An Exploration of Weather Threats to Road Safety in Tropical Country

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Abstract – Adverse weather could impair the performance of many important parts in road transportation. In a tropical country, the threats posed by the weather phenomenon can be viewed from a different perspective as the situation may not be as extreme as snow-related problems or excessive temperature in other countries. Specifically in Malaysia, the situation may be underestimated due to several reasons such as the deficiencies in accident reporting and lack of research work. This background research has looked into various publications as well as related data to explain the need of more comprehensive research in the future.

INTRODUCTION

Transport demand and unsafe operation factors are the two factors that influenced the rate and severity of road accidents – the former is related to traffic exposures i.e. volume and traffic characteristics, while the latter is concerning unsafe vehicle operations [1]. The risks in vehicle operation may be contributed by the deterioration in driving and vehicle performance as well as unfavourable road and environmental conditions. Adverse weather is one of the environmental factors that is known to affect the performance of a "moving vehicle", especially in the situations where road friction is reduced, visibility is poor visibility and many other factors that impair driving performance [2-3].

The climate in tropical countries such as Malaysia may be "monotonous" due to the fact that the local climate has three general attributes – uniform temperature, high humidity and copious rainfall – round the year [4]. Perhaps due to that reason, the effects of weather conditions towards road transportation safety in Malaysia may be underestimated, speculatively due to underreported weather-related accidents by the police, lacks of research work on the said issues as well as insufficient measures to aid motorists to handle the demanding driving conditions in adverse weather [5].

Malaysia has undergone rapid modernisation, however, the performance of Malaysia's road safety is still not satisfactory with the fatalities alone is at around 6,000 per year since the last two decades [6]. Road accidents have also caused hundreds of thousands of serious injuries and permanent disabilities. It is suspected that unfavourable weather conditions may play a role in the road accident statistics despite the provisions of decent road facilities, the construction of expressways, more quality vehicles in the market as well as more organized drivers' training and licensing. Hence, the knowledge of the subject matter is important in order to better understand the influence of weather in local traffic safety, mainly in determining the risks and severity of road accidents in relation to bad weather.

RESEARCH MOTIVATION & FUNDAMENTAL FRAMEWORK

The overall intention of this study is to enrich the knowledge on the subject matter in terms of local environment, so that necessary measures can be taken to improve safety of motorists. Since the effects of weather phenomenon are substantially dependent on various local factors – e.g. topography, demography, and socio-economic – the roles of weather in contributing to road mishaps in tropical countries such as Malaysia are perhaps different from the conditions in other countries, particularly those with snow-related problems and other extreme conditions. A platform for this concern has been created at the Malaysian Institute of Road Safety Research (MIROS) level via the research cluster program – the ***Weather-Related Road Accidents Preventive Program (WRRAPP)***. Is it hoped that this research endeavour will provide valuable insights in every aspects, ranging from fundamental knowledge and understanding to well-organized provisions of safety measures and countermeasures.

At this exploratory stage, the major concern is on explaining the status quo of the subject matter through the revision of published and non-published materials along with accessing related data. Literatures that have been used in this study include local and international peer-reviewed journals, proceedings, books, reports and materials acquired from the web. The keyword used, among others, include "weather-related accidents" (also crashes), "precipitation" and "transportation hazard". Simultaneously, road accidents data and climatologically records were obtained from the police record and the Malaysian Meteorological Department (MMD), respectively. This study is also supported by the evidence acquired from in-depth crash investigations carried out by MIROS' Crash Reconstruction Unit (CRU). From the CRU's investigation files, the issues related to weather are featured to further support the need of this comprehensive research.

FINDINGS

The discussion of the preliminary findings is divided into five sections – (1) *Weather threats to motorists*; (2) *Local weather profiles & potential threats*; (3) *Related statistics*; (4) *Evidence from in-depth crash investigations*; and (5) *Malaysia's related efforts at a glance*. It is hoped that the issues of the weather threats to road safety in the country will be clearly explained.

Weather threats to motorists

The "weather" is a phenomenon in the local atmosphere at a given time where the atmospheric state can be explained in the form of precipitation, wind, fog, ambient light, temperature, etc. The "climate", on the other hand, is referred to the average atmospheric condition over a long period of time [7]. In many literatures, more often than not, the issues discussed are based on the form of weather variables e.g. rain, snow, ice, high wind etc. The topics discussed are, by and large, relating to accident statistics, accident severity and related risk, lab studies, surveys, effectiveness of safety measures, etc. The following overview on weather variables has put aside snow/ice related problems for the obvious reason, and the quest on precipitation issues is channelled to rainfall.

