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Regional: Accelerating Innovation in Transport—Road Safety Performance Indicator Data Collection

Using New Technologies for Road Safety Performance Indicators

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For the Asian Development Bank

Asian Development Bank

ABBREVIATIONS

ADB	Asian Development Bank
AI	artificial intelligence
GPS	Global Positioning System
NGO	nongovernment organization
SPI	safety performance indicator
WHO	World Health Organization

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EXECUTIVE SUMMARY

Asia and the Pacific bear the highest road trauma rates globally, accounting for more than half of all road-traffic deaths worldwide, a burden worsened by constrained resources for data collection and road safety interventions. To address this considerable challenge effectively, the Asia-Pacific Road Safety Observatory was established as the regional platform for data collection, analysis, and knowledge sharing on road safety. The observatory supports member countries in strengthening their institutional capacity for evidence-based policy making.

Commissioned as the "Accelerating Innovation in Transport: Road Safety Performance Indicator Data Collection" technical assistance, this initiative set out to pilot new, data-driven methodologies in multiple Asian countries. In particular, the project sought to measure three critical safety performance indicators (SPIs):

- **Network carrying 75% of travel**: Identifying the smaller fraction of roads that carries the majority of traffic, thus offering the largest return on investment for safety upgrades.
- **Prevalence of speeding**: Globally, speeding is implicated in a substantial share of fatal crashes, magnifying crash severity. Identifying high-speed corridors allows targeted infrastructure measures and enforcement interventions.
- **Helmet-wearing rates among powered two-wheeler users**: Head injuries remain a leading cause of death and disability in powered two-wheeler crashes. Helmet compliance rates vary widely by country, requiring data-driven, culturally adapted enforcement and awareness.

Rather than relying on roadside surveys the project employed a number of novel data sources and technologies to calculate SPIs: commercial GPS Data (TomTom)for mapping high-traffic corridors and calculating speed distributions; and crowdsourced street-view images (Mapillary) for large-scale helmet use detection through a deep learning model trained to recognize helmets on riders and passengers.

These methods were piloted in Thailand, Viet Nam, and select Indian states to validate feasibility and to showcase how low and middle-income countries can adopt advanced data solutions even in contexts with limited traditional data infrastructure. These pilots validated that data can be collected and analyzed at scale, even in data-scarce environments.

Key results of the project are:

- **75% travel network**: The team combined open-source road network data with commercial probe data to map out road segments that together carry 75% of traffic. For example, in Thailand about 1/3 of the road network (by length) was shown to account for roughly 75% of total travel. In Maharashtra, just 1/8 of the road network accounted for 75% of total travel. These priority corridors represent the most cost-effective targets for speed management, enforcement, and infrastructure upgrades.
- **Speeding Indicators**: Using GPS probe data, the project assessed speeding on the 75% travel network in Thailand and Maharashtra. In Thailand, overall compliance is 70%, while compliance at lower posted limits (50–60 km/h) appears substantially lower, particularly in urban areas. Rural compliance (63%) trails urban (73%). Observed speeds appear to be influenced more by congestion than posted speed limits. Maharashtra records overall compliance of 54%, though trunk roads at 80 km/h show 96% compliance. Yet limits below 50 km/h see poor adherence.
- **Helmet-wearing rates**: Using computer vision (see photo below) of over a million crowd-sourced street-view images the project assessed helmet use among motorcyclists in Viet Nam, Thailand, and parts of India. Viet Nam's helmet compliance stood around 90% overall, reflecting the positive impact of long-standing mandatory helmet laws. Thailand's rates were lower at about 60%–70%. Helmet use in the state of Maharashtra was about 21%. However, urban areas differed greatly in helmet use, with motorcycle

drivers in Mumbai using a helmet in almost 70% of observations and Pune only in only 26%.

Computer vision based active motorcycle detection. This includes position specific helmet use registration (Siebert and Lin 2020).

This project has shown the potential of using big data, AI, and innovative analytics to overcome traditional barriers in collecting safety performance indicators (SPIs) in low and middle-income countries. By mapping the 75% travel network and detecting behaviors such as speeding and helmet use, it demonstrates how novel methods can support proactive, evidence-based policies even where conventional data is scarce. Moreover, the large sample sizes make it possible to make breakdowns by sub-nationally and by road type. By integrating these innovate methods, such countries can leapfrog traditional road safety barriers, ensuring life-saving interventions are efficiently targeted and rigorously evaluated.

The project is groundbreaking in delivering large-scale, spatially and temporally detailed helmet use data, a long-missing variable in global road safety. Results from Maharashtra highlight urgent needs: while one-third of riders are passengers, helmet use among them is minimal, despite proven life-saving effects. Contrasts between cities like Mumbai and Pune stress the role of enforcement, legislation, and education.

Beyond technical feasibility, the pilots also highlighted how SPIs can be embedded in institutional processes and national strategies. Countries can use SPI data to inform legislation, justify infrastructure investments on high-exposure roads, and prioritize enforcement and education where compliance gaps are greatest. By aligning SPI monitoring with global frameworks, such as the UN Global Performance Targets and the World Health Organization's (WHO) Status Report, governments and development partners can improve coordination, target funding, and measure progress toward the Sustainable Development Goals.

Scaling up this methodology across Asia and the Pacific and beyond is both urgent and achievable. Many countries already collect related data or have access to potential data sources, such as telematics or image platforms. The next step is integrating these into structured SPI systems with clear benchmarks and institutional roles. Regional organizations like the Asia Pacific

Road Safety Observatory, together with partners such as ADB and WHO, can play a catalytic role in supporting this expansion—by providing tools, training, and platforms for cross-country learning. This report demonstrates that, with the right partnerships and commitment, including also the private sector, SPI systems can be a cornerstone of smarter, faster, and more accountable road safety management.

Challenges remain, such as costs, institutional capacity, representativeness, and validation, but results confirm these can be addressed through close collaboration with data providers and partial ground-truth checks. Still, dependence on single providers carries risks, as illustrated by limited probe data coverage in India compared to Thailand or Viet Nam. Satellite-based methods are useful where GPS data is lacking, though current costs make them a fallback option.

1. INTRODUCTION

1.1 Background

1. Road traffic injuries and fatalities are a major public health issue and a developmental concern, particularly in low and middle-income countries where rapid motorization often outpaces safety infrastructures (WHO 2023). Road trauma in Asia and the Pacific is the world's highest, accounting for more than half of all road traffic deaths globally. Rapid urbanization, expanding motorcycle use, and mixed traffic environments combine to create high exposure to risk, especially for vulnerable road users. Many developing economies in the region face persistent data gaps and limited institutional capacity to monitor safety performance, which constrains the effectiveness of national road safety strategies.

2. Historically, collision-based indicators have guided road safety strategies. Although crucial, these lagging indicators cannot detect the nature and magnitude of risks until crashes occur. Moreover, relying solely on crash statistics is insufficient to guide effective interventions. Collection and analysis of road safety performance indicators (SPIs) offer a more proactive approach to road safety policy management. These indicators measure underlying or contributary risk factors, like speeding or wearing of seatbelts, before crashes happen. On the one hand, they bridge the gap between road safety interventions and road safety outcomes (deaths, injuries, property damage) and on the other, road safety measures and interventions. By regularly monitoring SPIs, authorities can identify emerging dangers and evaluate the effectiveness of safety measures.

3. This report contributes directly to the objectives of the Asia-Pacific Road Safety Observatory, the regional platform for data collection, analysis, and knowledge sharing on road safety. Established under the joint leadership of the Asian Development Bank (ADB), the United Nations Economic and Social Commission for Asia and the Pacific, and the World Health Organization (WHO), the observatory helps member countries strengthen their institutional capacity for evidence-based policy making. By piloting innovative methodologies for road safety performance indicators, the project provides practical tools and data approaches that can be adopted by observatory member countries to improve monitoring and reporting of regional progress.

4. The project addresses 3 of the 12 UN Voluntary Global Road Safety Performance Targets (WHO 2018, Van den Berghe et al. 2020) (Table 1). These targets provide a framework for measuring progress toward the Sustainable Development Goal of halving road traffic deaths and injuries by 2030.

Table 1: UN Voluntary Road Safety Targets Addressed by the Project

No.	Target (by 2030)	Addressed by the Project?
1	All countries establish a comprehensive multisectoral national road safety action plan with time-bound targets.	
2	All countries accede to one or more of the core road safety-related UN legal instruments	
3	All new roads achieve technical standards for all road users that take into account road safety or meet a three star rating or better.	
4	More than 75% of travel on existing roads is on roads that meet technical standards for all road users that take into account road safety.	Indirectly

5	100% of new (defined as produced, sold or imported) and used vehicles meet high quality safety standards such as the recommended priority UN Regulations, Global Technical Regulations, or equivalent recognized national performance requirements.	
6	Halve the proportion of vehicles travelling over the posted speed limit and achieve a reduction in speed-related injuries and fatalities.	Directly
7	Increase the proportion of motorcycle riders correctly using standard helmets to close to 100%.	Directly
8	Increase the proportion of motor vehicle occupants using safety belts or standard child restraint systems to close to 100%.	
9	Halve the number of road traffic injuries and fatalities related to drivers using alcohol, and/or achieve a reduction in those related to other psychoactive substances.	
10	All countries have national laws to restrict or prohibit the use of mobile phones while driving.	
11	All countries to enact regulation for driving time and rest periods for professional drivers, and/or accede to international/regional regulation in this area.	
12	By 2030, all countries establish and achieve national targets in order to minimize the time interval between a road traffic crash and the provision of first professional emergency care.	

Source:WHO 2018 for the first two columns

1.2 Objectives and scope of the project

5. The project is funded by the High-Level Technology Fund and the ADB initiative “TA-6763 REG: Accelerating Innovation in Transport—Road Safety Performance Indicator Data Collection. It set out to:

6. Analyze the potential of new data sources and analysis methods for three indicators: 75% of travel network, speeding prevalence, and helmet-wearing rates for motorcyclists.

7. Undertake demonstration pilots to validate the feasibility of new methods in some Asian countries with varying data availability and road safety conditions.

8. Offer guidance for governments, donors, and regional observatories for upscaling and replicating these methods across other low and middle-income countries.

1.3 Report structure

(i) **Chapter 2** sets out the importance and relevance of using SPIs and explains how novel data sources scan address low and middle-income country challenges where roadside surveys are expensive or impractical.

