# Navigating Road Safety: Factors, Legislations, Safety Audits, Technological Advances and Challenges in Nepal

Sakar Hada*
Raship Khadka**

## Abstract

*Road transportation has become increasingly lethal, highlighting a need for swift implementation of road safety measures and enhanced study to develop more effective safety strategies. All factors related to the road environment, including road design, human behaviour, and vehicle characteristics, should be thoroughly inspected to more accurately and precisely understand their involvement in road accidents. Currently, the state of road-related legislation, databases, and technologies in Nepal is poor compared to other countries. The road safety bill has been pending since 2017, leaving the National Road Safety Council (NRSC) without clear ownership and resources. Developing countries like Nepal tend to prioritize infrastructure development over the management of resources for road safety audits. Prioritizing the introduction of effective road safety policies is critical, as further delays will result in preventable loss of human life and significant monetary costs.*

*Nepal's challenging terrain and low-income status make it difficult to design, construct, operate, and maintain roads to the highest standards. However, with the availability of more affordable hardware and advanced software, there should be a clear focus on utilizing these tools to improve road safety and address these challenges. The development of the Kathmandu-Terai Fast Track brings with it a significant responsibility to maintain road safety.*

**Keywords:** road safety, road safety audits, roads in Nepal, safety challenges, road way factor

## Introduction

Every year, month, week, and even every day, people become victim of road traffic accidents (RTAs). These incidents result in injuries, ranging from minor to severe, and in the worst cases, cause death and there are financial losses due to damage to road infrastructure and vehicles. In last 20 years, road accidents have been the top worry for state officials, academics and automakers (Kaul & Altaf, 2022).

Road accident is a pandemic as every year nearly 1.3 million human life is lost which projects a loss of 13 million human life for the decade 2021-2030 AD (WHO & United Nations, n.d.).

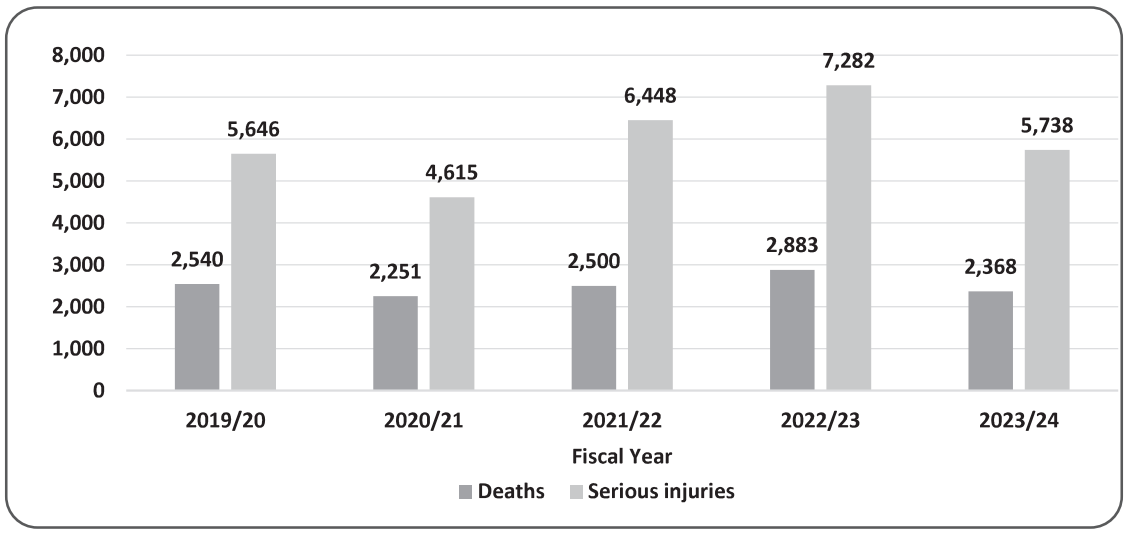
Nepal has faced 12,542 fatalities and sustained 29,729 serious injuries in the last five fiscal years. The no. of deaths and injuries of the year 2020/21 is comparatively lower due to COVID-19 and the data of 2023/24 is from mid-July to mid-February.

The sole healthcare problem where the government and the public acknowledge a considerable degree of death and disability as a result of mobility and commercial activity is road accident injuries (Mohan, 2003).

Road safety is the technique adopted for the action of reducing the chances of any traffic incidents that results in injuries or death of the road users and loss of the infrastructure (Wikipedia, 2024a). Road Safety provides the assurance for the decrease in loss of human life, and it also provides a significant reduction in financial loss as for a developing country, road traffic collision or crash costs up to 1.8% to 3% of countries' GDP (Eskandari Torbaghan et al., 2022). Financial burden from the medical

* Bachelor's in Civil Engineering, TU, IOE, Thapathali Campus <sakarsakar4@gmail.com>
** Bachelor's in Civil Engineering, TU, IOE, Thapathali Campus <khadkaraship@gmail.com>

Table 1: No. of deaths and serious injuries in the last five fiscal year




Source: Nepal Police (Khatri, 2024)

cost for the injuries, also leads victim and families towards the poverty.

The idea of road safety came into existence with the invention of the motorized vehicles. United Kingdom launched Road Traffic Act 1930 which initiated driver licensing system and the first Highway code in 1931(Driver and Vehicle Standards Agency, 2019). In the 1970s and 1980s, studies in North America and Europe examined traffic disputes, which were more pre-emptive than many accident investigation programs. However, these studies required road construction to be completed before implementing safety measures, emphasizing the necessity of a proactive strategy for traffic safety. Road safety audits, based on safety principles from Victorian-era railway networks, were introduced in the UK in the 1980s to address this need. (Sucharov et al., 2002).

## Factors in Road Safety

### Roadway factor

User safety should be the top priority in road design, even as it provides convenient, reliable, and efficient transportation access. This requires careful consideration of various infrastructure and road design factors. Standards set by relevant authorities guide these designs. In Nepal, Nepal Road Standard (NRS) 2070, and Nepal Urban Road Standard 2076 are excessively used.

The Kathmandu-Terai/Madhesh Fast Track (KTFT) (Expressway) Road project, currently under development, is country's first road project designed in Primary Class (Asian Highway Design Standard 1993) specifications, aiming to provide an 'A' level of service (Shrestha, 2021).

The aspects of road design and infrastructure are:

### Transportation Planning

Transportation planning aims to create safer, smarter, faster, and more efficient methods for assessing current conditions and preparing future plans and contingencies. It involves developing long-term and short-term strategies for the transportation system by formulating policies to maintain a high level of service for all road users. Additionally, transportation planning also considers land use and environmental quality control (PLAN RVA, 2022).

### Road Geometry

Road geometry design begins by creating a network that offers the most practical route, integrating all essential elements to establish a safe and efficient transportation pathway. This process involves planning for future widening, establishing speed limits, designing interfaces between new and existing roads, incorporating transition zones, reutilizing existing roads, and implementing appropriate signs and signals (Kwong, 2017).