Table 1, based on the Haddon matrix, summarizes the weather-related issues in road transportation safety based on the literature reviews. Similar approach has been referred by several studies, among others, by Andrey et al. [1], Rowland et al. [2] and FHWA [8]. In the absence of snow-related issues, rain appears as the next eminent threat among other weather variables. Rain effects exist at all stages in road safety concerns – pre-crash, crash (event), and post-crash. The distraction can be either instantaneous or becomes effective after a certain period of time. For example, heavy rainfall reduces the visibility distance, produces road traffic obstructions and causes traffic congestions. In the long run, regular exposures to water may damage road structures as well as vehicle components. Another interesting fact about rain is the period so-called "dry spell" which can also affect the road structures as well as the drivers' adaptation to wet condition [e.g. 9-10]. In the event of vehicle crash, the outcomes in terms of casualty severity and collision mechanism may be different in rainy condition e.g. vehicles that are running-off road may be further involved in submersion, especially in the place that are less likely to contain water during fine days. Also, rain can contribute to multiple or chain-reaction collision perhaps due to visibility and traffic behaviour issues. Rain can also cause delays and difficulties in emergency response due to environmental and traffic factors.

Other weather variables – wind, ambient temperature, ambient light and fog – bear the threats mainly in contributing to road accidents (pre-crash). As in rain, fog and ambient light do distract drivers' vision by reducing visibility distance and glare, respectively. With regard to wind, particularly crosswind, vehicle stability becomes the main concern especially for vehicles with relatively high centre of gravity and large flat surface [11]. Wind also plays a role in distracting drivers by blowing dust or debris as well as delaying the recovery of haze phenomenon due to local factors [12]. High temperature affects drivers through deterioration in both psychological and physiological factors, as well as endangers the road structure and vehicle components' life in the long run. The detrimental effects to human are in the form of fatigue and aggressive behaviours, and drivers may "take" the effect of heat prior to driving despite the provision of in-vehicle air-conditioning system [11, 13].

Table 1 – Weather-related issues with regard to weather variables

<table>
<tr><th rowspan="2">Weather Variable</th><th rowspan="2">Road Traffic Element</th><th colspan="3">Weather-Related Issues</th></tr>
<tr><th>PRE-CRASH</th><th>CRASH</th><th>POST-CRASH</th></tr>
<tr><td rowspan="3">RAIN</td><td>Road</td><td>• Reduced friction.
• Hydroplaning.
• Obstruction – debris.
• Visibility distance.
• Flood – lane submersion.
• Landslide.
• Traffic speed & delay.
• Dry spell effect – viscous hydroplaning.
• Long term:
  ○ Pavement damages.</td><td>• Water body capacity & current – possibility of vehicle submersion.</td><td>• Response time – traffic.
• Ease of evacuation – obstruction by landslide, flood, etc.</td></tr>
<tr><td>Vehicle</td><td>• Braking efficiency.
• Effectiveness of:
  ○ Wiper.
  ○ Demister.
  ○ Vehicle lighting.
• Long term:
  ○ Vehicle & component life.</td><td>• Multiple/chain-reaction collision.</td><td>• Door opening in case of submersion.</td></tr>
<tr><td>Human</td><td>• Distracted vision.
• Poor driving skills – braking, appropriate speed (tailgating), etc.
• Adaptation to "Dry spell effects".
• Travel decision – Delay/cancellation.</td><td></td><td>• Delay in emergency response.
• More severe crash outcomes – drowning.</td></tr>
<tr><td rowspan="3">WIND</td><td>Road</td><td>• Obstruction – debris.
• Visibility distance – blowing dust.
• Traffic speed.</td><td></td><td>• Response time – traffic.</td></tr>
<tr><td>Vehicle</td><td>• Vehicle stability.</td><td></td><td></td></tr>
<tr><td>Human</td><td>• Driving skills & awareness.</td><td></td><td>• Delay in emergency response.</td></tr>
</table>

Table 1 – Weather-related issues with regard to weather variables (continued)

