risk of collisions, assaults, and health problems. Consequently, well developed RSAs play an indispensable role in safeguarding driver health, ensuring compliance with hours of service regulations, and improving overall corridor efficiency through controlled and predictable stopping behavior (Budzyński & Cieśla, 2025; Monh et al., 2025).

Importance of Rest and Service Areas (RSAs)

Rest and Service Areas (RSAs) play a crucial role in highway operations by providing safe and convenient locations for drivers to rest, refresh, and access basic services. They enhance safety, improve travel comfort, and support efficient traffic flow while also contributing to local economic development. The following sections outline the major importance of RSAs in terms of safety, comfort, and regional growth.

Crash risk reduction and fatigue mitigation

Properly sited and designed RSAs are a primary countermeasure against fatigue related crashes because they provide legally sanctioned, convenient stopping opportunities that align with driver work rest cycles and hours of service regimes. The literature demonstrates that RSAs reduce the incidence of driver fatigue by enabling both short restorative stops and longer mandated rests, thereby lowering physiological sleepiness and attentional failures that precipitate highway collisions (Bertulienė & JuknevičiūtėŽilinskienė, 2014; Ramli, Hassan, & Hainin, 2018). In limited access and toll motorway contexts where alternatives are costly or distant RSAs serve as the only practical mitigation against prolonged driving without rest, directly reducing the exposure window for fatigue induced human error (Pérez-Acebo & Romo-Martín, 2019). Thus, from a systems safety perspective, RSAs operate as distributed safety islands that interrupt monotony, reestablish alertness, and reduce the probability of high severity single vehicle and run off road events.

Traffic operations, shoulder use and network efficiency

RSAs improve corridor operational performance by absorbing parking demand that would otherwise manifest as unsafe shoulder or ramp stops, which obstruct emergency lanes and create speed differentials that increase conflict points. By providing dedicated parking capacity for both heavy and light vehicles, RSAs reduce illegal and unpredictable stopping behaviours that fragment traffic streams and degrade throughput and travel time reliability (Alkhatni, Ishak & Milad 2021; Bertulienė & Juknevičiūtė-Žilinskienė, 2014). Moreover, strategically

spaced RSAs mitigate diversion and excess travel time: road users no longer need to detour off high-speed corridors to find basic services, thereby preserving limited access roadway functionality and minimizing induced delay (Alkhatni et al., 2021; Pérez-Acebo & Romo-Martín, 2019). In sum, RSAs act as operational buffers that stabilize traffic flows and reduce micro disturbances that cascade into macroscopic congestion.

Occupational health, security and freight resilience

For long haul truck drivers and other professional drivers, RSAs serve dual occupational health and security functions: they enable compliance with rest regulations, provide sanitary and recuperative facilities, and decrease exposure to hazards associated with roadside sleeping or illicit parking (Guo, Zhou, Dong, Li, Xiao and Li 2025; Lise et al., 2025). Safe parking locations at RSAs also reduce freight theft and personal security threats outcomes linked to reduced cargo loss, fewer driver incidents, and improved continuity of logistics operations (Bertulienė & Juknevičiūtė-Žilinskienė, 2014). By ensuring drivers can reliably access rest and services without seeking insecure alternatives, RSAs improve workforce wellbeing and reduce occupational injury risk, thereby strengthening supply chain resilience in corridors dominated by road freight.

Service quality, user comfort and behavioural inducement

High-quality RSAs deliver a service bundle (sanitation, food, information, driver facilities) that not only meets immediate physiological needs but also provides behavioural incentives for drivers to take restorative breaks. Efficient layouts, sanitary amenities, and ancillary services increase the perceived utility of stopping, converting an otherwise marginal choice into the preferred safety behaviour (Kolodinskaja & Bertulienė, 2020; Pérez-Acebo & Romo-Martín, 2019). Because many fatigue reduction strategies rely on driver compliance, the behavioural economics of RSAs is critical: the more comfortable, accessible and predictable the facility, the higher the uptake of safe stopping practices, which cascades into measurable reductions in crash exposure and improved public perceptions of corridor safety.