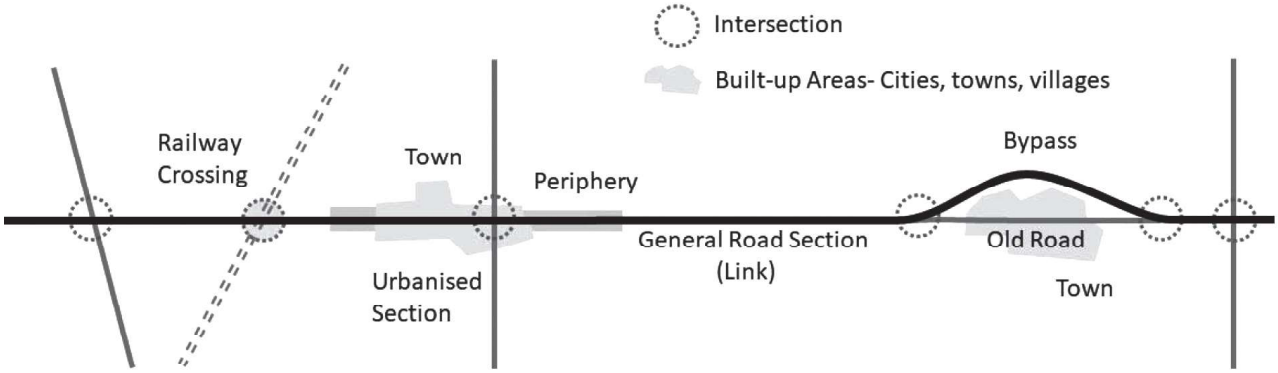



**Figure 1: General Components of Road Network**

Source: Extracted from AHDS for Road Safety –Design Guidelines, 2017, page 2

Road geometry includes:

a. Determination of the design speed
b. Stopping and Overtaking sight distance
c. Horizontal Alignment
   i. Horizontal curve
   ii. Set-back distance of Horizontal curve
   iii. Transitional curve
   iv. Hair-pin bends
   v. Extra Widening
d. Vertical Alignment
   i. Gradients
   ii. Climbing lanes
   iii. Emergency escape ramps
   iv. Vertical curves
e. Cross-section infrastructure:
   i. Carriageway
   ii. Shoulder
   iii. Camber

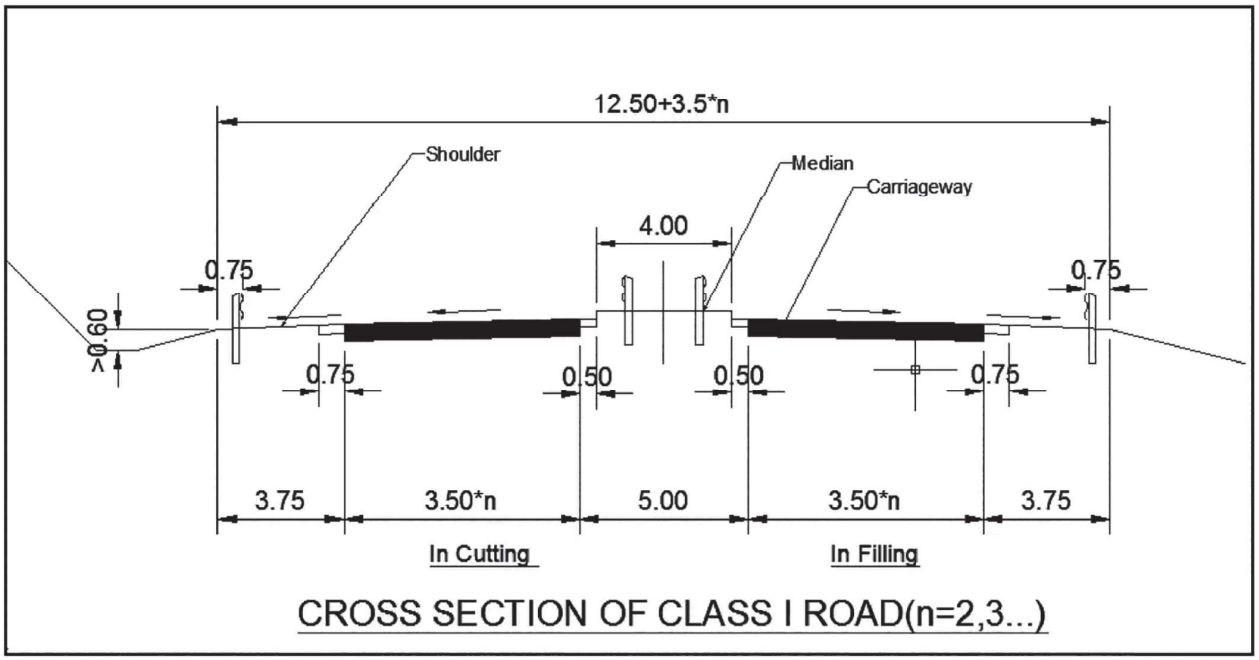



**Figure 2: Cross-Section Of Class-I Road**

Source: Nepal road standard 2070, page 19

iv. Median
v. Super elevation
vi. Side slopes
vii. Right of way and clearance

(DoR, 2013).

### Safety Infrastructure

Safety infrastructure plays a critical role in reducing fatal incidents on roads. Factors such as speed limits, crash-prone zones, road design, condition, and adjacent land use should all be considered when designing and implementing safety infrastructure (Kwong, 2017). These measures are prioritized and appropriately implemented can significantly enhance road safety.

Safety Infrastructure includes:

a. Guard rails and safety barriers
b. Road humps
c. Bicycle tracks
d. Pedestrian facilities (footpath and crossings)
e. Bus Lay Bys
f. Curbs
g. Road lighting
h. Road drainage
i. Roadside service facilities

(*GoN Ministry of Physical Infrastructure & Transport, 2013*)

### Intersections

Intersections, a place where two or more roads meet at grade, they are critical areas to focus on for safety improvements, as a large percentage of fatal collisions at these junctions. Enhancing the safety at intersections is crucial to provide secure movement of traffic on road (Bhattarai, 2019).

As there are many types of intersections such as cross-road, X-intersection, roundabout, misaligned, deformed, etc. for at-grade and grade-separated intersections (Wei et al., 2021). Traditional analysis of traffic conflicts identifies three fundamental types of conflicts between vehicles: conflicts when merging, conflicts when diverging, and conflicts when crossing paths. The design of intersection must mitigate the chance of conflicts to avoid the road collisions or crashes (Thompson, Kwon, et al., 2009).