(ii) **Chapter 3** describes the methodology used in the project, including how the project sourced and merged data, validated outputs, and managed pilot deployments.

(iii) **Chapter 4** presents the key findings for each of the three indicators, contextualizing differences in speed behaviors and helmet-wearing patterns across countries.

(iv) **Chapter 5** closes with lessons learned and recommendations for future action.

2. THE IMPORTANCE OF ROAD SAFETY PERFORMANCE INDICATORS

2.1 Why using SPIs?

9. Under the *UN Decade of Action for Road Safety (2021–2030)* (WHO, 2021), governments are encouraged to halve road deaths and injuries. Meeting these ambitious targets requires data that capture root causes, such as speeding and helmet-wearing (WHO 2018). International best practices increasingly emphasize SPIs for informed, results-oriented road safety management (European Commission 2019).

10. Countries with strong road safety records typically use a broad set of SPIs to inform their policies. Global frameworks, such as the UN's Voluntary Global Road Safety Targets, are based on SPIs (WHO 2019). Many European countries have established SPI programs, most involved in EU initiatives like "Baseline" and "Trendline", allowing harmonized international comparisons.[1] But very few low and middle-income countries have an approved set of SPIs to underpin their road safety policy activities.

11. Traditionally, road-safety authorities have calculated the frequency and socioeconomic costs of road crashes and injuries to assess the safety of transport systems. However, such indicators are incomplete as they investigate neither the causes of crashes nor progress towards a safe road system. Random fluctuations can also change the frequency of crashes. By contrast, SPIs can give a more holistic picture of the safety performance of a transport system and identify the safety issues that lead to road crashes. Regular and long-term SPI recording and monitoring can improve understanding of the processes that lead to crashes and, in turn, facilitate identification of targeted, effective interventions (European Commission 2022, Sohu and Zhang 2023, Van den Berghe et al. 2024).

12. SPIs support implementation of a "safe system" approach. They focus on contributory factors like speed management, vehicle safety, infrastructure quality, and user behavior. Policymakers can set concrete SPI targets (e.g., reduce the percentage of speeding vehicles by 50% in 5 years) and monitor progress. Without SPIs, it is difficult to determine which safety programs work and where to invest resources.

13. Many of the best performing countries in road safety have been using a broad set of SPIs that consider the contributing factors such as the quality of the road infrastructure, the safety technology in vehicles and the behavior of road users. The main purposes of SPIs in such countries are to reflect current road system safety conditions, to measure the influence of safety interventions, to monitor trends, and to compare different systems (e.g., countries, regions).

14. SPIs also allow monitoring of road safety plans and strategies. They can be used to set medium and long-term targets (e.g., reduction of numbers of speeders on rural roads by 50%), to monitor the progress towards targets, and to assess whether policy measures have led to the desired results. Without SPIs, policy makers and other stakeholders cannot assess policy and intervention effectiveness or identify measures still needed.

2.2 Challenges for low and middle-income countries in collecting SPI data

15. SPIs are underutilized in many low and middle-income countries for several reasons, despite clear benefits. Many such countries are working towards integrated crash data bases but struggle with limited crash data and almost no systematic SPI data due to resource and

[1] The details are available on the relevant websites: https://www.baseline.vias.be/ and https://trendlineproject.eu/ .

capacity constraints. Traditional data collection methods, such as roadside speed cameras or manual helmet use surveys, are difficult to set up, labor-intensive, and costly—sometimes even more expensive than in high-income countries. Decision-makers are often unfamiliar or not convinced yet of the added value of using SPIs.

16. Innovative technologies offer a chance to leapfrog these challenges. This project directly addresses the obstacles by demonstrating how big data and AI can circumvent reliance on conventional roadside surveys, reduce costs, and provide comprehensive network coverage. In high-income countries, abundant data from mobile GPS, connected vehicles, and traffic sensors have made SPI monitoring more feasible. These data sources are less available in low and middle-income countries, but their footprint is growing. Meanwhile, alternative approaches like computer vision and satellite imagery can generate data even where on-ground instrumentation is sparse.

2.3 Conventional versus novel data methods

2.3.1 Overview

17. Historically, speed and helmet-wearing rates have been and often still are measured via roadside surveys. These involve manual observation or short-duration camera setups or by using dedicated devices or set ups, such as loop detectors, automated counters, speed cameras, and laser guns. Such methods in general involve a relatively small number of samples of road sections.

18. This project examined several novel methods based on data sources that allow a significant increase in sample size, which has the additional advantage of allowing breakdown of the SPI values to subnational and even local levels, which is not possible with traditional methods. Specifically, the project team assessed the potential of using:

(i) AI-driven object detection of Earth observation satellite imagery; for estimating speeds of vehicles (reference).

(ii) Analysis of aggregated GPS-data from in-vehicle systems or smartphones for estimating traffic volume and speeds.

(iii) AI-based detection of helmet wearing by motorcyclists by using street view databases.

19. Overall, these technologies can provide continuous, wide-area coverage, often at relatively low marginal cost—a gamechanger for low and middle-income country regions where baseline data is lacking.

2.3.2 Earth observation imagery for speed estimation

20. The team has experience with an AI-based method, developed with the International Road Assessment Programme's "aiRAP" initiative, to derive vehicle speeds from satellite images, which had been successfully piloted in Africa AI-based methods track vehicle movements between rapid-succession images. In pilot tests in sub-Saharan Africa and select Indian locations, Earth-observation-based speeds appeared to correlate closely (~85%–90% agreement) with ground or probe data (Smith and Owen 2022). The photo below shows examples of simplified vehicle detection outlines in red, with ground truth labels in green, from the final model in Kenya.

Vehicle Detection. Based on satellite images in Kenya (Copyright Maxar/Agilysis).

21. During the project, however, it appeared that the current price structure for the satellite imagery required makes this method prohibitive for calculating speeding SPIs nationally in most countries. However, Earth-observation-based methods can be used for local analysis or when GPS data is not available (section 2.3.3).

2.3.3 GPS probe data for traffic and speeding

22. Past research has shown that in-vehicle GPS data can be a reliable base for estimating traffic speeds when penetration is sufficient (Cantisani, Del Serrone, and Peluso 2022). GPS data can be obtained from vehicles or from vehicle occupants; in this project the team only considered vehicle data that can be supplied nationally by commercial providers.

23. GPS probe data, when sufficiently representative for the traffic, allow calculating which road segments are used most heavily, because the frequency with which GPS traces occur on each segment serves as a proxy for traffic volume. Aggregation of such data then allows identification of road categories and road sections with 75% (or more) of traffic.

24. Moreover, by measuring the distance between two locations of the same vehicle over a certain period, it is possible to calculate the speed of the vehicle and then aggregate this into speeding SPIs such as the average speed, the percentage of vehicles exceeding the speed limit and the "V85" (85^{th} percentile speeds).

25. The project found that in many Asian countries, including Viet Nam, Thailand, and India, GPS data coverage from commercial providers was substantial, yielding robust speed metrics.

2.3.4 Imagery for detecting helmet use

26. Platforms such as Mapillary (a crowd-sourced street-view platform) or Google Street View supply millions of geotagged images. Mapillary images can be obtained free of cost and are amenable to AI-based behavior detection. These images can also be tied to national road infrastructure maps. A neural network, developed by team members, is able to identify active motorcycles on such images, distinguishing between riders and passengers, and classifying helmet use with very high accuracy.

27. Mapillary and Google Street View data are available in many Asian countries at sufficient quantity and resolution to allow helmet wearing detection, the team found. Within the project, Mapillary data has been used for piloting analysis in Thailand and India. In principle, however, other image databases could also be used, as has been shown in earlier projects in Nepal, Myanmar, and Indonesia (see photo below).

Recognition of motorcyclists and helmet wearing (Indonesia) (Source: Mapillary).

3. METHODOLOGY

28. Project data sources:

(i) National road network: Initially, the project used *OpenStreetMap* shapefiles, supplemented later on by the new *Overture Maps* for improved alignment. For speed analyses (requiring free flow traffic), *crossings* were filtered out of the network.

Figure 1 shows a map mainly of Tamil Nadu and Kerala, India, with the image on the left showing all the network data in Overture, and on the right filtered for trunk, primary, and secondary roads only.

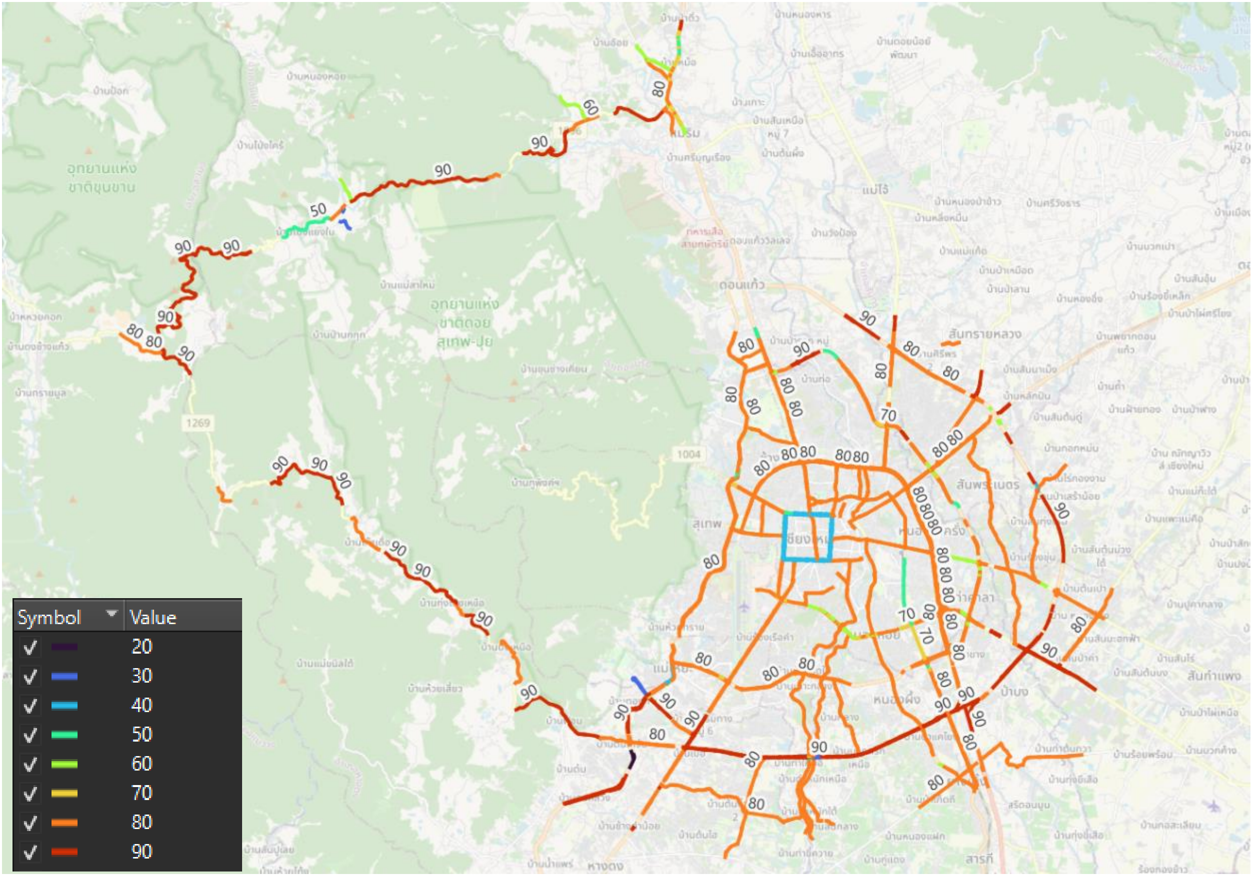
Figure 1: Overture Network Data for Complete Network (left) and Target Networks (right), Part of India

Source: Overture Maps Foundation (2024-12). Transportation Theme] data. Retrieved from https://overturemaps.org.