Weather Variable	Road Traffic Element	Weather-Related Issues		
		PRE-CRASH	CRASH	POST-CRASH
FOG (HAZE)	*Road*	• Visibility distance. • Traffic speed & delay.		• Response time – traffic.
	Vehicle	• Mist on vehicle glasses. • **Effectiveness of:** ○ *Demister.* ○ *Vehicle lighting.*	• Multiple/chain-reaction collision.	
	Human	• Vision. • Perception to speed. • Driving skills – appropriate speed (tailgating), etc.		• Delay in emergency response.
AMBIENT LIGHT	*Road*	• Reflection (also by roadside buildings, road furniture, etc.)		
	Vehicle	• Vehicle glasses – luminous resistance, reflection.		
	Human	• Vision – glare.		
AMBIENT TEMPERATURE	*Road*	• **Long term:** ○ *Pavement damages – softening, rutting, bleeding.*		
	Vehicle	• Traction. • **Long term:** ○ *Vehicle & component life.*		
	Human	• Comfort & endurance. • Optical illusion – hot road mirage.		

Local weather profiles & potential threats

Malaysia is situated in the Southeast Asia region, neighbouring Thailand, Singapore, Brunei and Indonesia. The country is separated by the South China Sea into two regions– the Peninsular (West Malaysia) and the Malaysian Borneo (East Malaysia). Its land area of 329,000 square kilometres is further divided into thirteen states and three federal territories. The majority of its 28-million population is concentrated in West Malaysia. On the whole, the landscape of Malaysia rises from the sea level to mountainous terrain with densely forested areas.

Being on the equator, Malaysia has a tropical climate with slight disparity in rainfall, temperature and wind across the country [4]. Despite the fact that the occurrence of extreme weather conditions is very rare as compared to other countries that experience winter or excessive heat effects, the atmospheric product such as rain is abundant, together with considerable amount of sunlight and relatively high ambient temperature. The wind in general may not be too strong but land-sea effect and mountainous terrain amplification create significant gusts of air. Additionally, although serious foggy condition rarely happens, some areas are prone to foggy condition especially during the wee hours. Also, the country in several occasions had experienced serious haze episodes due to biomass burning pollutants [e.g. 12].

The overall picture of local weather phenomenon and the potential threats carried by each weather variable are discussed as follows:

Rainfall

The mean annual rainfall for Malaysia is relatively high at 2,500 mm with the variation ranging from a low 1,500 mm up to over 4,000 mm. From a temporal perspective, heavy rainfall is very much determined by the wind flow pattern namely the Southwest monsoon (SW) and Northeast monsoon (NE). The SW monsoon takes effect from around early June to September, while the NE monsoon is from November through March. The period in between the two prominent winds, so called the inter-monsoon, presents relatively light and variable winds.

A more detailed rainfall dataset was provided by the Malaysian Meteorological Department (MMD) but it is limited only to data from 27 climatology stations in the Peninsular for an 11 year period (1997-2007). The daily rainfall data provides some insights on rain frequency and also the gap of dry spell period. On average, all places recorded rainfall occurrence on almost half of the days in a year, which means the exposure to rain is regular (mean = 178 days, 365 days a year). Furthermore, the gap of spell period usually took place between 1 and 7 days, more often from 1 to 3 days. Only in a few occasions did the spell periods extended for more than a month.

The above facts suggest that local motorists are highly exposed to driving in rain or on wet pavement. To an extent, it is a "good" exposure to encounter rain or wet condition rather frequently so that there is no "readjustment" issue – dry spell effects. However, in some other behavioural (driving) and vehicular issues, high exposure to such condition could bring serious threats instantly or in longer term, as mentioned earlier. At this stage, rain intensity in smaller temporal resolution is not available (minute/hour), but it has been observed that heavy rain in the country also creates serious visibility problems. Also, in some occasions, especially in built up areas, rain caused floods or flash floods that in turn caused traffic closure and vehicle submersion. A special mention goes to the highest population of road users in the country – the motorcyclists – whereby the presence of rain or wet pavement will create further disadvantages. Motorcycles will be less visible to car drivers (also other vehicles with drivers in cabin), and the motorcyclists themselves will find their vision being distracted by the rain droplets.