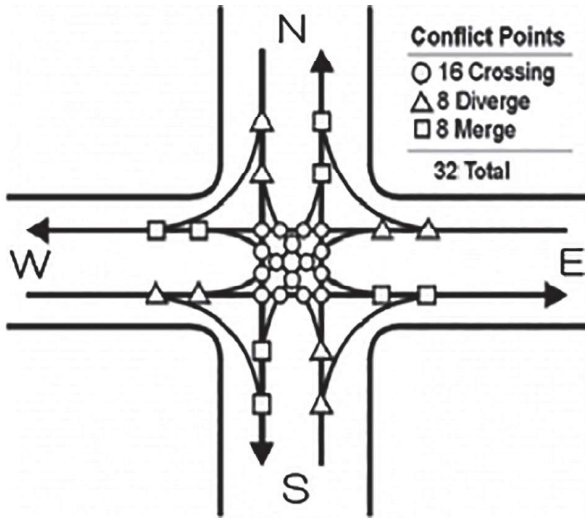



Figure 3: Conflicting points at Cross-road of two lane roadway

Source: The Fifth International Conference on Axiomatic Design Campus de Caparica – March 25-27, 2009, page 130

### Maintenance, Repair and Rehabilitation

Maintenance, repair, and rehabilitation are essential for keeping road sections in good condition for daily use, as degradation is inevitable. In addition to proper design and construction, a comprehensive maintenance, repair, and rehabilitation plan is necessary to address the degradation of roads and their infrastructure, which can create unsafe conditions for users. Additionally, preventative maintenance measures can be implemented as needed to prolong the road's lifespan.

The various types of repairs that may require are:

a. Concrete panels and concrete overlay
b. Asphalt Overlay
c. Grouting
d. Shingling
e. Grading
f. Patching
g. Piping and draining

(Sahoo et al., n.d.)

### Traffic Management

The organization, planning, direction, and control of both stationary and moving traffic, including bicycles, pedestrians, and all kinds of vehicles, is known as traffic management. Its goals are to safeguard and, to the extent feasible, improve the quality of the surrounding environment on and around traffic infrastructure, as well as to facilitate the efficient, safe, and orderly flow of people and commodities (Underwood, 1990).

Enhancing road safety involves continuous tasks in road and traffic management:

- Regular road safety and standards reviews.
- Eliminating hazardous spots.
- Managing vehicle speeds.
- Updating traffic organization procedures (Szczuraszek et al., 2016).

### Human Factor

Numerous investigations established on thorough accident assessments have attempted to determine the relative importance of vehicle, road, and human factors as contributing variables to traffic accidents. The findings unequivocally identify the human factor as the main contributory factor (Rumar, 1982). The primary cause of road crashes or collisions is attributed to motorists, accounting for over 90%, which is significantly higher compared to factors related to the vehicle or road environment (National Highway Traffic Safety Administration, 2018)

The PIEV theory outlines the cognitive process drivers undergo:

1. Perception Time: Time to register a situation.
2. Intellection Time: Time to comprehend circumstances and consider alternatives.
3. Emotion Time: Time between emotional states, such as fear or anger.
4. Volition Time: Time to decide and act, like applying brakes.

(Khanna & Justo, 2011)

Extended perception and reaction times can be caused by several factors, including age, DUI, exhaustion, and the intricacy of the required response (Roess et al., 2011). Driver fatigue is recognized as a major factor negatively affecting road traffic safety. Lack of sleep and nodding off while operating a vehicle are among the primary contributors to road accidents (Jamroz & Smolarek, 2013). Distracted driving has been divided into three primary categories by the NHTSA and the CDC. These consist of visual, where the eyes are removed from the wheel; manual, where the hands are removed from the wheel; and cognitive, where the thoughts are removed from the driving (Kawanaka et al., 2013).

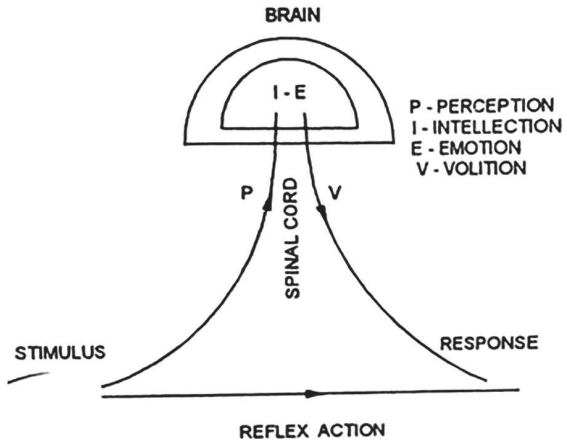



**Figure 4: PIEV Theory**

Source: Highway Engineering, page 89. Khanna and Justo

### Vehicle Factor

Safety engineers design to produce vehicle body structures that can endure both static and dynamic loads experienced throughout the vehicle's lifecycle. The vehicle body, in conjunction with the suspension system, is engineered to reduce road vibrations and limit the transfer of aerodynamic noise to passenger (Bois et al., 2004).

To create a better response for the road crash or collision, active and passive safety system have been introduced on the vehicles. The main goal of active safety systems is to assist the user in controlling the automobile to prevent crashes and improve the driver's familiarity across different road conditions and traffic situations while passive safety systems have been proven to be successful in lowering both injuries and fatalities resulting from accidents ("Automotive Active Safety Systems [Introduction to the Special Section]," 2010).

**Table 2: Objective, Type and Use of IVSS**

| | Objective | Type | Use |
|---|---|---|---|
| Active safety | To notify | Anticipatory navigation solutions | Digital map-based systems |
| | To assist | Alerting and supporting systems | Traffic movements information |
| Help after accident | | | |
| Passive safety | Minor | Low -level systems | Airbags, crash resistance |
| | Fatal | High-level systems | Smart restraint mechanism |

Source: Extracted from A. Jarašūnienė, G. Jakubauskas / TRANSPORT – 2007, Vol XXII, No 4, page 286

Vehicle maintenance should be given priority because the vehicle's mechanical condition is a major factor in user safety. Maintenance should be conducted on a periodic schedule based on the vehicle's usage, and the technicians performing the maintenance should be qualified.