(ii) In some low and middle-income countries, the posted speed limits are absent or outdated in OpenStreetMap data. Hence, project teams licensed proprietary telematic datasets from **TomTom**, providing speed distributions, speed limit references, and traffic counts. The team found *coverage to be ~70–90% complete in pilot regions, with some missing rural roads.*

Figure 2 shows speed limits for Chang Mai in Thailand and are given for all roads, although this is occasionally modelled.

Figure 2: Speed Limits in Chiang Mai, Thailand



Source: TomTom, Open Street Map

(iii) Mapillary images were used for imagery. These were filtered by recency (images from 2020 onward) to ensure relevance. Duplicates and images with poor resolution or obstructed views were discarded. The data collection effort resulted in a substantial volume of street-view images from key regions across South and Southeast Asia (Table 2).

Table 2: Number of Mapillary Images Available per Percentage of the Road Network

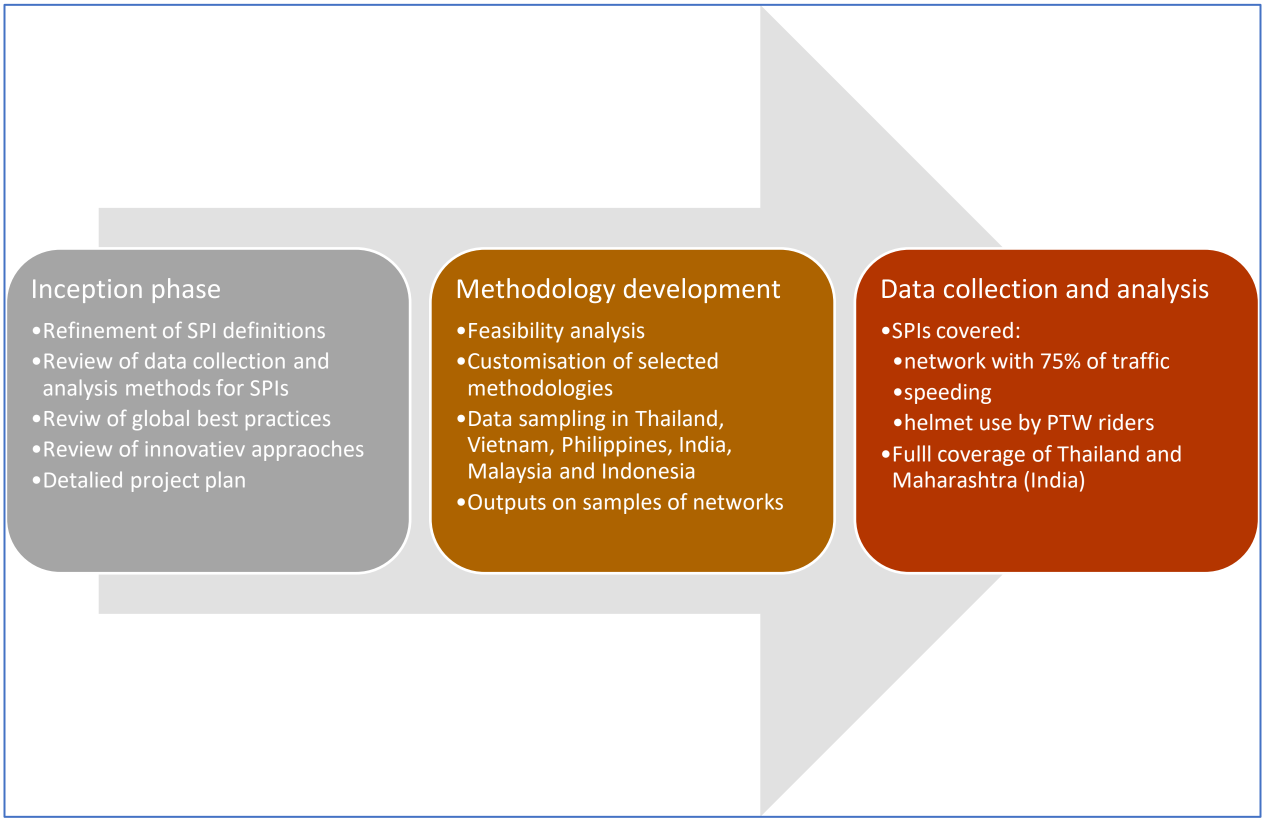
Country/Region	Travel Network Covered (%)	No. of Images	No. of Images Including Motorcycles
Viet Nam	6.0	1,225,411	964,892
Malaysia	13.4	1,507,722	509,069
Luzon (Philippines)	13.5	1,997,705	1,097,193
Karnataka (India)	5.7	230,295	155,588
Tamil Nadu (India)	4.9	88,372	42,886
Thailand	20.0	4,239,851	1,395,754
Indonesia	8.4	5,401,938	3,726,594

29. All data sources used adhered to anonymization protocols, ensuring no personally identifiable information was used. Image-based AI detection was restricted to identifying helmets, with no retention of facial or license plate data.

3.1 Process steps

30. The project proceeded in several phases. The key phases were the inception stage, the methodology development, the data and method feasibility analysis, and the full data collection and analysis (Figure 3).

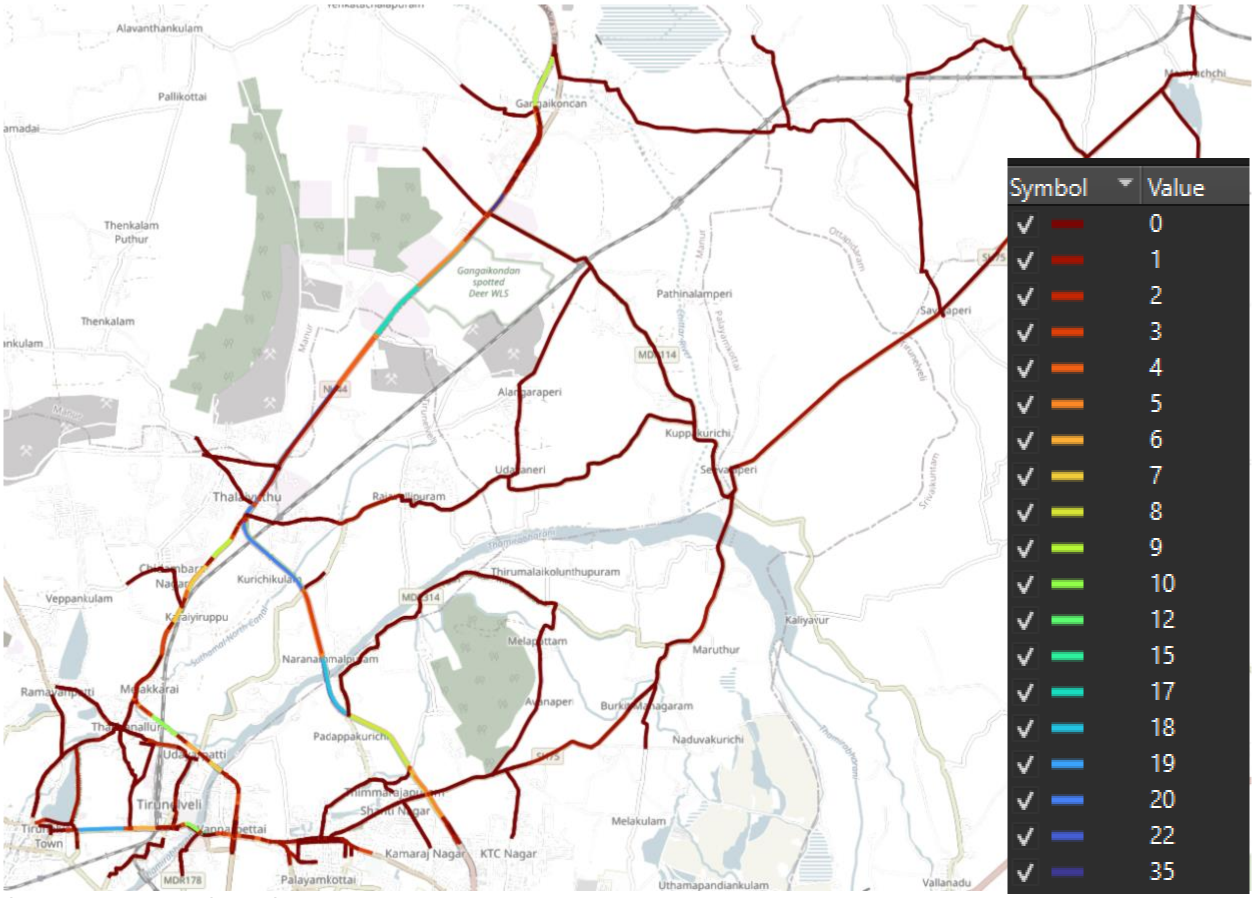
Figure 3: Key Phases of the Project



31. First, an inception phase refined SPI definitions and reviewed global best practices on SPIs. The team confirmed the three target indicators and scoped innovative data sources for each indicator (traffic volume, speeding, helmet use). A detailed methodology review then documented traditional versus novel approaches and set criteria for data quality and sampling.