Socioeconomic multipliers and regional development

Beyond immediate safety and operational benefits, RSAs generate positive externalities for local economies. Facilities integrated with local value chains mich-in-oeki style service stations, tourist information points, and marketplaces stimulate microenterprise, capture tourist spending, and create platforms for local advertising and product distribution (Bertulienė & Juknevičiūtė-Žilinskienė, 2014; Yunusa, 2015). On toll roads in particular, RSAs can be deliberate regional development instruments: they provide sustained commercial demand that supports employment, diversifies rural incomes, and contributes to sustainable socioeconomic upliftment of host communities (Parbowo, Suwaryo, Mulyawan, Yuningsih, Kusnianti & Cahyadi, 2023; Pérez-Acebo & Romo-Martín, 2019). Consequently, RSA planning should be viewed as a transportled development tool that aligns mobility goals with regional economic policy.

Emergency staging, information provision and network resilience

RSAs function as prepositioned staging points for emergency response, traveler information dissemination, and short term shelter during adverse events. By offering safe pullover spaces and communication interfaces, RSAs reduce secondary crash risk during incidents and provide controlled locations for traffic management interventions (Alkhatni et al., 2021; Guo et al., 2025). The presence of RSAs therefore augments network resilience: they enable more efficient incident clearance, quicker medical access for impaired drivers, and a reliable node for disseminating real time travel advisories capabilities that are particularly valuable on rural stretches and long intercity links where alternative services are sparse.

CURRENT SITUATION AND CONTEXT OF REST AND SERVICE AREAS (RSAS) IN NIGERIA

Nigeria's highways operate under high freight and passenger loads amid growing travel distances and persistent deficiencies in ancillary infrastructure. The provision of formal Rest and Service Areas (RSAs) facilities that mitigate driver fatigue, supply sanitary and safety services, and stabilize corridor operations is largely inadequate

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or absent across many intercity corridors. Consequently, informal and privately operated roadside stops and restaurants have proliferated, producing a fragmented roadside service landscape that neither meets safety standards nor supports predictable traffic operations (See Figures 1). The subsections below synthesize the empirical observations and policy relevant shortcomings documented in the Nigerian context and identify the precise gap this study addresses.

Figure 1: Vehicles parked at Informal Rest and Service Area along Highway in Nigeria

Prevalence of Fatigue Related Crashes and the Safety Imperative

Driver fatigue is a dominant contributor to Nigeria's road crash burden and is especially acute among long haul and commercial drivers whose schedules and working conditions elevate physiological sleepiness and cognitive lapses (Obiadi, Mbadugha, & Aniegbuna, 2024). National and comparative evidence indicates that fatigue related collisions are disproportionately likely to produce severe injuries and fatalities; in Nigeria this pattern is compounded by long travel distances, irregular enforcement of hours of service, and limited access to safe resting nodes (Obiadi et al., 2024; Kikanme, Obiadi, Enete & Kikanme 2024). This safety imperative underpins the technical rationale for strategically located RSAs as an engineering, operational, and regulatory countermeasure to reduce exposure to fatigue induced crashes.

Proliferation of Informal Stops and Roadside Hazards

In the absence of structured RSAs, roadside economies have organically filled the service vacuum: food vendors, ad-hoc accommodation, and fuel/service stations have become de-facto rest stops located at village edges and highway margins (Yunusa, 2015). These on road parking spots are frequently unplanned, lack safe ingress/egress geometry, and produce environmental disorder, pedestrian vehicle conflicts, and unpredictable stopping behaviour that magnify crash risk (Yunusa, 2015). Observational assessments document overcrowding during peak periods, insufficient parking capacity, and vehicle layouts that encroach on running lanes and emergency shoulders operational failures that RSAs are designed to prevent.

Service Quality Failures: Sanitation, Security, and User Experience

Field evidence highlights systemic shortfalls in service quality at existing informal stops: poor restroom hygiene, inadequate seating and shaded areas, insufficient sanitary maintenance, and low levels of lighting and surveillance (Obiadi et al., 2024). These deficits degrade the restorative value of stops, reduce drivers' willingness to use them, and increase the propensity for risky behaviour such as shoulder parking or extended roadside halts. Moreover, inadequate security infrastructure at many stops increases drivers' exposure to theft and personal harm, undermining both occupational safety and the attractiveness of stopping behaviours that

would otherwise improve alertness (Obiadi et al., 2024).