Wind

In approximately 40% of the time in a year, weak low level wind occurs in the country's atmosphere by virtue of stable condition in the equatorial region of Southeast Asia [12]. The monsoon wind blows between 10 and 30 knots (18 – 55 km/h), and the daily wind speed data (average) provided by MMD shows that areas closer to the shore recorded higher average wind speed than the inland areas. Normally, wind does not appear as an obvious hazard in Malaysia other than being the contributor to copious rain in the monsoon months. However, certain locations such as high terrain are exposed to wind amplification by the mountainous landscape. Since some substantial portion of the road network in Malaysia are built in such area, the possibility of sudden crosswind impacting the vehicle is high and such effect is rather unpredictable. Also, in heavy rain, the presence of wind could cause obstruction by flying debris, etc.

Fog/Haze

In general, serious foggy condition is very rare except light fog at certain areas during wee hours. Two kinds of fog are associated with these areas where the road networks are built – radiation fog in mountains or valleys, and advection fog near the coastline. It is assumed that this weather variable may only affect the nocturnal drivers but it is not as serious as the case in some other countries such as the United States – where chain collisions involving many vehicles occurred due to serious visibility problem [8].

In the case of air pollutants, Malaysia and the neighbouring countries had experienced several serious haze episodes in the past. This was due to plantation or farming activities involving biomass burning. In a more localized scenario, some paddy farmers set fire to their agricultural by-products (straw, etc.) near the road network. This haze condition not only caused health-related problems but also reduced visibility distance more than the fog in local environment.

Ambient light

Being close to the equator line, Malaysia receives abundant sunlight, on average of six hours per day. There are certainly some seasonal and spatial variations. For example, the northern part of the Peninsular is exposed to longer period of sunshine per day (as recorded in Alor Star and Kota Bharu). Road users in Malaysia are exposed to intense sunlight especially at noon and afternoon that causes vision's problem due to glare. During sunrise and sunset, the situation is more acute, when the sun is low and the rays shine directly into the eyes of the drivers. Coupled with ambient light, this is a harsh distraction for the vulnerable road user (VRU) groups especially the motorcyclists.

Ambient temperature

The temperature is unvarying round the year with the annual variation below 3°C. In a more time-specific scale, the temperature during the day is between 27°C to 32°C and between 21°C to 24°C at night. The lowest temperature ever recorded was 7.8°C in Cameron Highland (1978; 1,500 above mean sea level) and the highest was recorded at 40.1°C in Chuping (1998; northern, near to Thailand) [5]. Even though there is no clear cut desirable temperature, the ambient temperature can be categorized into cold (5°C), thermoneutral (20°C) and warm (35°C) [14]. Thus, local motorists are exposed to temperature between thermoneutral (night-time) and warm (daytime). As mentioned earlier, the effects of high temperature may start before driving in spite of the provision of in-vehicle air conditioning. So, it is hard to prove the contribution of ambient temperature to motorists' safety. On another note, motorcyclists may directly be affected by hot road and warm ambient temperature and thus the risk is speculatively elevated for this group of road users and also other VRUs like pedestrians and cyclists.

Related statistics

National accident records by Royal Malaysian Police

All road traffic accidents are managed by the police, specifically the Traffic Police Contingent of the Royal Malaysian Police (RMP). Their duties, among others, are ensuring traffic control, managing the scene and victims, collecting evidence and conducting interviews with crash participants and witnesses. In their procedure, the accident details will be recorded in a form coded as POL 27. This collection of the accident data is the official source of Malaysia's road accident database.

In POL 27, the prevailing weather condition is noted under the Surrounding Environment section (Item C, No. 34). The options to describe the weather condition are: fine (*baik*), strong or crosswind (*angin kuat atau lintang*), fog (*berkabus*) and rain (*hujan*) – original terms are in Malay (*italic*). Unfortunately, the percentage of this weather section being omitted in the record was quite high. For the 11-year record (1997-2007), the total number of investigated accident cases was approximately three million (all kind of accident severities), but the cases with recorded weather condition were only around 98,000. This figure represented merely 3% of the total cases, with the yearly basis performance was highest in 2007 (8.73%) and lowest in 2003 (3.44%). **Table 2** describes the distribution of cases based on weather classification using the available data. Despite the data deficiency, the distribution of accident cases with regard to weather classification still shows similar pattern as found in other countries like the United States [15], Canada [16], England/Wales [17], and Saudi Arabia (Riyadh) [18]. Road accidents mostly occurred on fine days, or in dry/non-adverse weather, followed by precipitation-based and subsequently other weather classifications.