32. Next, data collection and analysis methods were selected, customized, and tested on sample areas in several countries. The project selected India, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam, based on data availability. For Thailand, the Philippines, and India, small parts of the road network were sampled and a target “75% traffic” network was identified using available probe data. Using TomTom data, the team generated pilot traffic maps—ranking road segments by traffic and highlighting those that cumulatively carry 75% of travel (vehicle-kilometers). In one Indian pilot area (Tirunelveli), the TomTom data on probe counts was analyzed and roads were color-coded by quartile of traffic volume (Figure 4). The map shows in blue and green shades the busy roads that fall within the 75% threshold, and in yellow and dark red the lighter-travelled roads outside the threshold.

Figure 4: Tirunelveli Traffic Distribution Travel Map



Source: TomTom, Open Street Map

33. Parallel to mapping traffic volumes, the team addressed speeding using TomTom data. These data included detailed distributions of vehicle speeds for each road segment. This was used as the base to calculate the percentage of vehicles exceeding the speed limit on each major road. The focus was on “free flow” speeds (filtering out data near intersections or heavy congestion) to align with standard SPI definitions. A challenge encountered was the lack of reliable speed limit data in open sources for some countries. The team resolved this by using TomTom’s proprietary speed limit information to the extent available, although this also varied in quality and coverage.

34. In parallel, an Earth observation approach was reviewed in which high-resolution satellite images were processed with a pre-trained AI model to detect vehicles and calculate their speeds from image sequences. This had initially been validated in the United Kingdom and then tested on sample roads in Kenya and Ethiopia, with promising correlation to telematics data. However, due to cost constraints (satellite imagery can be expensive for large areas), the project team decided to rely on the more readily available probe (GPS) data for speeding in the main target country.

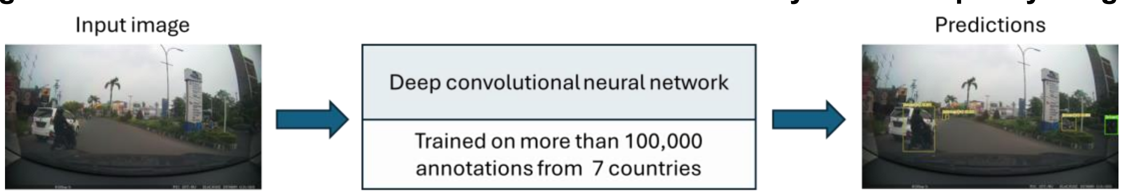
35. For helmet use, the project employed computer vision on street-level images. As Table 2 shows, many millions of images were selected from the Mapillary database and queried for target countries. The images were processed with a deep neural network to detect motorcycles and classify whether riders and passengers wore helmets. The methodology ensured sampling across different road types and regions by spacing out the image query points (minimum 15 meters apart to avoid clustering). A custom helmet detection model was trained and validated, detecting helmet use with only 2% deviation from human observers of the same data, which was deemed sufficient for SPI purposes.

36. Using these methods, the project proceeded to a full data collection and analysis phase in late 2024 and in 2025. Thailand was chosen as the primary country for full-scale implementation (due to its data availability and regional importance) for the 75% travel network and speeding. The team streamlined the process for Thailand: merging open road network data (using the new Overture Maps Transport Network) with TomTom's data, identifying the national 75% traffic network, and calculating speeding and helmet indicators for that network.

37. A secondary test was done for Maharashtra state in India for additional insights, given the partial coverage of the data sources.

38. For helmet use, Thailand was chosen, this time for its good Mapillary image coverage. Over 1.2 million images were analyzed, covering about 6% of the road sections. Figure 5 shows that the AI system identifies motorcycles and helmet use in these images.

Figure 5: Visualization of Workflow for Detection of Motorcycles on Mapillary Images



Source: Mapillary.

3.2 Analysis steps for each indicator

39. The specific analysis steps for each of the three indicators were the following:

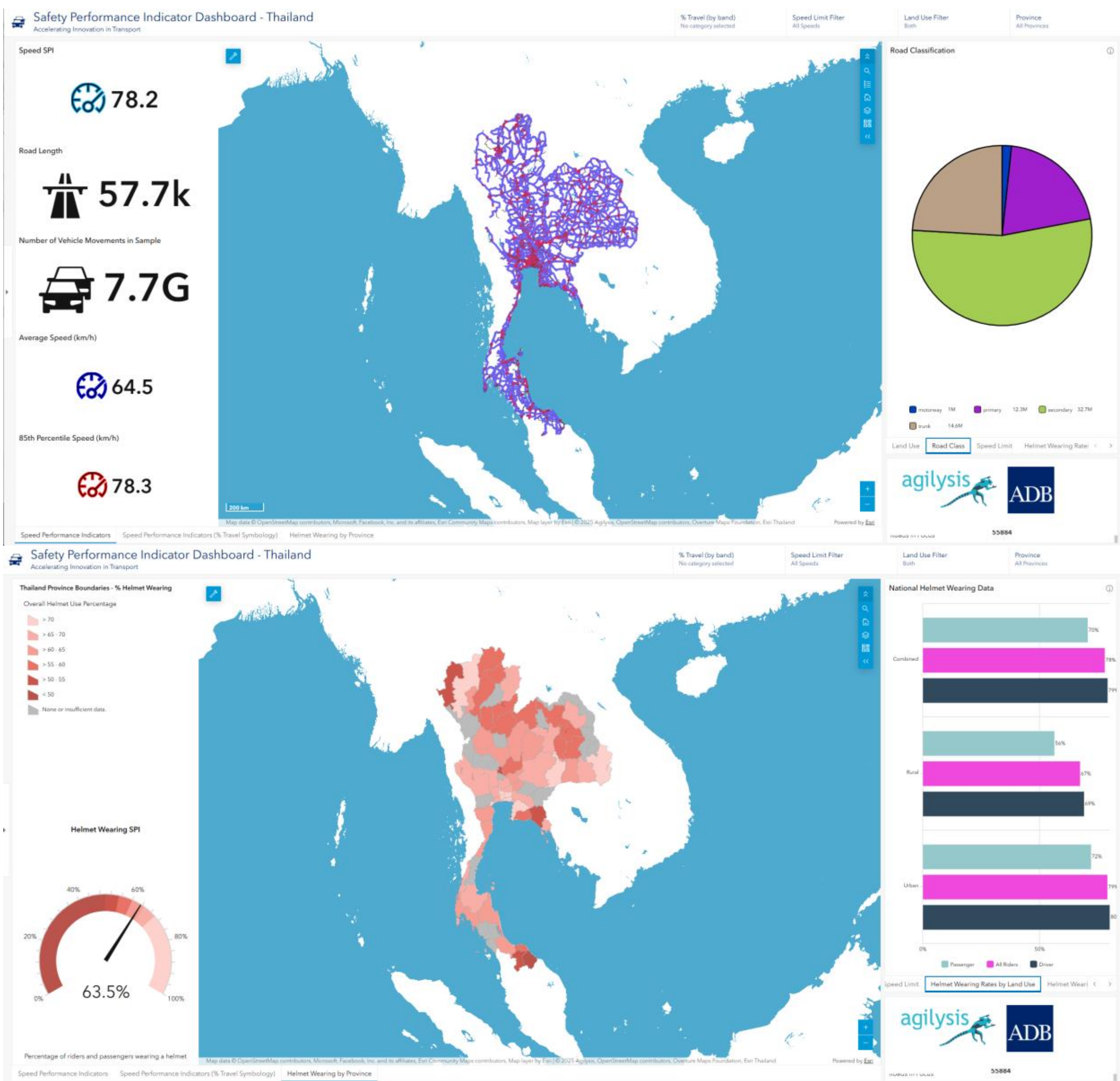
(i) For the calculation of the *75% of travel network*, first each road section was assigned an approximate traffic volume using aggregated GPS probe counts. Second, road sections were linked from the highest to the lowest volume, and then cumulatively summed until reaching 75% of the traffic total. During that process, trivial segments (e.g., local alleys) or data anomalies were excluded.

(ii) For the *speeding indicator*, the first step was to eliminate data which didn't meet the free flow criterion such as data from peak congestion periods or near large junctions to avoid artificially low speeds. For each road section retained, a computation was made of the daily/weekly percentages of vehicles above the posted limit. Data were aggregated by speed limit and segmented by urban, rural, motorway classes.

(iii) For the helmet wearing indicator, the first step was to map the image to relevant road segments, ensuring coverage distribution across different road categories. The AI-model processed images in batches, detecting motorcycles, riders, and passengers and subsequently classifying helmet use. The classification results were aggregated by geographic unit (province, district) and by road type (urban, rural, highway).

All data was subsequently made easily accessible via a dashboard (Figure 6).

Figure 6: Screenshots of the Safety Performance Indicator Dashboard for Thailand



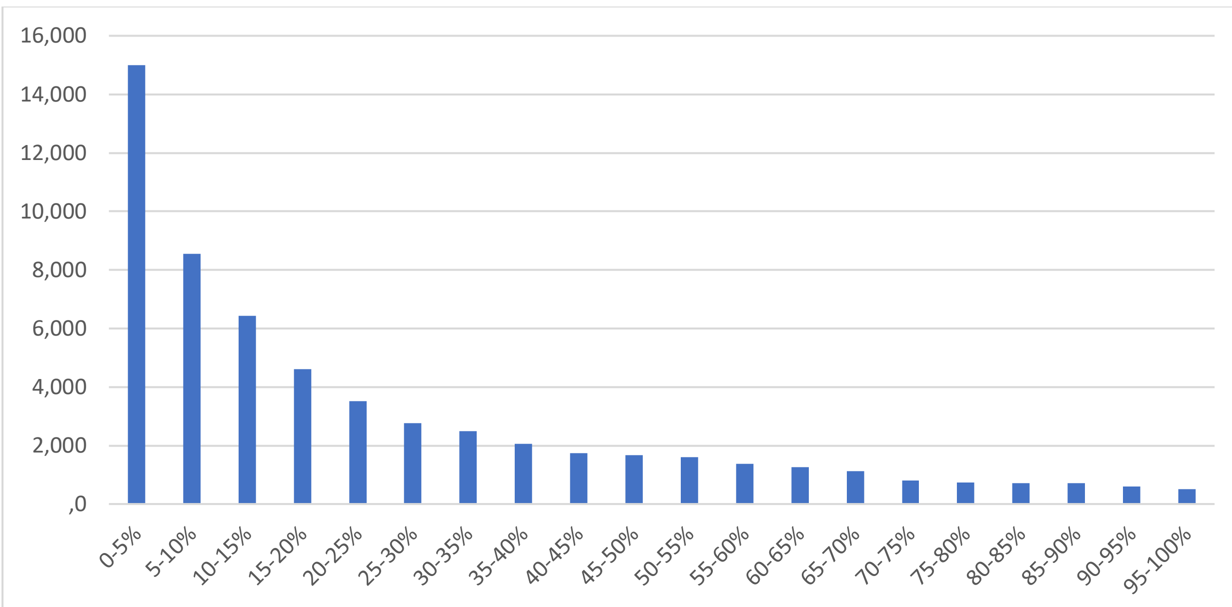
Source:

4. KEY RESULTS

4.1 Network with 75% of traffic

40. The analysis of data for Thailand and Maharashtra confirms that road traffic is highly concentrated on a relatively small share of the network, a pattern seen in other countries. In Thailand, 75% of travel is captured on 20,180 kilometers (kms) of roads, representing 34.6% of the sampled network (Figure 7). The total road network in Thailand is 390,026 kms compared to the 58,324 kms of roads in the sampled network, although the amount of traffic on the remaining roads is likely to be very small as they account for low functional class roads with little through traffic and minor roads in rural areas. It is therefore likely that 75% of national traffic may occur on a slightly longer road length than the 20,180km reported, but not significantly so.