Institutional Fragmentation and Governance Shortfalls

Although multiple agencies nominally supervise roads planning, maintenance, and safety (e.g., road authorities, vehicle inspection bodies, traffic enforcement agencies), institutional fragmentation and weak enforcement have hindered coordinated RSA planning and operations (Yunusa, 2015). The absence of clear mandates, design standards, and funding mechanisms for RSAs means that roadside service provision remains largely ad hoc and market driven rather than integrated into corridor design and safety management frameworks. This governance vacuum limits the ability of authorities to ensure adequate spacing, capacity, and service mixes aligned with driver work–rest cycles and regulatory standards.

Implications for Highway Safety and Mobility

The continued absence of organized RSAs along Nigerian highways has direct and cascading implications for driver fatigue, roadside safety, and traffic operations. Without purpose built facilities, drivers are compelled to rest in unsafe and unregulated spaces, exacerbating fatigue related crashes and operational inefficiencies. The problem extends beyond safety to broader issues of corridor performance, public health, and economic vitality. This study therefore seeks to fill the critical knowledge and policy gap by empirically assessing how the lack of RSAs undermines highway safety, reduces mobility efficiency, and weakens the resilience of Nigeria's transport infrastructure (Ayeni & Iyeke, 2024; Obiadi et al., 2024; Yunusa, 2015).

Identified Gaps and Research Significance

Collectively, the Nigerian evidence base reveals two interrelated gaps. First, there is a quantitative and qualitative deficiency in the supply of organized RSAs that are designed, sited, and managed to meet safety, parking capacity, and occupational health needs (Obiadi et al., 2024; Yunusa, 2015). Second, existing informal facilities suffer systemic quality and governance failures sanitation, security, and capacity shortfalls that negate their potential safety benefits (Obiadi et al., 2024; Kikanme et al., 2024). The significance of this study lies in establishing an evidence based understanding of how these deficiencies translate into measurable safety and mobility challenges, while illuminating the missed opportunities for socioeconomic and environmental improvement along Nigeria's major transport corridors (Ayeni & Iyeke, 2024).

PLANNING AND DESIGN CONSIDERATIONS FOR RSA DEVELOPMENT

High-speed limited access highways inherently induce driver fatigue, reduced attention and recognition ability due to monotonous geometry and long travel segments (Jung, Joo, & Oh, 2017). Thus, the planning and design of Rest and Service Areas (RSAs) must be approached as an integrated safety, traffic operation and infrastructure strategy specifying spacing, layout, service mix, accessibility, vehicle parking capacity, and user comfort as interdependent parameters as reflect in Figure 2.

Figure 2: Aerial photo of the De Lucht Rest Area along the A2 Holland: Source: Dennis, (2019)

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Site Selection, Spacing and Functional Classification

Effective RSA planning begins with strategic site selection and functional classification. According to Bertulienė and Juknevičiūtė-Žilinskienė (2014), RSAs should be divided into categories with services and without services, with spacing guided by vehicle rest need and traffic volume. They recommend that larger rest areas with full services may be spaced approximately 5060 km (or up to 80 km in low volume corridors) while simpler rest zones without full services may occur every 1520 km (exceptionally 25 km) (Bertulienė & Juknevičiūtė-Žilinskienė 2014; Kolodinskaja & Bertulienė, 2020). Furthermore, Alkhatni et al., (2021) emphasize that planning must account for demand of parking lots, heavy vehicle rest needs, sanitary facilities, safe access at high speed, and unimpeded parking and pedestrian movement. (See Figure 3)