Table 2 – Number of accident cases with recorded weather classification

Weather Classification	Number of Cases	Percentage
Fine	88,875	90.82
Rain	6,970	7.12
Fog	1,705	1.75
Strong wind/crosswind	306	0.31
TOTAL	97,856	100.00

Weather-related accidents in Malaysia's longest highway network

The longest highway network in the country, formally known as PLUS, runs for about 900 kilometres from south to north on the west coast of the Peninsular. It connects major cities and small towns, and serves as an alternative to the existing Federal routes. Since its operation in 1994, PLUS had handled a relatively high traffic volume each year and it surpassed 300 million vehicles per year from 2003 to 2007. Even though the police are responsible for road accidents on the highway, PLUS also operates its own accident/incident management and data collection. With the abovementioned facts, it is somewhat reasonable to use PLUS data as another source that could help to explain the situation, but with the understanding that this data only represents a portion of the accident counts and also limited to high speed traffic group – speed limit is mostly 110 km/h.

In the span of five years, from 2003 to 2007, approximately 37,000 road accidents occurred on PLUS that came with classified weather condition. The weather classifications are similar to the ones in POL 27 except for foggy and haze cases that are categorically grouped together. **Table 3** describes the data according to prevailing weather classifications. Again, the distribution according to weather condition was fairly similar to the previous dataset – in ranking order – but rain-related cases had a higher rate at around 27%. The two other classifications – fog/haze and strong wind/crosswind – represented only around 0.5% of the total accident cases.

Table 3 – Number of accident cases with recorded weather classification at PLUS (2003-2007)

Weather Classification	Number of Cases	Percentage
Fine	26,919	72.92
Rain	9,809	26.57
Fog/Haze	102	0.28
Strong wind/crosswind	87	0.23
TOTAL	36,917	100.00

Evidence from the in-depth crash investigation

MIROS has been carrying out in-depth crash investigations since its inception in 2007. This operation was inspired by the need to produce more comprehensive analysis and proper documentation of road safety issues – a common practice by the Ministry of Transport (MOT) with the help of local universities prior to the establishment of MIROS. MIROS through the Crash Reconstruction Unit (CRU) can be considered as successful at convincing the cabinet to introduce new rules/policies, or amend the obsolete ones based on the presented evidences. At this moment, the focus is more on high-fatality cases, heavy good vehicle (HGV) and express buses (long distance) operations, and assessing existing safety measures e.g. guardrail. Also, the team is responsible to any requests by MOT (classified as "Minister of Transport's Inquiry"; usually high-profile cases) or by other government agencies e.g. the traffic police for related services.

Within three years of operation, the team had attended more than 400 cases of various types of road accidents in terms of severities and collision mechanisms. Since the current operation basically covers the focal issues mentioned above in a nationwide scale, the investigation of weather-related cases can be considered rather indirect, but still the presence of the weather threats can be seen as one of the contributors to road accidents. The details of the findings are discussed as follows:

1. *Weather variables*
   As mentioned earlier, road accidents mostly occurred on fine days. However, from the investigation, it was found that 20% of the cases can be attributed to bad weather conditions, and almost all of them were rain-related cases. It was also observed that some accidents had not only happened due to single weather condition but combined with other conditions such as rain and light fog.

2. *Weather-related issues*
   There were several issues that can be associated to the weather threats as mentioned earlier in **Table 1**. For example, there were cases related to hydroplaning, visibility and conspicuity.

3. *Combined factors*
   The reconstruction analysis has revealed that some of the accidents were not only caused by bad weather condition (single or multiple weather variables), but also with impaired road and vehicle condition, which is also detailed out in **Table 1**.
   a. Road conditions:
      - There were pavement defects such as potholes, significant rut, etc.
      - Pools of water (rain) due to poor water mitigation.
   b. Vehicle profiles:
      - Poor vehicle condition especially bald tires and the use of snow tires.
      - Aged cars and roadworthiness issues.

4. *Collision mechanism*
   Due to the abovementioned reasons – whether or not the reasons being merely speculations (due to lack of evidences) – some of the accidents had ended up in more severe events. For example, an accident may be caused by poor pavement condition combined with rain, where the vehicle skidded, but subsequently, caused a chain-reaction collision. Another example is a car that went out of control and entered the opposite traffic, and caused frontal-to-frontal collision that usually resulted with more severe injury outcomes. Also, there were cases related to single vehicle accident (SVA) and running-off road, with the initial cause of the accident contributed by effects of bad weather conditions.