Figure 7: Distribution of Road Length by Travel Percentile in Thailand



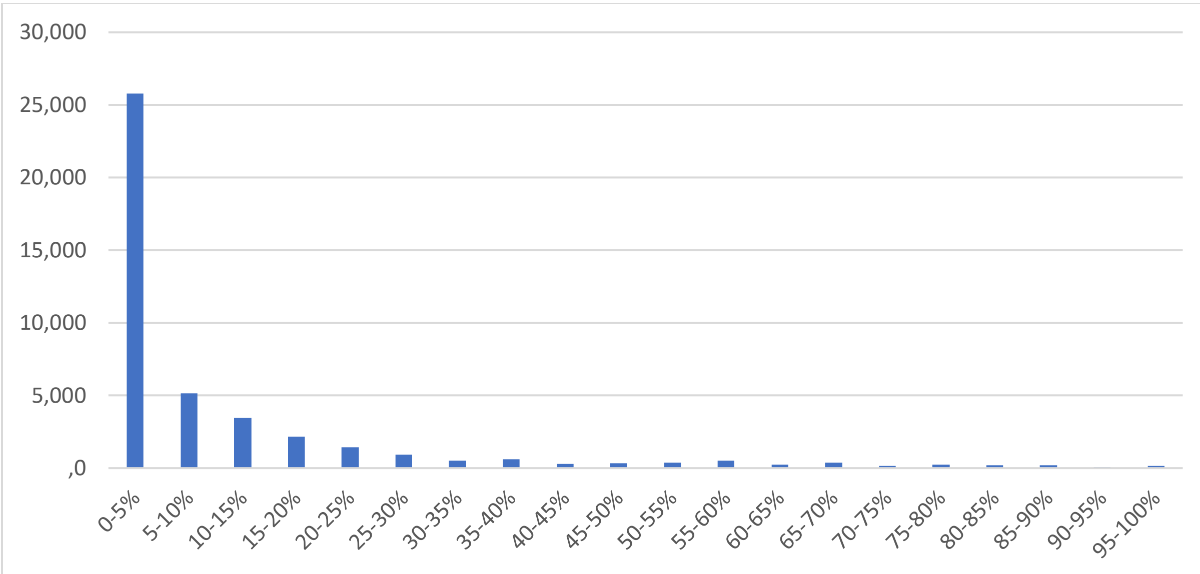
Source: Author's analysis.

41. Distribution is broadly consistent across road classes, with only minor differences between rural and urban areas, suggesting the sampling strategy is representative. Trunk roads dominate, carrying 18.4% of travel, while secondary roads account for just 7.2% despite forming more than half of the sampled network. This highlights both the efficiency of focusing monitoring on higher-class roads and the limited contribution of secondary routes to overall traffic.

42. In the state of Maharashtra (India) the concentration is even stronger: 75% of travel occurs on just 5,262 kms, only 12.2% of the sampled network (Figure 8). The total road network length was reported at 303,350kmin 2018and the same comments around low-flow roads constituting the remaining road links apply equally to Maharashtra as Thailand. Here, trunk roads overwhelmingly dominate, accounting for more than 90% of the traffic. Motorways and primary roads carry a modest share, while secondary roads are nearly absent from the critical 75% travel network.

43. Together, these results illustrate the value of identifying core networks: in both settings, targeting interventions on a small portion of the road system could address the majority of exposure and risks, supporting more efficient safety management.

Figure 8: Distribution of Road Length by Travel Percentile in Maharashtra



Source: Author's analysis.

4.2 Speeding

4.2.1 Speeding indicators

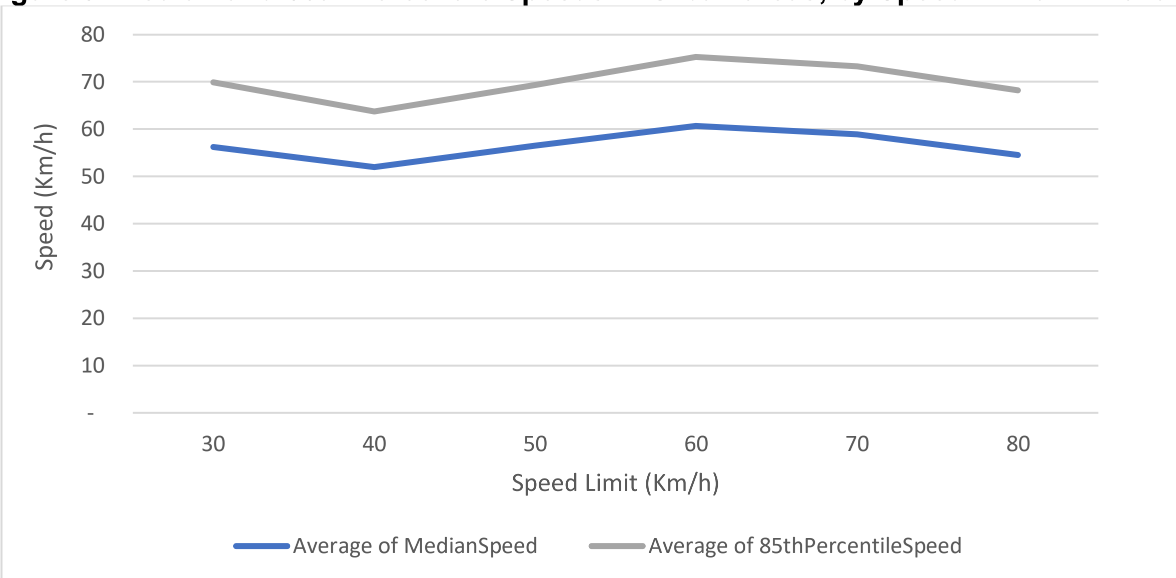
44. Using GPS probe data, the project calculated speeding rates on the 75% network. In Thailand, overall compliance across all road classes and speed limits is 70%. However, compliance varies significantly by speed limit. Drivers adhere well to higher limits, especially 120 km/h (99% compliance), but compliance drops sharply at lower limits of 50–60 km/h, averaging below 30%. This is concerning given that these limits typically apply in urban or vulnerable road user environments. The rural compliance (63%) lags behind the urban (73%), though in both settings actual speeds show little differentiation between posted limits of 30–80 km/h.

45. As Figure 9 shows, median and 85th percentile speeds remain remarkably similar across these limits, implying that congestion and road quality, rather than legal limits, primarily determine speeds. These findings suggest the need to review the alignment between posted limits, road function, and enforcement strategies in Thailand's urban areas.

46. In Maharashtra, compliance is lower overall at 54%, though this masks strong variation by road class and speed limit. Trunk roads with an 80 km/h limit show very high compliance (96%), aligning with Thailand's pattern that drivers respect higher limits. By contrast, compliance on roads with limits below 50 km/h is weak, often below 45%. Uncertainty remains about the accuracy of some recorded speed limits, which complicates interpretation, especially for unusual categories such as 45 or 55 kms. Nevertheless, the main conclusion is clear: drivers overwhelmingly comply where limits are higher, but compliance falls drastically at lower thresholds, exactly where pedestrian and motorcycle risks are greatest.

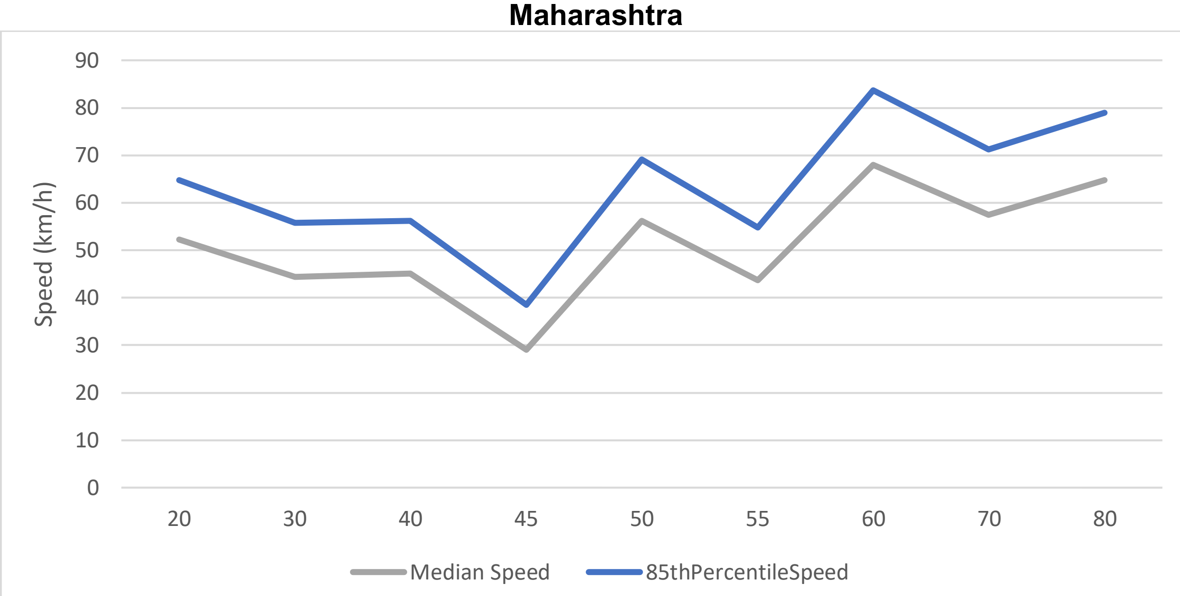
47. Analysis of median and 85th percentile speeds (Figure 10) reveal inconsistencies, with unexpected drops at 45 and 55 km/h, suggesting possible data weaknesses but also underlining the need for further validation.