**Table 3: Activities for Vehicle Inspection**

| Item | Activities to perform |
|---|---|
| Tires pressure | Check for the tire inflation and damage.<br>Learn about correct tire inflation pressure and check for spare tire. |
| Lights and signals | Ensure all lights (high beams, low beams, fog lights, taillights, brake lights, signal lights, and emergency flashers) are functioning properly. |
| Horn | Ensure the horn is functioning. |
| Seating position and seat-belt | Adjust seat, steering column, and headrest for comfort; ensure seatbelts and mechanisms work correctly. |
| Rear-view mirrors | Ensure mirrors are clean, undamaged, and adjusted for your driving position. |
| Brakes | Test the brakes gently before entering traffic to confirm they are working.<br>Periodically test the ABS in a safe area by reaching 60 km/hr, gripping the steering wheel, and firmly applying the brakes. |
| Vehicle documents | Carry your driver's license and vehicle registration. Check and renew insurance before it expires. |
| First aid kit | Ensure your vehicle's emergency kit is stocked and check expiry dates, replace items as needed. |

Source: Vehicle Inspections and Maintenance (Road safety at work, 2024)

## Road Safety Audit


Figure 5: % of Road length rated 3-star or better of Nepal

Source: iRAP Safety Insights Explorer. IRAP.Org. https://irap.org/safety-insights-explorer/

International Road Assessment Program (iRAP) is a charity which inspects hazardous roadways and develop a star ratings for the existing roads. Star rating depends upon the sidewalk present, signalized crossing, street lighting, dedicated separate motorcycle lane, no roadside hazard, safety barriers and other parameters (iRAP, 2021). iRAP considers a minimum 3-star rating as the standard for roads. The chart shows road length in Nepal with a 3-star or higher rating for Pedestrians, Bicyclists, Motorcyclists, and Vehicle occupants indicating that the road conditions in Nepal are considerably poor. Roads should be thoroughly inspected to guarantee each user's safety. To achieve this, a road safety audit is conducted. This audit involves an independent team performing a safety assessment of a proposed or current road, identifying any problems with road safety, and suggesting modifications to guarantee each user's safety (Federal Highway Administration, 2023).

In 1980, Great Britain introduced the concept of Road Safety Audit addressing the security concern of road users. Following the steps of the Great Britain, many countries introduced RSA in their respective countries (Jain et al., 2011) and in 1997, RSA manual was put together under the Traffic Engineering and Safety Unit (TESU) of DoR in Nepal which was developed with the help of UK's technical assistance (Tiwari & Luitel, 2023). After more than two decades of using the RSA 1997 manual, the revised manual-2022 was developed by Nepal road safety council (NRSC) with the support from Quality Infrastructure investment partnership, jointly hosted by Government of Japan and World Bank. RSA is the conventional performance examination of the road for the various factors which affects the safety of the people who use the road either as pedestrians, cyclists, drivers or passengers. RSA assess the condition of the present or future road and determine the faults which declines the safety of the road users. RSA is a qualitative approximation of the potential safety issues arising for the road users, it reports on the issue and also recognizes the steps for the possibility for the improvement of the road.

### Improvements in the revised manual of RSA

The objectives of RSA are clearly stated in points in the new manual, whereas the old manual only mentions that RSA is conducted to identify road safety deficiencies and provide recommendations to address them (TESU, 1997). The RSA Manual-2022 emphasizes the UN's second decade of action for road safety 2021-2030. The revised manual details every step and process, including a list of figures and tables. It clearly specifies that auditors must be qualified, experienced, and independent (NRSC, 2022).

The new manual outlines that the audit is conducted in six stages: feasibility, draft design, detailed design, construction, pre-opening, and road safety inspection. The RSA stages vary depending on the type of road (national, provincial, urban, or rural). It is the project manager's responsibility to make the final decision and arrange any redesigns according to the audit report. In contrast, the old manual indicates that design changes must be approved by the Director General of the Department of Roads.


**Figure 6: Steps in RSA**

Source: FHWA Highway Safety Programs

The figure above outlines the general steps taken by the Federal Highway Administration of the US Department of Transportation. These steps are similar to those included in the revised RSA Manual of Nepal.

First, project scoping is conducted to determine if the road project needs to be audited. The project employer then appoints a project manager responsible for drafting a Terms of Reference (ToR). A consulting firm is selected via tender, and all necessary information and drawings are provided to the audit team leader. A meeting is arranged

between auditors and designers to help the audit team leader better understand the project. The project site is then inspected both during the day and at night. This field inspection allows auditors to visualize the completed road project.

A report is prepared in response to the ToR. This comprehensive report lists all safety concerns, provides their locations, offers practical and realistic recommendations, and includes photographs to clarify the locations. The report is presented to the project manager, with a blank column in the audit matrix for the project manager to respond. The audit team is responsible for suggesting safety improvements, but it is the project manager's responsibility to decide whether to implement the recommended measures. Finally, the project manager instructs the designers to incorporate the suggested measures to ensure the safety of the road project.

## Status of RSA in Nepal

The Government of Nepal established the Nepal Road Safety Council (NRSC) through a formation order. The NRSC is chaired by the Ministry of Physical Infrastructure and Transport (MOPIT) Secretary and includes representatives from various ministries, government departments, NGOs, and the private sector (Tiwari & Luitel, 2023). However the Road Safety Bill is yet to be enacted by the Government of Nepal which gives ownership of road safety agenda to NRSC (Schafer, 2021). As a result, NRSC has not been fully effective. As of now on April, 2024, the draft of National Road Safety Act is currently under review (Sharma, 2024). Often, these high-level safety committees do not convene regularly, and implementing their decisions in the field can be a lengthy process (Regmi, 2021). There are shortcomings in the road safety audit that pertain to the planning and execution of road constructions in Nepal. (Situala, 2022). Currently, there is no requirement for a certified road safety auditor in Nepal, as the road safety auditor accreditation training, supported by the World Bank, was only introduced in 2023 (Adhikari, 2023). At present, the Department of Roads (DoR) simply requires civil engineers with a Master's in Highway Engineering and experience in road safety inspection unit (RSTU, 2022).

Developing countries like Nepal, India, and Bangladesh focus more on infrastructure development rather than investing in the management of resources and systems for RSA. Road safety audits (RSAs) are more frequently conducted in developed countries due to higher awareness, well-established systems, and available resources. The RSA manuals in developing nations do not typically address legal validity, whereas there are mentions of legal aspects in the RSA manuals of developed countries like the UK, USA, and Ireland (Ashish & Mhaske, 2023).

With the development of the new highway KTFT, a new challenge arises: maintaining safety on the highway. The road safety audit of the KTFT road project would mainly aid in lowering the project's long-term expenses and crash risk.

## Legislations, Policy and Campaigns

**Table 4: Five Key Risk Factors and Best Practice Criteria**

| Risk factor | WHO Best Practice Criteria |
|---|---|
| Speeding | National law sets urban speed limits at 50 km/h or lower, and local authorities can adjust these limits further. |
| Drink driving | National law defines alcohol limits by BAC: ≤0.05 g/dl for the general driving population and ≤0.02 g/dl for novice drivers. |
| Motorcycle helmet use | National law mandates that all riders, on all road types and engine types, must wear a fastened helmet that meets safety standards. |
| Motorcycle helmet use | National law requires seatbelt use in all seating positions within vehicles. |
| Child restraint system use | National law mandates that children up to 10 years old or 135 cm in height must use a standard-approved child restraint system. Additionally, children of certain ages or heights are prohibited from sitting in the front seats. |

Source: WHO best practice criteria for legislation on the five key risk factors (WHO, 2023)

The table above shows the best WHO criteria for legislations on the five key risk factors of road accidents. Currently, Nepal meets none of the five laws for best practice according to the Global Status Report on Road Safety 2023 (WHO, 2023). In Nepal, most road accidents occur due to driver negligence, which includes overtaking, speeding, overloading, and drunk driving (Thapa, 2013).