Malaysia’s related efforts at a glance

One way to look into the efforts in road safety intervention is the three E’s – engineering, enforcement and education [1]. With regard to weather-related road accidents, engineering advances such as vehicle and road traffic technologies are needed to help mitigate accidents risks. For example, vehicles nowadays are equipped with advanced brake systems such as anti-lock braking system (ABS) to prevent wheel lock-up especially in wet condition, and proper design of the road helps further to counter the problems of skid resistance and hydroplaning. The enforcement efforts could also reduce the risk by lowering the speed limit during bad weather, which can be done through the automated enforcement system (AES) and variable speed limit (VSL) system. And through educational-based interventions, drivers could benefit from comprehensive driver training program. Drivers could also benefit from dissemination of information e.g. weather forecast and near real-time traffic update. As of now, Malaysia does not have anything to declare as a “dedicated program” focusing on the road-weather problems. However, there are efforts that have been put in place to offset the effects of weather, as discussed below.

Road engineering

1. The Public Works Department (PWD) as the agency responsible for the construction and administration of roads in Malaysia has looked into the environmental issues such as surface runoff, drainage, flood-prone areas and other topographical concerns [19].
2. Road signs are planted to remind motorists of the possible hazards they might encounter e.g. the signs for “crosswind-prone area”, “slippery road when wet” and “landslide-prone area”. Some of them are retrofitted with light-flashing devices for additional warning and better conspicuousness of the signs, or accompanied by indicators such as wind sock.
3. For motorcyclists, there are special lay-bys or shelters constructed along highways that could accommodate up to 50 riders (and their bikes) at one time.
4. Variable message sign (VMS) is one of the Intelligent Transport Systems (ITS) technologies that has been utilised in Malaysia. Traffic advisory related to bad weather can be displayed to the motorists in real time.
5. Malaysia recently executed a road assessment project through the International Road Assessment Program (iRAP). The iRAP at the end of the day will help to determine high risk areas, and this effort, albeit indirectly, will also help to reduce weather-related accidents due to road deficiencies [20].

Vehicle profile

1. The trend of equipping the vehicle with advanced safety technologies is now growing. For the passenger car segment, the installation of ABS is becoming more common; however, this technology (or better, e.g. Electronic Stability Program – ESP) is still an option rather than standard fitment.
2. The use of tinted film is becoming more popular among local car owners. The film can filter out the sunlight and heat, but there is an unhealthy trend of installing over-tinted film. This, in turn, will cause visual impairment due to low-contrast condition.

Enforcement

1. Since enforcement by human-operated system is also affected by bad weather, the introduction of the Automated Enforcement System (AES) will optimise such activities. Malaysia is now in the progress of implementing AES in the country [21].

Media contribution

1. Weather forecast is available on the television, radio and websites. However, how the information affects the motorists behaviour is yet to be studied.
2. Most radio stations provide traffic updates especially during peak hours and this effort also covers any concerns related to adverse weather condition.

CONCLUSION & FUTURE RESEARCH

The weather condition in the tropical countries such as Malaysia may not be as extreme as in other countries that have to deal with snow and ice, extreme temperatures, frequent typhoon, and others. However, the considerable amount of precipitation as well as other form of weather variables may be significant contributors to road mishaps in the country. From the literature reviews, the weather threats are presented in a matrix that explain the possible situations in three important stages in road accidents – pre-crash, crash and post-crash. Road accidents in precipitation-based conditions that include rain (and snow) should be the next eminent case after accidents in fine condition. Without details on snow/ice issues, rain has emerged as the eminent threat among all weather variables. Even though this fact cannot be strongly supported by a conclusive analysis at this level of the research, the distribution of the accident cases according to weather classification was fairly similar to the pattern in other countries. The evidences that had been collected from the in-depth crash investigation activities also support the need of a comprehensive research and solutions for the issues.

Future research should consider both the fundamental knowledge and the intervention efforts. First and foremost, the accident reporting behaviour relating to weather needs to be reviewed so that the actual situation can be correctly interpreted. Concurrently, the research to support different parts of the intervention efforts must also be done e.g. relating to motorcyclist and other VRUs, vehicle profile such as active safety and roadworthiness issues, road and environment factors, etc. The partnership between related government agencies and local universities could aid the exploration of the subject matter in the future, with the main goal of improving safety of the motorists in the country.

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