Figure 9: Median and 85th Percentile Speeds in Urban areas, by Speed Limit in Thailand



Source: Author's analysis.

Figure 10: Median and 85th Percentile Speeds in Urban areas, by Speed Limit in Maharashtra



Source: Author's analysis.

48. Taken together, both case studies demonstrate the potential of big data to track speed-related SPIs. They also highlight a critical policy dilemma: while higher speed roads show encouraging compliance, the most pressing safety risks lie in lower-speed environments where compliance is poor. Strengthening enforcement, reassessing the validity and

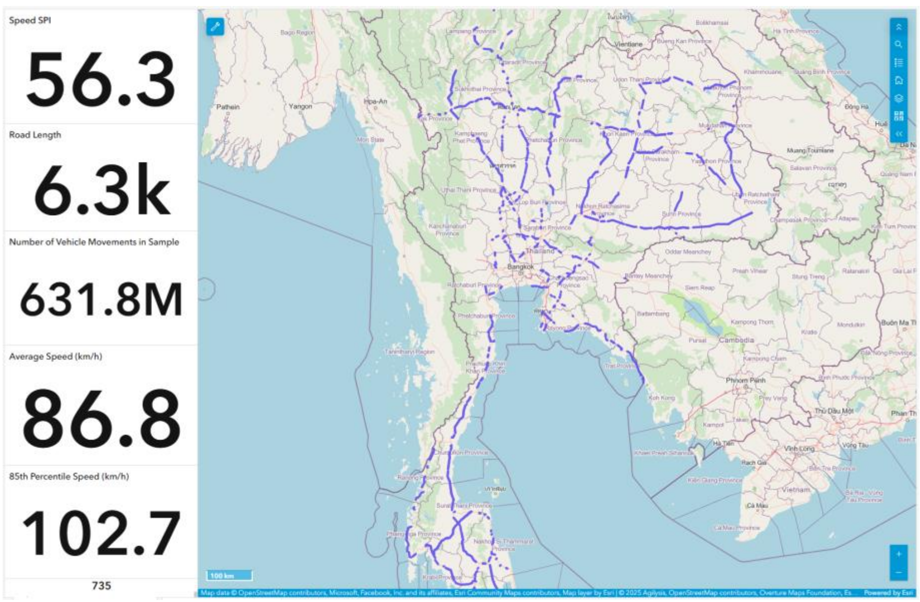
design of speed limits, and aligning limits with safe-system recommendations (e.g., 30 km/h in urban areas) are essential next steps.

4.2.2 Interactive dashboard

49. All of the results for both areas can be explored in more detail in the supplied interactive dashboard which will be hosted by ADB following the completion of the project. A separate document and user guide has been produced detailing how the dashboard works and the data processes used to create it and therefore only highlights of the functionality are noted here.

50. The two dashboards have exactly the same functionality for the speed SPI. Statistics are supplied for each individual road section which allows them to be grouped and analyzed based on a number of variables including land use, road classification, and speed limit. Additionally for Thailand, results can be filtered for individual provinces.

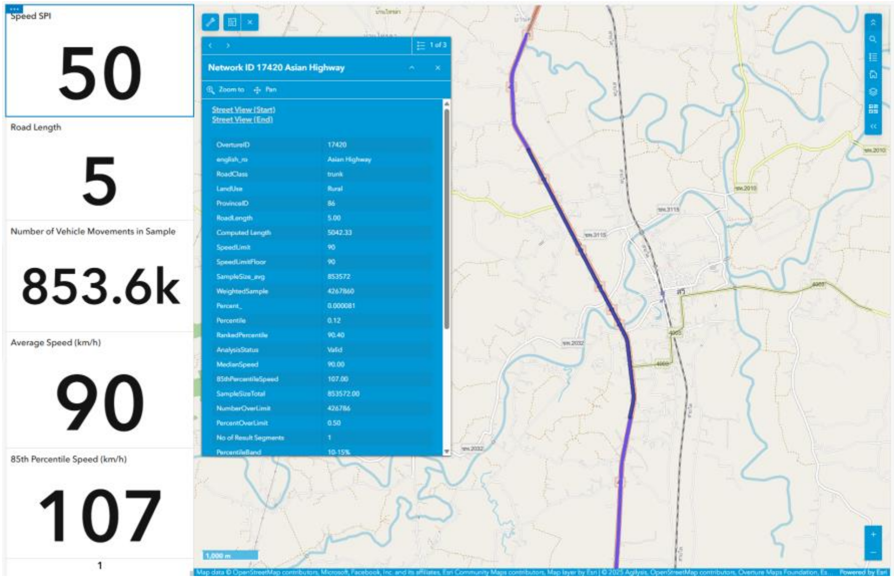
Figure 11: Speed SPI Dashboard Analysis in Thailand



Source: OpenStreetMap contributors, Overture Maps Foundation, Esri Thailand

51. In Figure 11 results are shown based on the filters applied for rural trunk roads with a 90 km/h speed limit. The key indicator is shown in the top-left-hand corner indicating the level of compliance with the limit. Below this are figures for the total road length analyzed and the number of vehicle movements included in the sample data. Finally, two additional figures are shown for average speeds (median) plus 85th percentile speeds. The analyzed network is shown visually on the map.

Figure 12: Speed SPI Analysis for a Single Road Section



Source: OpenStreetMap contributors, Overture Maps Foundation, Esri Thailand

52. Data for individual roads are also available by selecting an individual link. In the case here, a short, 5 km section of road has been selected with the indicators shown values for that road section only (Figure 12). The on-screen pop-up illustrates the raw data that sits behind the map for reference. All datasets have been supplied separately for future use. Pop-ups also contain a direct link to the most recent Google Streetview imagery for the start and end point of the road section (see photo).

Start points. A single road section (Google Streetview image).

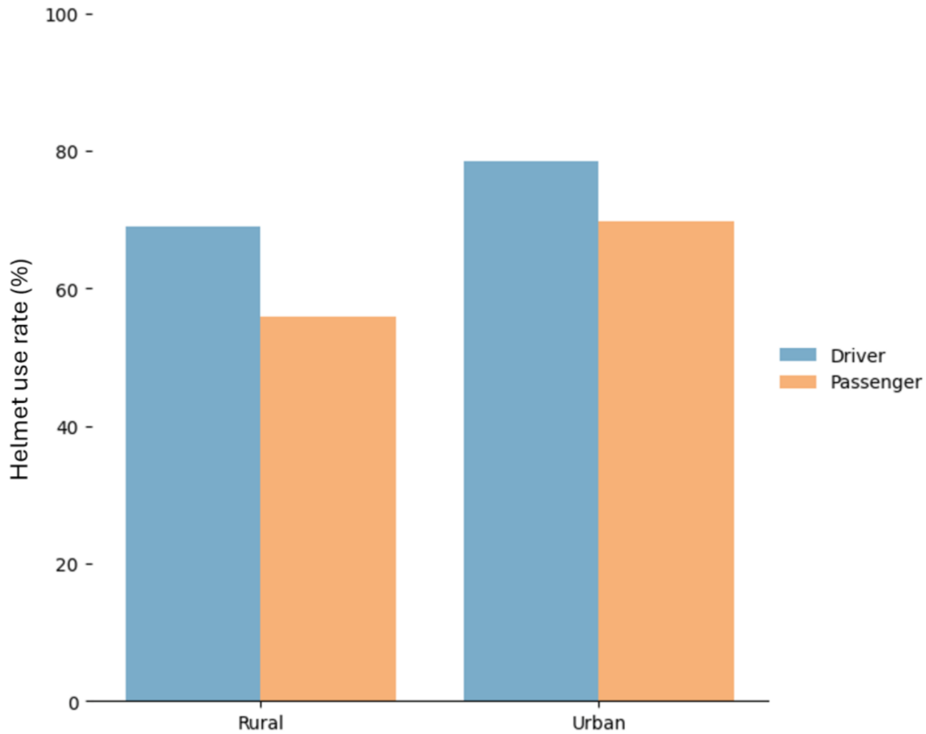
4.3 Helmet-wearing rates

53. Insightful results came also from the AI analysis of motorcycle imagery. In Thailand, average helmet use was observed with 76.2% overall in the timespan 2021–2024. This overall percentage was stable over the observed years, ranging from 73% to 79%. A large difference

was found between driver and passenger helmet use, where drivers had considerably higher helmet use (79.0%) than passengers (70.5%), a frequently effect.

54. Overall helmet use observed was higher in urban areas (78.9%) than in rural areas (67.2%) (Figure 13) (also a well-known effect). In this project, no stratification of samples was conducted; i.e., for the national helmet use indicator, all observations were considered, hence the indicator might overestimate helmet use since more Mapillary image data is available in urban areas, where helmet use is relatively high compared to rural areas. This also helps explain differences with WHO numbers , which put driver helmet use approximately 20% lower than what we found.