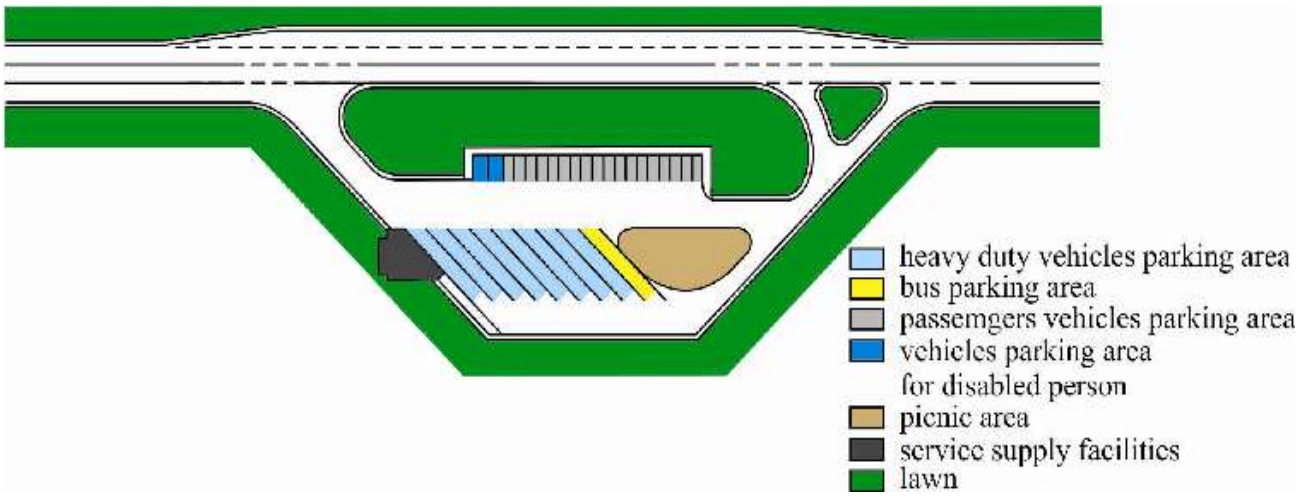

Figure 3: Expected Facilities within RSA Source: Bertulienė & Juknevičiūtė-Žilinskienė 2014

Geometric and Traffic Operation Design Criteria

A robust RSA must integrate geometric and operational design: adequate deceleration and acceleration lanes, safe ingress/egress, separation of heavy and light vehicle parking, clear signage and traffic control within the site. Jung et al. (2017) categorize freeway rest areas (regular, truck specific, simplified, supplemental) and their study of Korean expressways demonstrates that smaller "supplemental" rest areas can significantly reduce fatigue related crashes when properly spaced (Jung et al., 2017). Moreover, crash and simulation research indicates that deceleration lanes of 240260 m and acceleration lanes of 385400 m led to improved safety for high-speed RSAs. (While the latter study is not one of your original citations, the reference indicates the level of detail required.) Hence for Nigeria, design guidance should adapt similar geometric lengths adjusted for design speed and traffic composition.

Parking Capacity, Service Mix and User Comfort

The planning must accommodate both passenger vehicles and heavy-duty trucks (HDTs). Bertulienė & Juknevičiūtė-Žilinskienė (2014) propose that rest area construction be divided into functional zones: car parking, heavy duty vehicle parking, holiday/visitor zone, service facilities zone and green plantation zone (Bertulienė & Juknevičiūtė-Žilinskienė 2014). Complementing this, Alkhatni et al. (2021) describe that major benefits of rest areas include comfort and convenience amenities such as drinking fountains, bathrooms, vending machines, parking for heavy and light vehicles, communication and entertainment services (Alkhatni et al., 2021). These service mix decisions influence driver behaviour, uptake of safe stops and ultimately safety outcomes.

Environmental, Maintenance and Governance Considerations

The planning process must integrate environmental protection, landscape preservation, cost efficiency in investment, operation and maintenance (Bertulienė & JuknevičiūtėŽilinskienė, 2014). The choice of site must minimize adverse impact on nature and landscape, while ensuring safe and comfortable surroundings for users. Governance mechanisms should include maintenance standards, surfacing, lighting and security infrastructure.

Alkhatni et al. (2021) emphasize that availability of safe parking and accessible facilities strongly influences driver willingness to stop, which is critical for fatigue mitigation.