Research has shown that locals do not feel safe while riding public buses, as bus drivers are primarily motivated by earning more money, often disregarding passenger safety. Although the majority of motorists are conscious of the laws governing traffic, they are not concerned of being prosecuted because the penalties are not harsh. The panellists proposed that stiff penalties for infractions and strict law enforcement might enhance driver safety practices. (Joshi et al., 2022). Currently, fines for traffic violations such as speeding, overloading, drunk driving, red light violations, and not wearing seatbelts or helmets range from Rs. 500 to Rs. 1500 (Shafiq et al., 2020). Countries like Canada, Japan, Germany, and the UK have provisions for a demerit point system (DPS). Under DPS, points start from zero and accumulate with each traffic rule violation. Once offenders reach a certain point limit, their license is suspended or withdrawn (Toriumi et al., 2022). These countries maintain excellent databases recording drivers' historical offense records and license suspensions. For example, in Sydney, Australia, residents have access to the government app "Service NSW," which allows drivers to check their demerit points and pay fines. Additionally, the UAE has a reward system offering discounted vouchers at restaurants and hotels for drivers who have no demerit points in a year.

In Japan, the license renewal process includes a short lecture that lasts between 30 minutes and 2 hours. This lecture provides information on changes to traffic rules, the latest road crash statistics, and other relevant topics (Toriumi et al., 2022). Additionally, newly licensed drivers are required to display a "Wakaba mark," a V-shaped green and yellow symbol, on the front and rear of their cars for a year after obtaining their driver's license (Wikipedia, 2024b).

The Kathmandu Valley Traffic Police Office launched the "Traffic Awareness Special Campaign-2081" in April 2024. The campaign aims to effectively amend policies, rules, and acts, and introduce rewards for those who report traffic rule violations. Its goal is to promote a civilized road culture through public awareness (Republica, 2024). Social media can be a vital tool for educating the public about road safety and traffic regulations. The World Health Organization released "Road Safety Mass Media Campaigns: A Toolkit" to provide a 10-point media campaigning checklist for low- and middle-income nations (World Health Organization, 2016).

Additionally, various organizations such as schools, colleges, and clubs are conducting road safety awareness campaigns. In May 2023, the Rotaract Club of Kathmandu, in collaboration with the Rotary Club of Kathmandu, organized a road safety campaign highlighting the importance of adhering to traffic rules (Rotaract 3292, 2023). Schools and colleges are also running programs to educate about traffic signals and road safety (DAV college, 2022).

A study has shown that use of helmets in two-wheeler can lower the risk of fatality by 40% (Liu et al., 2008) and child restraints has lower the major injuries by around 70% (MIROS, 2009). Nepal should introduce amendments to mandate seatbelt use for all passengers in four-wheeled vehicles and safety-standard helmets for motorcycle rider and child restraint laws should be implemented. Additionally, a proper database for recording drivers' offenses and enforcement of cameras to detect traffic violations should be encouraged.

### Safe system approach and five pillars of road safety

The Safe System approach is an integrated strategy that prioritizes road safety as a key driver of sustainable development. It aligns with the Global Plan for the Decade of Action for Road Safety 2021-2030, which seeks to reduce road traffic fatalities and injuries by 50% by 2030 (WHO & United Nations, n.d.-b). Sweden was one of the pioneering countries to adopt the Safe System approach in the 1990s, successfully reducing car-related fatalities by 60% from 2000 to 2010. This initiative is also known as "Vision Zero" (Swedish Transport Administration,

2016). The Vision Zero policy brings new hope by acknowledging human error and promoting "forgiving" mistakes. It emphasizes designing road systems to protect users at every turn. (European federation of road traffic victims, 2018).

**Table 5: Five Principles of Safe System Approach**

| SN | Key components | Description |
|---|---|---|
| 1 | Establish robust institutional governance | Permanent institutions are needed to manage government intervention in research, funding, legislation, regulation, and licensing, ensuring road safety remains a national priority. |
| 2 | Share responsibility | Designers, builders, managers, users of roads and vehicles, and post-crash care providers share the responsibility to prevent serious injuries or deaths from crashes. |
| 3 | Strengthen all pillars | When all road-safety pillars are strong, their effects are amplified, ensuring road users remain protected even if one part of the system fails. |
| 4 | Prevent exposure to large forces | The human body can only tolerate a limited amount of crash force before harm occurs. |
| 5 | Support safe road-user behaviour | While road-user errors can cause serious harm, the Safe System emphasizes designing roads and vehicles for safe interaction with users. It aims to prevent mistakes and align tasks with human capabilities. |

Source: The Safe System Approach in Action, 2022. www.itf-oecd.org

There are five pillars of road safety: road safety management, safe users, safe vehicles, safe roads, and post-crash care (United Nations, 2011).

In Nepal, road safety implementation has been ineffective due to lack of awareness, inadequate funding, and poor coordination among stakeholders. The first pillar involves leading the national road safety strategy through data collection, research, and monitoring (United Nations, 2011). Despite passing the road safety strategy long ago, Nepal's road safety bill is still pending, leaving the NRSC without authority (Situala, 2022). The second pillar focuses on improving road network quality, with some new roads meeting 3-star iRAP ratings. The third pillar aims to enhance vehicle safety technology, but public vehicles like buses and minibuses in Nepal do not meet reasonable safety standards and remain in use. The fourth pillar promotes safer road user behaviors, but driver negligence is the leading cause of accidents (Thapa, 2013). The fifth pillar emphasizes prompt response to traffic accidents and immediate treatment, yet most emergency facilities are in cities, not high-risk areas. Additionally, the International Transport Forum's 2022 report identifies safe speed as a sixth pillar, highlighting that speeding is a major cause of road fatalities.

## Technologies for the Road Safety

To identify susceptible locations, implement preventative measures, and plan interventions for road safety, AI must be fused into the safety sector alongside the rapid advancement of autonomous and updated automobile technology. AI enhances road safety monitoring and data gathering involving human, vehicle, and road factors, simplifying subsequent analysis. Additionally, technological advances are revolutionizing road network catalogue, improving network-based road safety evaluations with more effective, precise, and data-driven outcomes (Katsarov & Penkov, 2023).