Figure 13: Driver and Passenger Helmet Use in Rural and Urban Areas of Thailand

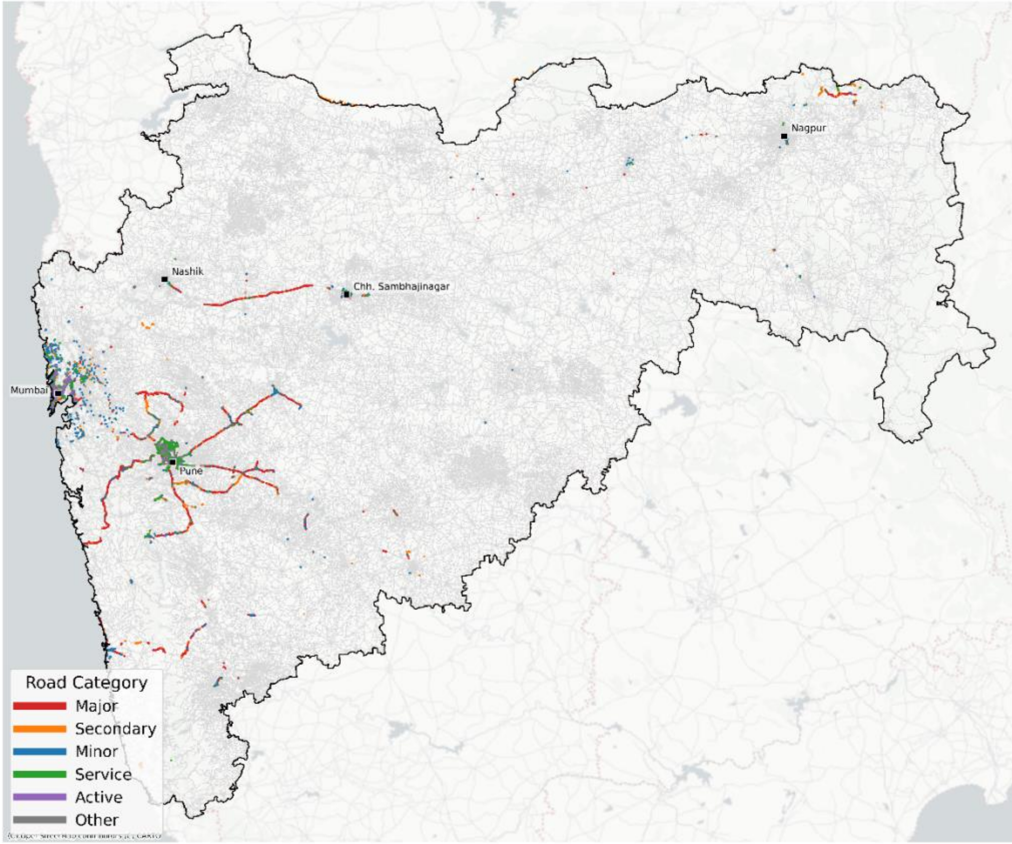


Source: Author's analysis.

55. Helmet use in Thailand is lower than necessary for effective injury prevention, and this data provides clear evidence base for targeted interventions (e.g., passenger helmet campaigns). The analysis also enabled breakdown by road type and region. The findings may reflect contextual factors, including behavioral norms and enforcement patterns, which warrant further analysis. Targeted campaigns may be more effective if tailored to local rider demographics.

56. An additional in-depth helmet use analysis was carried out for Maharashtra, India. The availability of Mapillary images collected between 2022–2025 is visualized in Figure 14. In total, 455,550 images were available for the researcher timespan.

Figure 14: Location of 455,550 Mapillary Images Available for Different Road Categories in Maharashtra in the Timeframe 2022–2025.



Source: Mapillary; OpenStreetMap contributors; CARTO.

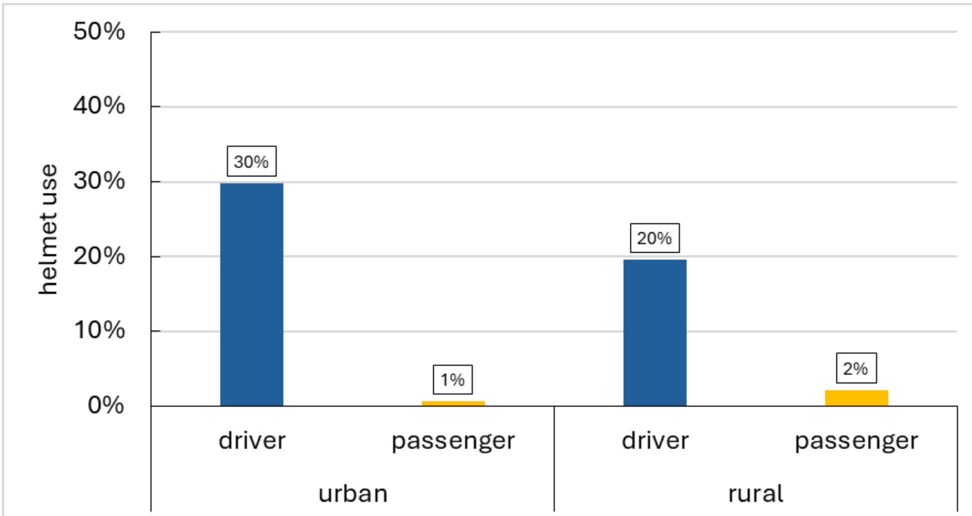
57. Since there was considerably less data than in Thailand, Maharashtra image data was not mapped to the 75% of travel road network, so as not to lose any data. Instead, all images within the boundaries of Maharashtra (collected in 2022–2025) were used for analysis. As expected from prior data collection in Thailand and Viet Nam, clustering of images can be observed around urban centers, where most Mapillary images are collected in Mumbai and Pune (Figure 14).

58. A new workflow for helmet detection was trialed for the Maharashtra data, where first, active motorcycles were detected (motorcycles with at least one person on them), and these detections were then assessed for image size and quality before rider number and helmet use were registered through the computer vision algorithm. This ensured higher helmet use detection accuracy, as detection was found to be suboptimal for very small motorcycles in the background of images in test runs on Maharashtra data. In total, more than 58,000 active motorcycles were detected on the Maharashtra Mapillary images about 40,000 motorcycles with only the driver, and 18,000 with driver plus passenger(s).

59. Overall, motorcycle riders in Maharashtra were observed to have 20.9% of average helmet use (disregarding rider position or distinction of urban vs rural observations). For drivers, a helmet use rate of 26.7% was registered, i.e., less than every third driver observed was using a helmet in our observation. For passengers, helmet use was 1.2% in this pilot study. A dedicated analysis of urban and rural areas shows that a similar pattern to helmet use in Thailand, where helmet use in urban areas is higher than in rural areas (Figure 15). Driver helmet use was observed during this pilot study as higher in urban areas (29.8%) than in

rural areas (19.6%). Passenger helmet use as observed during this pilot study was dangerously low, with only 0.7% in urban and 2.2% in rural areas.

Figure 15: Helmet Use for Drivers and Passengers Observed in Urban and Rural Areas of Maharashtra



Source: Author's analysis.

5. LESSONS LEARNED AND RECOMMENDATIONS

5.1 Lessons

60. This project has demonstrated the power and feasibility of leveraging big data, AI, and flexible analytics to overcome limitations for data collection for SPIs in low and middle-income countries. Innovative data methodologies can dramatically improve road safety monitoring in countries with limited traditional data.

61. From mapping the 75% travel network to detecting speeding and helmet-wearing patterns, these SPIs offer a pathway to proactive, evidence-based road safety policies. Even in low and middle-income countries, the novel data can be used to produce robust SPIs. While challenges such as cost, institutional capacity, representativeness and data completeness remain, the results obtained show that these hurdles are surmountable. Close collaboration with data providers is crucial for cost and coverage negotiations.

62. The pilot studies in Thailand and Maharashtra demonstrated the value of three key safety performance indicators in identifying critical road safety issues. The 75% Travel Network highlights how a small portion of roads carry most traffic; speeding SPI reveals where compliance is weakest; helmet-wearing SPI findings from the pilot suggest dangerously low helmet use in certain regions. Such data-driven insights allow policymakers to target interventions where they will save the most lives; Table 3 shows example interventions to address the highlighted risks.

Table 3: Potential Policy and Infrastructure Interventions Linkable to SPI Results

SPI	Potential Policy/Infrastructure Interventions
Speeding *(% of drivers*	• Establish and enforce 30 km/h zones in urban and pedestrian-heavy areas (aligning with global best practice for vulnerable road user safety).

respecting speed limit)	• Invest in automated speed enforcement (speed cameras, radar) on high-risk corridors and around schools/hospitals. • Traffic calming and engineering (speed humps, chicanes, rumble strips) on secondary roads where speeding is common. • Strengthen police enforcement on rural highways and improve signage; review speed limits to ensure they are appropriate and credible, then publicize and strictly enforce them.
Helmet wearing *(% motorcyclists wearing helmets)*	• Strengthen enforcement of helmet laws: Consistent fines and checkpoints targeting both drivers and passengers. • Launch public education campaigns on helmet safety, focusing on areas with low use (e.g., Pune) and on pillion riders (passengers). • Implement helmet distribution or subsidy programs for low-income riders and promote quality, standard-approved helmets. • Engage community and schools in promoting a “helmet culture”, and work with ride-share companies to mandate helmets for riders.
75% travel network ***(road network carrying 75% of total travel)***	• Prioritize safety upgrades on high-traffic corridors: ensure the roads carrying most travel meet high safety standards (e.g., upgrade to iRAP 3★ or better, add median barriers, improve junctions and pedestrian facilities) in line with UN Target 4. • Focus speed management and enforcement on these busy corridors for maximum impact (e.g., average speed cameras on highways, strict policing of speeding and drunk driving where most travel occurs). • Use 75% network mapping to guide infrastructure investment (targeting “high exposure” roads first) and to monitor progress toward the global goal of >75% travel on safe roads by 2030.

iRAP = International Road Assessment Programme.
Source:Authors

63. The project also highlighted some limitations. For example, reliance on a single provider’s data could be risky if coverage is uneven. In this project, India’s probe data sample was relatively low, making India less suitable for immediate rollout of travel and speeding indicators compared to countries like Thailand or Viet Nam with higher data coverage.

64. The ground-truth data gap was another issue. Due to difficulty securing recent on-ground traffic surveys, full validation was limited, including validations of existing speed limits. This is politically important since even partial on-site checks bolster confidence in novel methods. Nonetheless, the consistency of results and comparisons with known values (e.g., Viet Nam’s helmet rate, European speed trends) reassured that the novel methodologies are sound.

65. Importantly, the project also noted that Earth observation satellite methods, while useful for any location, are cost-effective only where other data (like GPS) are absent, due to current satellite imagery costs. Thus, in data-poor countries, they remain a viable last resort.

5.2 Overall recommendations

66. By combining big data and AI, policymakers now have access to actionable indicators—from which roads carry the most traffic to where speeding levels are comparatively high, to whether motorcycle riders are protecting themselves. Embracing these methodologies will enable evidence-based interventions aligned with the safe-system approach and help nations meet the ambitious targets of the UN’s Second Decade of Action for Road Safety.