Adaptation to Nigerian Context: Standards and Specification Framework

Applying these global standards to Nigeria requires context sensitive adaptation: estimating required spacing based on Nigerian design speeds, freight/truck volumes, driver rest behaviour profiles; specifying deceleration/acceleration lengths suited to Nigerian heavy vehicle performance; determining heavy duty truck parking bays per traffic, calibrating service mix (sanitary, food, vending) per demand; and embedding governance models for maintenance, security and revenue sustainability. In sum, a specification framework for Nigeria could propose: (a) rest areas with full services every 60 km on major corridors, (b) lighter rest zones every 20-30 km, (c) separate truck parking bays sized per heavy vehicle volumes, (d) deceleration/acceleration lanes adapted to 100-120 km/h design speed, (e) 24/7 sanitary and security staffing, (f) signage from 2 km and 1 km to the facility as recommended by best practice (Kolodinskaja & Bertulienė, 2020). This tailored framework addresses identified gaps and aligns with safety, mobility and occupational health objectives on Nigeria's highways.

ANALYTICAL TABLES FOR RSA PLANNING AND DESIGN

This section presents analytical tables developed to guide the systematic planning and design of Rest and Service Areas (RSAs) on Nigerian highways. The tables consolidate technical parameters derived from international standards, empirical estimates, and functional requirements discussed in earlier sections. They provide a structured framework for determining optimal parking capacity, spacing intervals, facility typologies, and service level classifications. These tables are intended to support planners, engineers, and policymakers in translating conceptual RSA models into implementable design standards suited to Nigeria's highway conditions and projected traffic demand.

Table 1 RSA Typology, Spacing and Minimum Functional Offer (Nigeria adapted)

RSA Type (functional class)	Typical role / users	Recommended spacing (on major corridors)	Minimum functional offer
Full service RSA (Type A)	Long-haul freight, intercity coaches, tourists	50-70 km between Type A sites on trunk corridors (proposed; adapted from Bertulienė & Juknevičiūtė-Žilinskienė, 2014)	Fuel, restrooms, ≥10 HDT bays, driver shower/amenities, food outlet, basic maintenance/tyre, parking for cars, 24/7 lighting & security.
Intermediate RSA (Type B)	Mixed users (HDT + private cars)	25-40 km (proposed; aligns with literature recommending smaller rest zones between larger ones)	Restrooms, ≥6 HDT bays, parking for cars, vending/food kiosk, information board, sanitary maintenance.
Simple rest layby / stop (Type C)	Short restorative stops for motorists	10-20 km (or near nodes of local demand) (Bertulienė & Juknevičiūtė-Žilinskienė, 2014)	Short stay parking, toilets, shaded seating, signage from approach.
Truckonly staging/parking (Type D)	Overnight truck parking for compliance with hours of service	Provided at major nodes/junctions and near Type A RSAs; frequency by demand analysis	Dedicated HDT bays, lighting, guarded perimeter, toilet & waste disposal. (Alkhatni et al., 2021)

Sources: Bertulienė & Juknevičiūtė-Žilinskienė (2014); Alkhatni et al. (2021).

Table 1 outlines a Nigeria adapted typology and spatial hierarchy for Rest and Service Areas (RSAs), integrating international benchmarks with local transport realities. The four RSA classes (Types AD) reflect a graded system that supports differentiated highway users ranging from long haul freight operators and intercity passengers to local motorists. Type A (Full service RSA) represents the highest functional level, strategically spaced every 5070 km to provide comprehensive amenities such as fuel, rest, food, and heavy duty truck (HDT) facilities, ensuring driver welfare and compliance with rest hour regulations on trunk corridors. Type B and Type C RSAs fill intermediate and shortstop roles, respectively, offering essential services at shorter intervals (2540 km and

1020 km) to mitigate fatigue and maintain safety continuity along corridors. Type D facilities serve as truck only staging points for overnight parking and regulatory compliance, addressing Nigeria's recurrent roadside truck encroachment and accident risks.

The typology's significance lies in providing a structured framework for RSA planning and policy formulation within Nigeria's federal highway network. By adapting spacing standards from European models (Bertulienė & Juknevičiūtė-Žilinskienė, 2014) and operational provisions from Saudi highway systems (Alkhatni et al., 2021), it ensures functionality tailored to Nigeria's traffic mix, freight intensity, and informal roadside dynamics. Establishing this classification supports more rational RSA investment prioritization, improves highway safety through reduced fatigue related crashes, and enhances corridor level mobility efficiency critical for trade and logistics performance.