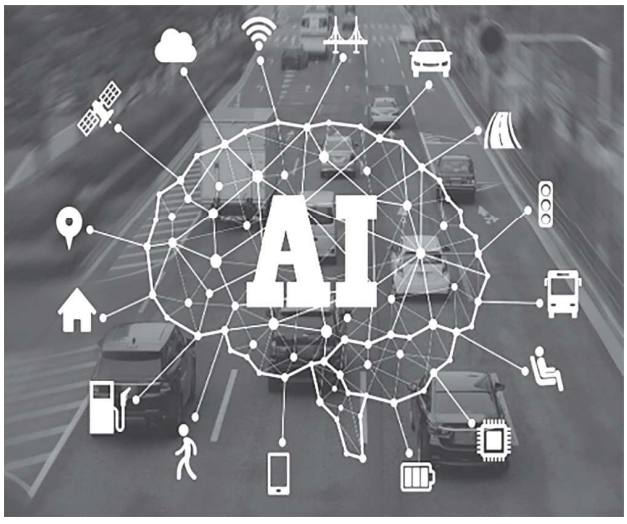



**Figure 7: Use of AI in Road**

Source: https://www.georgeyannis.com/key-challenges-for-applying-artificial-intelligence-into-road-safety

AI-powered systems monitor traffic, road conditions, and near-miss incidents, while connected vehicles share location and speed data. This data collection enables preventive maintenance to reduce accidents. Predictive modelling forecasts future hotspots and identifies trends in accident risk. AI proactively identifies hazardous locations, enabling timely enforcement and traffic adjustments. Integrating AI with road safety management prevents accidents and saves lives. (Santacreu, 2021).

For applications such as training programs, assessment, and research, simulation technology has grown in dependability and efficacy. Validation tests corroborate its usefulness, and its usage have grown with more affordable equipment and advanced software. The increasing acceptance of simulation is expected to continue growing as more people become aware of its advantages (Allen et al., 2007).

## Data in Road Safety

Data collection is crucial for road safety reform as it enables effective decision-making for safety planning. Reliable and comprehensive data helps practitioners identify issues, evaluate risk factors, establish focus areas, create plans, set goals, and track accomplishments.

High-quality crash databases are crucial for accurate road safety research and the development of effective countermeasures. However, issues such as inaccurate crash location and time estimates, inconsistent database entries hindering data linkage, incorrect crash severity classification, imprecise demographic data, and inaccurate identification of crash contributing factors pose significant challenges to data quality (Imprialou & Quddus, 2019).

The figure below shows how data are used to identify issues and determine associated risk factors. This information is then used to develop risk-reduction strategies and monitor their effectiveness, as well as to identify emerging problems (World Health Organization. et al., 2010).

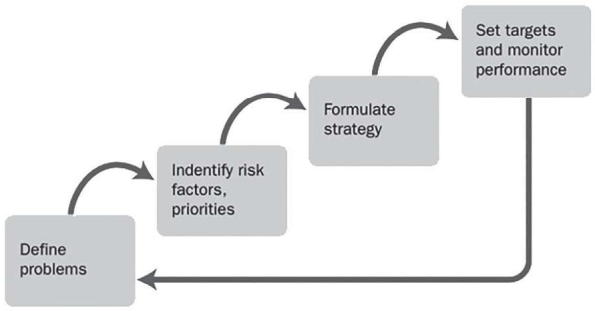



Figure 8: Process of Data usage in Road Safety
Source: Data systems: a road safety manual by WHO, 2010

## Challenges of Road Safety

The stakeholders' collaborative effort in managing road safety has been ad hoc, weak, and frequently hindered by the duplication of operations from parallel committees established under different agencies while interventions have been executed arbitrarily. The majority of Nepal's road network consists of hilly roads, which raise several safety hazards. These include the absence of climbing lanes, insufficient safety barriers at precipitous vertical cliffs, excessively high grades in some places, etc. The primary issues with regard to safety along the plain roads (Terai) include the following: inadequate pedestrian space, inadequate marking at bridge/culvert crossings, small carriageways close to populated areas, etc.(MoPPTM, 2013).

Nepal struggles with a lack of accurate accident data due to manual collection methods and limited digital records. This hinders the development of effective road safety policies and complicates the reimbursement process for traffic accident victims, which is already difficult due to complex investigative procedures and an underdeveloped legislative framework for insurance plans (Katahira and Engineers International, 2015). Nepal's road safety legislation falls short of the WHO's best criteria, as indicated by a 2023 report(WHO, 2023). The NRSC in Nepal struggles with limited capacity to lead road safety efforts, primarily coordinating with agencies and implementing the National Road Safety Action Plan (NRSAP 2021-2030) (Gairapipli,

2024) For eight years, the road safety bill has stalled, leaving the NRSC unrecognized as a legal body for national road safety (Raj Pant & Sedain, 2024).

Erased road markings like zebra crossings, cycle lanes, and shoulder lines need attention for road safety, particularly at night, due to their low visibility.

**Figure 9: Erased road marks of zebra crossing and cycle lane at Pulchowk, Lalitpur**

The main barriers preventing road traffic injuries include the current traffic culture and safety behaviour of road users. This is particularly evident among rural residents, who often disregard traffic laws. Factors contributing to this include a lack of understanding and trust in traffic rules, as well as a general sense of urgency among road users reflected in their driving behaviour. (Khorasani-Zavareh et al., 2009).

Inadequate trauma hospitals and emergency ambulance services contribute to a consistent loss of life, injuries, and increased exposure risk along roadways. (Giribabu et al., 2024).

## Conclusion

Road safety has received significant attention from the governments of all nations as well as from several international organizations. Numerous strategies and policies have been developed to improve the state of road safety worldwide. However, over the past few decades, several factors, such as insufficient funding, poor governance, difficulties in monitoring policies, and issues in collecting and analysing data, have hindered implementation and prevented the desired outcomes from being achieved. The 2010 Global Decade Plan has not yet reached its full potential. Thus, efforts to ensure that all these plans are carried out correctly should take priority over the development of new rules and plans, leaving unfinished business undone. While Nepal has long participated in initiatives to increase traffic safety, the introduction of new technologies, such as artificial intelligence (AI), is becoming increasingly vital. This will enable the road safety industry to progress and eliminate remaining stages that involve outdated technologies. With the development of the Kathmandu-Terai Fast Track, it is imperative to prioritize measures that ensure safe transportation and minimize the risk of road traffic accidents. By addressing these critical areas, we can make significant strides towards achieving safer roads in Nepal.

## Bibliography

Adhikari, M. (2023, April). Road Safety Status in Nepal. *Department of Roads Newsletter*, 21–22.

Allen, R. W., Cook, M. L., & Rosenthal, T. J. (2007). Application of driving simulation to road safety. In *Advances in Transportation Studies an international Journal*.