67. The SPI pilots in Thailand and India’s Maharashtra demonstrate the feasibility and value of applying new data-driven methods in diverse contexts. Many countries across Asia and the Pacific face similar challenges, making this approach broadly relevant. Scaling up requires institutional ownership of SPI monitoring, regional training, and technical assistance (e.g., through the Asia-Pacific Road Safety Observatory, the South Asia Subregional Economic

Cooperation, academic partners), and wider access to digital data sources such as GPS probes and crowdsourced imagery. A phased roll-out strategy, starting with high-priority indicators like speeding and helmet use, would allow rapid deployment, early wins, and sustained institutional capacity development.

68. Knowing the 75% travel network can be a gamechanger, because it is a strategic way to concentrate efforts. Policymakers can adopt this concept to define a core road network for regular monitoring and interventions. By knowing which roads carry most traffic—and risk—the limited enforcement and engineering resources can be deployed more efficiently. The project's findings suggest this core network is often around 10%–15% of total road length. Focusing on 10%–15% of roads can yield disproportionate safety gains, especially where budgets and enforcement manpower are limited.

69. The project also underscores the importance and usefulness of using national and subnational SPIs. Measuring SPIs is not an academic exercise; it should directly inform policy and action. Countries adopting these new methodologies need to embed SPI targets in their road safety strategies. For example, if data show that 60% of motorists in a country routinely speed on highways, national and local authorities should formulate targeted speed management programs (such as enhanced enforcement, smart speed cameras, or infrastructure calming measures) and then use the SPI data to track progress. Likewise, if helmet use in certain provinces is lagging, this data provides a baseline to justify and evaluate public awareness campaigns or stricter enforcement.

70. By specifying numeric goals (e.g., reduce speeding from 50% to 25% of drivers in 3 years), governments can track interventions more dynamically. Routinely refreshing data (quarterly or annually) can help track progress and highlight emerging hotspots. Looking ahead, broad adoption of these methods can make a decisive contribution toward global targets—helping to halve road deaths and serious injuries by 2030 and beyond.

71. For global motorcycle helmet use assessment, this project is groundbreaking, and not just for low and middle-income countries. Never before has such a central, life-saving variable of powered two-wheeler helmet wearing been assessed countrywide with such temporal and spatial resolution. This opens doors for launching targeted remedial measures.

72. Taking Maharashtra as an example, any campaign that increases rider and passenger helmet use is likely to have immediate and tangible effects on saved lives, hospital costs decreased, and families protected from tragedy. For the driver helmet use, Mumbai offers good practice lessons, which has more than double the driver helmet use of riders in Pune.

73. The helmet use data collected in this project are the large-scale actionable evidence base that road safety practitioners have been hoping for since the start of the UN's first Decade of Action for Road Safety and the SDGs. The next step must be to scale this type of data collection up and advance it to more countries. One can easily envision a rolling assessment framework, where helmet use status is determined, interventions are tracked, their effectiveness assessed, and successes recorded.

5.3 Specific recommendations by target group

5.3.1 Recommendations to national and subnational authorities

(i) **Integrate SPIs into national and subnational strategies:** Embed key safety performance indicators (speeding, helmet use, etc.) into road safety action plans with clear targets (for example, halve speed violations in three years and raise helmet-wearing rates). Align these targets with global road safety goals (UN Decade of Action) and the safe-system approach so progress on SPIs directly contributes to halving fatalities by 2030.

(ii) **Focus on high-risk corridors and speeds:** Use the "75% of travel" network concept to prioritize enforcement and engineering on the small set of roads carrying most traffic (often 10%–15% of network length). Deploy speed management measures on these priority corridors and in urban areas where data shows rampant speeding. Adopting Safe System speeds (e.g., default 30 km/h limits in dense urban zones) will protect vulnerable road users and address the low compliance observed on lower speed roads.

(iii) **Strengthen helmet use enforcement and awareness:** Enforce helmet laws rigorously and conduct public campaigns, especially targeting motorcycle passengers and regions with poor compliance. Combine increased fines and roadside checks with education programs to shift behavior. Monitoring helmet-wearing SPI data by province or city will help pinpoint hotspots and track improvement over time.

(iv) **Invest in data systems and partnerships:** Establish or enhance road safety observatories or national road safety lead agencies to routinely collect and analyze SPIs using new technologies. Leverage partnerships with the private sector and research institutions to obtain cost-effective data (GPS probe speeds, crowdsourced images for helmet detection) and local expertise. Regularly updating these indicators will enable authorities to evaluate interventions and quickly address emerging risk areas.

5.3.2 Development banks and donors

(i) **Finance innovation in SPI data:** Support governments in scaling up modern data collection for road safety. This includes funding technical assistance and tools (e.g., procurement of speed probe data, AI systems for image analysis) to institutionalize SPIs in low- and middle-income countries. Such investments build capacity for continuous, evidence-based monitoring where traditional data is lacking.

(ii) **Embed SPIs and Safe System in projects:** Incorporate SPI metrics and safe-system principles into project design and policy dialogue. For example, for road safety loans or grants, baseline SPI measurements could be required. Focus investments on high-risk corridors identified by the 75% travel network and on interventions addressing prevalent risks (such as speeding on rural highways or non-helmet use in cities), then use SPI data to measure the project's impact.

(iii) **Broker partnerships to expand data access:** Convene collaborations between governments, tech firms, and data providers to widen SPI data coverage. For example, facilitate regional licensing deals for GPS traffic data or public–private partnerships for crowdsourced imagery, reducing costs per country. By fostering these partnerships, development banks help replicate the pilot's success across more regions and ensure that data gaps are filled cost-effectively.

(iv) **Align programs with global targets:** Ensure funded activities and national road safety strategies supported by development partners are aligned with the UN Global Plan targets (e.g., 50% reduction in speed-related deaths and near 100% helmet use). Use regional forums such as the Asia-Pacific Road Safety Observatory to share best practices and SPI results from pilot areas like Thailand and Maharashtra. Such exchanges can guide countries and donors in directing resources toward the most impactful, data-driven interventions.

5.3.3 Observatories and international organizations

(i) **Integrate SPIs into monitoring frameworks:** Include key SPIs (travel exposure, speeding prevalence, helmet wearing rates, etc.) as standard indicators tracked by national and regional road safety observatories. By institutionalizing these measures, organizationally the Asia-Pacific Road Safety Observatory and the South Asia Subregional Economic Cooperation can consistently monitor underlying risk factors and help countries gauge progress toward safe-system objectives between official crash statistic reports.

(ii) **Build capacity for data-driven safety management:** Provide member countries with technical guidance, training, and tools to collect and use SPI data. Regional observatories and organizations (Asia-Pacific Road Safety Observatory, ADB, United Nations, etc.) should facilitate workshops and twinning programs. Strengthening local analytical skills ensures that SPI data translates into effective policy action on speeding and helmet use.

(iii) **Coordinate data sharing and innovation:** Lead efforts to improve data access by pooling regional resources. Establish data-sharing agreements or collective procurement of commercial data (satellite imagery, probe data), especially to assist countries that lack coverage from any single provider. Observatories can also promote innovation challenges and research partnerships to refine SPI methodologies, ensuring that issues found in pilots (like uneven data coverage or validation needs) are addressed through collaborative solutions.

(iv) **Track regional progress toward global goals:** Publish regular reports on SPI trends (speed compliance, helmet usage, etc.) across countries to highlight achievements and flag ongoing risks. Linking these indicators to UN voluntary targets (targets 6 and 7 on speeding and helmets) provides a clear benchmark for the Decade of Action. International organizations should use these findings to advise governments and donors on priority actions. For example, if regional data shows persistently low helmet use among motorcycle passengers, prompt a coordinated response and resource mobilization to tackle it.

5.3.4 Nongovernment Organization and civil society

(i) **Advocate using evidence:** Leverage SPI findings to push for stronger policies and accountability. For instance, data showing widespread speeding or low helmet use can be used as evidence in campaigns for tougher laws, better enforcement, and adoption of safe-system measures (such as lower urban speed limits). Grounding advocacy in local data (e.g., a province's helmet-wearing rate) makes a compelling case for action.

(ii) **Community education and social campaigns:** Develop targeted outreach programs to address risky behaviors highlighted by SPI data. Focus on vulnerable groups and areas; for example, promote child helmet use in provinces with low rates, or anti-speeding campaigns in communities around high-crash corridors. Work with schools, employers, and media to change social norms, so that wearing helmets and respecting speed limits become broadly expected behaviors.

(iii) **Support enforcement and grassroots initiatives:** Partner with police and local authorities to reinforce on-the-ground action. NGOs can help organize community speed watch groups, assist with helmet distribution drives or incentive programs, and provide training to volunteers. These grassroots efforts, informed by SPI hotspot data, augment official enforcement and extend safety outreach into remote or high-risk areas that pilots identified as needing attention.

(iv) **Collaborate on data collection and transparency:** Contribute to improving data availability by crowd-sourcing information and sharing local knowledge. Encourage the public to report hazardous speeding zones or upload street images (to platforms like Mapillary) that feed into helmet use analysis. NGOs should also disseminate SPI results in easy-to-understand formats (scorecards, infographics) to inform citizens and maintain pressure on authorities to improve road safety outcomes.

5.3.5 Private sector

(i) **Provide data and tech solutions for safety:** Companies with relevant data or technology should actively support SPI monitoring. Map providers, telematics firms, and rideshare platforms can share anonymized speed and travel data or develop open APIs for government use. Likewise, AI and analytics companies can tailor their products—for example, helmet detection algorithms or dashboard analytics—to help detect risk factors at scale. Such contributions not only aid public safety but can open new markets for private innovation.

(ii) **Adopt safe practices and policies internally:** Employers and industry should use SPI insights to improve their own road safety footprint. Fleet operators and delivery companies can monitor driver speeding via telematics and enforce compliance; motorcycle manufacturers and retailers can promote quality helmets and incentivize their use. Setting corporate policies (like mandatory helmet rules for staff and clients, or speed governors on company vehicles) in line with safe-system principles will reduce crashes and demonstrate social responsibility.

(iii) **Invest in road safety initiatives:** Through corporate social responsibility programs or impact investments, private sector actors can fund and support interventions targeting the gaps revealed by SPIs. Insurance companies, for example, might sponsor community helmet campaigns or offer premium discounts for safe driving behavior. Large employers could partner with cities on improving high-risk corridors (e.g., lighting, signage, speed cameras). By directing resources to evidence-backed initiatives—whether increasing helmet use in a low-compliance region or curbing speeding on dangerous routes—businesses help accelerate progress toward shared road safety goals.

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