Table 2 Geometric & traffic operation minimums (Design speed: 80–100 km/h corridor)

Design element	Minimum / recommended value (Nigeria adapted)	Basis / notes
Advance signage	2 km and 1 km advance signs to RSA (approach)	Recommended by best practice; increases predictability and safe deceleration. (Kolodinskaja & Bertulienė, 2020)
Deceleration lane length	200-26 m (proposed range; select by design speed & heavy vehicle mix)	Source literature emphasizes need for safe ingress; exact length to be calibrated with local speed and heavyvehicle braking performance. (Jung, Joo, & Oh, 2017 concept of geometric accommodation)
Acceleration lane length	180-380 m (proposed range; depending on grade and vehicle mix)	Acceleration lane must allow safe reentry to high speed flow; use conservative values where heavy trucks dominate.
Minimum internal carriageway width (HDT circulation)	6.0-7.5 m for truck circulation lanes; car lanes 3.0-3.5 m	Ensure unhindered manoeuvre and separation of flows. (Bertulienė & Juknevičiūtė-Žilinskienė, 2014)
HDT bay length (single bay)	15-18 m per HDT bay (proposed)	To accommodate articulated rigs and allow off tracking.
Clear delineation / internal signage	Legible markings and direction indicators; segregated pedestrian paths	Emphasized as essential for safe traffic organization. (Bertulienė & Juknevičiūtė-Žilinskienė, 2014)

Source: Jung et al. (2017) Kolodinskaja & Bertulienė (2020)

Table 2 presents proposed geometric and traffic operation standards for Rest and Service Areas (RSAs) along Nigerian highways designed for speeds between 80 and 100 km/h the upper limit permitted under national traffic regulations. The parameters adapt international geometric guidelines to local traffic realities, ensuring that vehicle ingress, circulation, and egress within RSAs occur safely without disrupting through traffic flow. The advance signage distances (2 km and 1 km) align with global best practices for advance driver awareness, improving predictability and safe deceleration for approaching vehicles. Deceleration and acceleration lane lengths (200260 m and 180380 m, respectively) are designed to accommodate the braking and acceleration performance of heavy duty trucks (HDTs), which dominate long distance corridors in Nigeria.

Similarly, the proposed internal carriageway and HDT bay dimensions reflect the geometric needs of articulated vehicles common on freight routes. The specification of 6.07.5 m truck circulation lanes and 1518 m HDT bay lengths ensures adequate maneuverability and minimizes collision risks during entry or parking. Proper delineation and pedestrian segregation, supported by internal signage, further enhance the safe coexistence of mixed users within RSAs.

The significance of these standards lies in their potential to guide the geometric design and safety engineering of RSAs within Nigeria's federal road network, bridging the gap between existing roadside stops and international service area benchmarks. By calibrating geometric elements to Nigeria's legal speed limit (100 km/h) and traffic composition, the table offers a technical framework for highway designers, concessionaires,

and regulatory agencies to implement safer, more functional rest facilities that reduce fatigue related crashes and improve freight logistics efficiency.

Table 3. Parking Capacity Estimation Method and Sample Calculation for Heavy Duty Truck (HDT) Bays

Parameter / Step	Description	Illustrative Value (Type A RSA)	Notes
Formula	Required HDT bays = (Peak hourly HDT arrivals × Average dwell time [hours]) ÷ (Peak hour occupancy factor) × Safety factor	-	Formula derived from Alkhatni et al. (2021) and Bertulienė & Juknevičiūtė-Žilinskienė (2014).
Peak hourly HDT arrivals	Observed or modeled number of HDTs arriving during peak hour (vehicles/hour)	12 HDT/hr	Determined through traffic count or model.
Average dwell time	Typical stop duration for that RSA type (hours)	1.5 hr	Varies: 0.5 hr for short stops, 8 hr for overnight.
Peak hour occupancy factor	Proportion of total bays available for rotation (0.7–0.9)	0.8	Reflects parking turnover rate.
Safety factor	Factor allowing additional capacity for surges (1.2–1.5)	1.25	Ensures spare capacity at peak demand.
Computation	(12 × 1.5) ÷ 0.8 × 1.25 = 22.5 × 1.25 = 28 bays	28 bays	Rounded to nearest whole bay.
Interpretation	For the illustrative inputs, approximately 28 HDT bays should be planned at peak nodes. This method enables demandresponsive RSA design.	-	Supports dynamic rather than fixed spacing design.