Ashish, & Mhaske, S. Y. (2023). Road Safety Audit (RSA) Guidelines of Selected Nations – a Comparative Review. *Journal of Road Safety*, 34(4), 42–50. https://doi.org/10.33492/JRS-D-23-209291

Automotive Active Safety Systems [Introduction to the special section]. (2010). *IEEE Control Systems*, 30(4), 36–37. https://doi.org/10.1109/mcs.2010.937044

Bhattarai, S. (2019). CRASH PREDICTION FOR PRIORITIZATION OF INTERSECTIONS FOR SAFETY IMPROVEMENT: CASE STUDY OF KATHMANDU VALLEY. In *Jacem Journal of Advanced College of Engineering and Management* (Vol. 5).

Bois, P. Du, Chou, C. C., Fileta, B. B., Khalil, T. B., King, A. I., Mahmood, H. F., Mertz, H. J., Wismans, J., Prasad, P., & Belwafa, J. E. (2004). VEHICLE CRASHWORTHINESS

AND OCCUPANT PROTECTION *Automotive Applications Committee American Iron and Steel Institute Southfield*, Michigan.

DAV college. (2022, August 25). *Traffic Awareness for Road Safety*. Davcollege.Edu.Np. https://davcollege.edu.np/single-news/Traffic-Awareness-for-Road-Safety

DoR, G. of N. (2013). *NEPAL ROAD STANDARD* 2070.

Driver and Vehicle Standards Agency. (2019, February 22). *History of road safety, The Highway Code and the driving test*. Government of UK.

Eskandari Torbaghan, M., Sasidharan, M., Reardon, L., & Muchanga-Hvelplund, L. C. W. (2022). Understanding the potential of emerging digital technologies for improving road safety. *Accident Analysis & Prevention*, 166, 106543. https://doi.org/10.1016/J.AAP.2021.106543

European federation of road traffic victims. (2018). *Vision Zero*. Welivevisionzero.Com. http://www.welivevisionzero.com/about-program-we-live-vision-zero/

Federal Highway Administration. (2023). *Road Safety Audits* (RSA). US Department of Transportation. https://highways.dot.gov/safety/data-analysis-tools/rsa/road-safety-audits-rsa

Gairapipli, P. (2024, May 15). Nepal's road safety measures in focus. *The Annapurna Express*. https://theannapurnaexpress.com/story/48865/#:~:text=Toward%20safer%20roads&text=Among%20them%2C%20the%20home%20ministry,heightened%20awareness%20among%20the%20public.

Giribabu, D., Ghosh, K., Hari, R., Chadha, I., Rathore, S., Kumar, G., Roy, S., Joshi, N. K., Bharadwaj, P., Bera, A. K., & Srivastav, S. K. (2024). Road accidents on Indian National highways, ambulance reachability and transportation of injured to trauma facility: Survey-based introspection of golden hour. *Journal of Family Medicine and Primary Care*, 13(2), 704–712. https://doi.org/10.4103/jfmpc.jfmpc_1832_23

GoN Ministry of Physical Infrastructure & Transport. (2013). *Nepal Road Standard-2070*. Government of Nepal.

Imprialou, M., & Quddus, M. (2019). Crash data quality for road safety research: Current state and future directions. *Accident Analysis & Prevention*, 130, 84–90. https://doi.org/https://doi.org/10.1016/j.aap.2017.02.022

iRAP. (2021). *Are our roads 3-star or better?* IRAP. Org. https://irap.org/safety-insights/how-safe-are-our-roads/#:~:text=is%20the%20safest.-,1%2Dstar%20is%20the%20least%20safe,5%2Dstar%20is%20the%20safest.&text=Many%20countries%20have%20made%20adopted,injuries%20that%20occur%20every%20day.

Jain, S. S., Singh, P. K., & Parida, M. (2011, September). ROAD SAFETY AUDIT FOR FOUR LANE NATIONAL HIGHWAYS. *3rd International Conference on Road Safety and Simulation.*

Jamroz, K., & Smolarek, L. (2013). Driver fatigue and road safety on Poland's national roads. *International Journal of Occupational Safety and Ergonomics : JOSE*, 19(2), 297–309. https://doi.org/10.1080/10803548.2013.11076987

Joshi, E., Gautam, P., Khadka, A., Pilkington, P., Parkin, J., Joshi, S. K., & Mytton, J. (2022). Experience of living near a highway in Nepal: Community perceptions of road dangers in Makwanpur district. *Journal of Transport and Health*, 24. https://doi.org/10.1016/j.jth.2022.101337

Katahira and Engineers International. (2015). *Government of Nepal Ministry of Physical Infrastructure and Transport Department of Transport Management NEPAL INDIA REGIONAL TRADE AND TRANSPORT PROJECT (NIRTTP) Road Transport Safety and Axle Load Control Study in Nepal ROAD ACCIDENT INFORMATION MANAGEMENT SYSTEM.*

Katsarov, I., & Penkov, S. (2023). Application of artificial intelligence in road network inventory and network-wide road safety assessment. *IOP Conference Series: Materials Science and Engineering*, 1297(1), 012020. https://doi.org/10.1088/1757-899x/1297/1/012020

Kaul, A., & Altaf, I. (2022). Vanet-TSMA: A traffic safety management approach for smart road

transportation in vehicular ad hoc networks. International Journal of Communication Systems, 35(9). https://doi.org/10.1002/dac.5132

Kawanaka, H., Miyaji, M., Bhuiyan, M. S., & Oguri, K. (2013). Identification of cognitive distraction using physiological features for adaptive driving safety supporting system. *International Journal of Vehicular Technology*, 2013. https://doi.org/10.1155/2013/817179

Khanna, S. K., & Justo, C. E. G. (2011). *Highway engineering* (I. Khanna & L. Justo, Eds.; 9th ed.). Nem Chand and Bros.

Khatri, P. (2024, April 7). Road fatalities taking a serious toll in Nepal. *The Rising Nepal*. https://risingnepaldaily.com/news/41231#:~:text=Similarly%2C%205%2C646%20persons%20were%20seriously,and%205%2C738%20in%202023%2F24.

Khorasani-Zavareh, D., Mohammadi, R., Khankeh, H. R., Laflamme, L., Bikmoradi, A., & Haglund, B. J. A. (2009). The requirements and challenges in preventing of road traffic injury in Iran. A qualitative study. *BMC Public Health*, 9(1), 486. https://doi.org/10.1186/1471-2458-9-486

Kwong, J. T. H. (2017). *Asian Highway Design Standard for Road Safety Design Guidelines*.

Liu, B. C., Ivers, R., Norton, R., Boufous, S., Blows, S., & Lo, S. K. (2008). Helmets for preventing injury in motorcycle riders. In *Cochrane Database of Systematic Reviews* (Issue 1). John Wiley and Sons Ltd. https://doi.org/10.1002/14651858.CD004333.pub3

MIROS. (2009). PHASE 1: *Achievements of First 3-Month Advocacy Program - Rear Seatbelt Use: Public Awareness and Practice.*

Mohan, D. (2003). Road traffic injuries- a neglected pandemic. *Bulletin of the World Helath Organization,* 684–685.