Source: Adapted from Alkhatni et al. (2021) and Bertulienė & Juknevičiūtė-Žilinskienė (2014).

Table 3 presents a practical, formula based approach for estimating the required number of Heavy Duty Truck (HDT) parking bays within Rest and Service Areas (RSAs). The model integrates observed or modeled peak hourly arrivals, average dwell time, occupancy factor, and a safety margin to account for traffic surges. In the illustrative case for a Type A (full service) RSA, the computation results in approximately 28 HDT bays, reflecting realistic parking needs based on actual operational dynamics rather than arbitrary allocation.

This estimation framework is significant because it provides a data driven and scalable method for RSA capacity planning in Nigeria. It enables highway designers and planners to tailor parking provisions to corridor specific freight patterns, particularly where long haul truck volumes fluctuate with time of day or season. By adopting this method, planners can reduce illegal roadside parking, enhance safety, and ensure compliance with rest hour regulations for heavy vehicle drivers. The approach thus strengthens the rational and evidence based design of RSAs within Nigeria's developing highway infrastructure system.

Table 4 Minimum service & facility checklist (operational requirements)

Service category	**Minimum standard for Type A (full service)**	**Type B (intermediate)**	**Type C (simple)**
Sanitary facilities	Clean toilets with hand washing; 24/7 cleaning roster	Toilets + scheduled cleaning	Portable or simple toilets
Lighting & security	24/7 perimeter lighting; CCTV; guarded hours	Lighting; CCTV recommended	Basic lighting; periodic patrols

Waste management	Bins, sewage connection or septic, scheduled removal	Bins + scheduled removal	Bins, routine emptying
Water supply	Mains or borehole + safe drinking water	Mains or tanker supply	Drinking water point
Food & vending	Restaurant / canteen + kiosks	Food kiosk / vending	Vending machine
Driver comfort	Shower + rest room (Type A); seating and shaded areas (B/C)	Seating, shaded area	Bench seating, shade
Information	Travel and emergency info boards; mobile network coverage	Info board	Directional signage

Sources: Alkhatni et al. (2021); Bertulienė & Juknevičiūtė-Žilinskienė (2014); Pérez-Acebo & Romo-Martín (2019)

Table 4 outlines the minimum operational and service standards expected across the three functional classes of Rest and Service Areas (RSAs), ranging from full service (Type A) to simple laybys (Type C). It establishes a tiered framework that aligns facility provision with the intensity of use and user needs. Type A RSAs are designed for long haul drivers and intercity passengers, thus requiring comprehensive amenities such as 24hour sanitation, security, water supply, food services, and driver comfort facilities. Type B RSAs serve mixed traffic and offer intermediate facilities, while Type C sites provide only essential shortstop utilities such as toilets, basic lighting, and shaded seating.

The significance of this table lies in its practical contribution to standardizing RSA service quality and operational safety in Nigeria. By defining minimum service thresholds, it provides a benchmark for infrastructure concessionaires, state transport agencies, and private operators to maintain consistent user welfare and environmental hygiene across corridors. Implementing these minimum standards can substantially improve travel experience, reduce fatigue related crashes, and promote cleaner, safer, and more inclusive roadside environments. This structured framework, adapted from international best practices (Alkhatni et al., 2021; Bertulienė & Juknevičiūtė-Žilinskienė, 2014; Pérez-Acebo & RomoMartín, 2019), supports the transition toward sustainable, safety oriented highway management within Nigeria's transport system.

POLICY RECOMMENDATIONS

Based on the synthesis of empirical findings, international benchmarks, and Nigeria's current RSA deficiencies, the following policy recommendations are proposed to establish a structured, safe, and sustainable RSA network nationwide:

i. **Establish a National RSA Policy and Design Standards**:
The Federal Government, through the Federal Ministry of Works and Housing, should develop and promulgate a comprehensive National RSA Policy that specifies design speed based spacing, functional classifications, geometric layouts, minimum service levels, and environmental safeguards. These standards should be integrated into the Nigerian Highway Design Manual and reflected in all new and rehabilitated highway contracts to ensure consistent national application.

ii. **Pilot RSA Development on Strategic Corridors**:
Implementation should commence on priority corridors such as Lagos-Abuja, Lagos-Benin-Port Harcourt, and Abuja-Kaduna-Kano using mixed typologies of basic laybys, intermediate RSAs, and full service areas. These pilot projects should be rigorously evaluated using key performance indicators (KPIs) including crash reduction, facility usage rates, travel time reliability, and local economic benefits.

iii. **Adopt Public-Private-Partnership (PPP) Frameworks**:
To ensure financial sustainability, PPP concession models should be promoted for full service RSAs, while government intervention should focus on providing basic RSAs along low volume routes where private investment may be unviable. Concession terms should include performance metrics, service level monitoring, and maintenance obligations.

iv. **Strengthen Fatigue Management and Enforcement**:

The Federal Road Safety Corps (FRSC) should integrate RSA usage into national fatigue management regulations for commercial drivers, including mandatory rest break compliance tracking. Complementary driver awareness campaigns, onboard telematics monitoring, and industry collaboration can enhance behavioural change and fatigue prevention.

v. **Integrate Local Economic Participation**:
RSAs should be designed as community linked economic nodes that incorporate spaces for local vendors, agricultural produce markets, and microenterprises. This inclusion will ensure that RSA investments generate sustainable local employment, reduce rural poverty, and enhance social acceptance of the facilities.

vi. **Institutionalize Data Driven RSA Planning**:
Establish a centralized RSA monitoring platform that captures real time data on traffic volume, parking occupancy, facility usage, and incident records. This evidence base will enable iterative adjustments to RSA spacing, capacity, and functional design in response to actual demand trends and safety outcomes.

vii. **Create a National RSA Coordination Task Force**:
An interagency RSA task force should be established comprising the Ministry of Works, the Ministry of Transport, the Federal Road Maintenance Agency (FERMA), and the FRSC. The task force will coordinate planning, financing, regulation, and enforcement, ensuring coherent multi-sectoral implementation.

viii. **Enhance Capacity Building and Maintenance Funding**:
Continuous training should be provided for RSA operators, maintenance staff, and regulatory officers to ensure operational efficiency and user satisfaction. Dedicated maintenance funds or maintenance obligations within PPP contracts must be instituted to prevent facility deterioration and sustain service quality across the RSA network.

CONCLUSION

Organized Rest and Service Areas (RSAs) represent a strategic, cost effective, and multidimensional intervention for enhancing highway safety, operational efficiency, and socioeconomic resilience in Nigeria's transport sector. Their integration into the national road network addresses critical deficiencies such as driver fatigue, unregulated roadside stopping, and delayed emergency response all of which currently heighten crash risk and reduce corridor reliability. By providing structured facilities for rest, refueling, vehicle servicing, and emergency support, RSAs function as safety, logistics, and economic nodes along major corridors.

The study underscores that Nigeria's current deficit in organized RSAs has direct implications for crash frequency, journey reliability, and freight logistics productivity. A coordinated national RSA framework anchored on clear design standards, phased pilot corridor implementation, public–private partnership financing, enforcement mechanisms, and community participation can transform the functionality and safety of the nation's highways.

In moving forward, policy attention should focus on the institutionalization of RSA standards within the Federal Highway Design Manual, creation of a multiagency RSA coordination platform, and the establishment of long term maintenance and monitoring systems. Further empirical research should evaluate pilot RSA corridors using performance indicators such as fatigue related crash reduction, emergency response time, and socioeconomic spillover benefits. Such evidence based insights will be pivotal to scaling up RSA deployment nationwide, thereby ensuring safer, more efficient, and economically vibrant highway systems across Nigeria.

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