MoPPTM. (2013). *February 2013 Government of Nepal Ministry of Physical Planning & Transport Management Nepal Road Safety Action Plan (2013-2020).*

National Highway Traffic Safety Administration. (2018). *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*.

NRSC. (2022). *Road Safety Audit Manual.*

PLAN RVA. (2022). *What is Transportation Planning*? PLAN RVA. https://planrva.org/transportation/what-is-transportation-planning/

Raj Pant, P., & Sedain, B. (2024, January 10). Focus on road safety. *The Kathmandu Post*. https://kathmandupost.com/columns/2024/01/10/focusing-on-the-road-safety-agenda

Regmi, M. B. (2021). What does it Take to Improve Road Safety in Asia? *Journal of Road Safety,* 32(4), 29–39. https://doi.org/10.33492/JRS-D-21-00040

Republica. (2024, April 14). Traffic Awareness Special Campaign launched. *Myrepublica. Nagariknetwork.Com.* https://myrepublica.nagariknetwork.com/news/traffic-awareness-special-campaign-launched/

Road safety at work. (2024). *Vehicle Inspections and Maintenanc*e. Roadsafetyatwork.Ca. https://roadsafetyatwork.ca/resource/tool-kit/vehicle-inspections-and-maintenance/#:~:text=Proper%20vehicle%20inspections%20and%20regular,how%20to%20inspect%20your%20vehicles

Roess, R. P., Prassas, E. S., & McShane, W. R. (2011). *Traffic engineering*. 734.

Rotaract 3292. (2023, May 18). *Road Safety Awareness.* Rotaract3292.Org. https://rotaract3292.org/details/?project_id=34918

RSTU, D. of R. (2022, September 6). *EOI-Road Safety Inspection of Birgunj - Pathlaiyaa Road (31.72 km)*. Bolpatra.Gov.Np.

Rumar, K. (1982). Linköping National Road & Traffic Research Institute. *Sweden Reprint From, 11.*

Sahoo, D., Choudhury, S. P., & Saha, P. (n.d.). *URBAN ROAD MAINTENANCE MANAGEMENT & REPAIRING TECHNIQUES.*

Santacreu, A. (2021). *Artificial Intelligence in Proactive Road Infrastructure Safety Management: Summary and Conclusions.*

Schafer, H. (2021). *Renewing Our Commitment to Road Safety in Nepal*. End Poverty in South Asia, World Bank Blogs.

Shafiq, S., Dahal, S., Siddiquee, N. K. A., Dhimal, M., & Jha, A. K. (2020). Existing Laws to Combat Road Traffic Injury in Nepal and Bangladesh: A Review on Cross Country Perspective. In *Journal of Nepal Health Research Council* (Vol. 17, Issue 4, pp. 416–423). NLM (Medline). https://doi.org/10.33314/jnhrc.v17i4.2363

Sharma, B. (2024, April 19). MoPIT prepares draft of National Road Safety Act, proposes rescue within an hour of an accident. *MyRepublica*.

Shrestha, A. (2021). Kathmandu - Terai/Madhesh Fast Track (Expressway) Road Project (KTFT): Blessing Or Curse? *KTFT Journal*, I, 12–19.

Situala, T. (2022, August). Road safety initiatives in Nepal: An overview. *Department of Roads Newsletter*, 17–20.

Sucharov, L. J. (Lance J. ), Brebbia, C. A., & Benitez, F. G. (2002). *Urban transport VIII : urban transport and the environment in the 21st century*. WIT Press.

Swedish Transport Administration. (2016). *Översyn av etappmål för säkerhet på väg: till 2020 och 2030, med en utblick mot 2050*. Trafikverket.

Szczuraszek, T., Klusek, R., & Bebyn, G. (2016). ENHANCEMENT OF ROAD SAFETY THROUGH MORE EFFECTIVE ROAD AND TRAFFIC MANAGEMENT. *Journal of Civil Engineering, Environment and Architecture*, 367–374. https://doi.org/10.7862/rb.2016.96

TESU. (1997). *Road Safety Audit Manual*.

Thapa, A. J. (2013). *Status Paper on Road Safety in Nepal*.

Thompson, M., Kwon, O., & Park, M. (2009). *The Application of Axiomatic Design Theory and Conflict Techniques for the Design of Intersections: Part 1*.

Tiwari, H., & Luitel, S. (2023). Re-orienting towards Safer Roads Infrastructure in Nepal. *Journal of Recent Activities in Infrastructure Science,* 8(3), 14–26. https://doi.org/10.46610/jorais.2023.v08i03.003

Toriumi, A., Abu-Lebdeh, G., Alhajyaseen, W., Christie, N., Gehlert, T., Mehran, B., Mussone, L., Shawky, M., Tang, K., & Nakamura, H. (2022). A multi-country survey for collecting and analyzing facts related to road traffic safety: Legislation, enforcement, and education for safer drivers. *IATSS Research*, 46(1), 14–25. https://doi.org/10.1016/j.iatssr.2022.01.004

Underwood, R. T. (1990). *Traffic management : an introduction*. 222. https://www.ebay.com/p/94270016

United Nations. (2011). *Global Plan for the Decade of Action for Road Safety 2011-2020*. http://www.who.int/violence_injury_prevention/publications/road_traffic/UN_GA_resolution-54-255-en.pdf

Wei, L., Li, Z., Gong, J., Gong, C., & Li, J. (2021). *Autonomous Driving Strategies at Intersections: Scenarios, State-of-the-Art, and Future Outlooks.* https://doi.org/10.1109/ITSC48978.2021.9564518

WHO. (2023). *Global status report on road safety 2023*.

WHO, & United Nations. (n.d.-a). *Global plan for road safety 2021-2030*.

WHO, & United Nations. (n.d.-b). *Global plan for road safety 2021-2030*.

Wikipedia. (2024a). *Road traffic safety*. Wikipedia. Com. https://en.wikipedia.org/wiki/Road_traffic_safety#:~:text=Road%20traffic%20safety%20refers%20to,(mainly%20buses%20and%20trams).

Wikipedia. (2024b). *Shoshinsha mark*. Wikipedia.Org. https://en.wikipedia.org/wiki/Shoshinsha_mark#:~:text=The%20shoshinsha%20mark%20(%E5%88%9D%E5%BF%83%E8%80%85%E3%83% 9E%E3%83%BC%E3%82%AF,after%20they%20obtain%20a%20standard

World Health Organization. (2016). *ROAD SAFETY MASS MEDIA CAMPAIGNS*.

World Health Organization., FIA Foundation for the Automobile and Society., & World Bank. (2010). *Data systems : a road safety manual for decision-makers and practitioners*. World Health Organization.