Human and Animals Conflicts:
A case study of wildlife roadkill in Malaysia

Norhafezah Kasmuri [1], Nadirah Nazar , Abdullah Zawawi Mohd Yazid [2]

[1] Faculty of Civil Engineering,
Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia
[2] Department of Wildlife and National Parks (PERHILITAN),
KM 10, Jalan Cheras 56100 Kuala Lumpur, Malaysia

norhafezahkasmuri@uitm.edu.my, nazarnadirah@gmail.com, zawawi@wildlife.gov.my
Tel: 603-55436482

Abstract
Conflicts between humans and animals have been a challenge due to rapid urbanization. Most of the forest is cleared to build roads and highway. Thus, animals need to migrate or move for their survival. This paper aims to review wildlife roadkill data from PERHILITAN and arranged it under several groups of species. Here, quantitative analysis of the roadkill data is used to select one species as the primary subject (Malayan Tapir). It has been observed that Malayan Tapir has involved in 68 vehicle collisions with a total loss of RM6.8 million in 5 years. From these results, long-term mitigation measures have been addressed in this study.

Keywords: human; road construction; wildlife roadkill; mitigation

1.0 Introduction
The fast development planning for the overall economic and social expansion of the country makes Malaysia become a more productive country. The infrastructure, especially roads and highways are convenient for the public to commute from one place to another place in short or long distances. The facilities provided have encouraged the citizens of Malaysia to do their various types of business and economic activities. Hence, the result of the rapid development planning in Malaysia has made the country gained proper progress and greater success in economic growth and productivity.

However, the rapid urbanization of Malaysia in urban and sub-urban areas has significantly impacted the surrounding environment. Here, deforestation is a must to build roads and the highway. During the construction of this infrastructure, trees need to be cut as land is cleared to ensure the road and highway can be built. Thus, this creates conflict between humans and animals as the wildlife's habitat is gone and they are forced to migrate for their survival. This wildlife needs to find their necessities such as food source, water and shelter. This condition has dramatically reduced the quality of ecology and ecosystem services. If the situation prolongs, Malaysia is facing a severe problem with species extinction.

Furthermore, certain species can be found only in Malaysia's forest (WWF, 2018), which is valuable to the country. Road, while central to the function of human society, create barriers to animal movement through collisions and habitat fragmentation. Barriers to animal movement affect the evolution and trajectory of populations (Jacobson et al., 2016). Even though the quality of life for humans

is upgraded due to road construction, this contrasts with the wildlife. Here, this animal's existence is denied from the result of infrastructure development towards the economic expansion of the country (Sodhi et al., 2010).

1.1 Malaysia's Transportation System
Transportation infrastructure affects the structure of ecosystems, the dynamics of ecosystem function, and has direct effects on ecosystem components, including their species composition. The construction of transport lines results in the direct destruction and removal of existing ecosystems and the reconfiguration of local landforms (Coffin, 2007). Here is a lesson learned that not only humans should require to travel from one place to another to achieve specific purposes, but so do the wildlife's migrating for their purpose too. This whole situation is a disaster to the wildlife habitat, ecology system and diminishing the species for the overall 'resident' that living together in the tropical forests ecosystem.

Tropical forests are highly diverse systems involving extraordinary numbers of interactions between species, with each species responding in a different way to the abiotic environment. Understanding how these systems function and predicting their response to anthropogenic global change is extremely challenging (Fayle et al., 2015). The tropical forest ecosystems are highly complex and heterogeneous, comprising diverse networks of interactions between those communities and the environment. The knowledge of ecosystem services is vital. Here, the function, including carbon sequestration, climate regulation, and supply of water and conservation of biodiversity, need to be further understood (Fayle et al., 2015).

After World War II, Malaysia has achieved independence from the British, and from that, Malaysia has continued to gain pride in developing and fast-growth countries until today. However, due to all modernization, development and business, we tend to forget that our natural resources had been 'depleted' day by day. This decrease of natural resources, including land, forest, flora and fauna and freshwater in a few years ahead, would impact the quality of life for humans and wildlife significantly. From this scenario, it is crucial to sustaining our natural assets as this resource is valuable for us and our future generation. Environmental ethics on human relationships with the environment is vital for a sustainable ecosystem.

In line with Sustainable Development Goals 11 (to make cities and human settlements inclusive, safe, resilient and sustainable) by 2030, people need to reduce the adverse per capita environmental impact of cities to the surroundings (Pradhan, et al., 2017). From here, Malaysia continues to strive to boost its economy in line with getting profit from the development of road, infrastructure, buildings and housing. However, the implementation of sustainable pillars (environment, economy and social) imbedded in green structure would reduce the adverse impact on the environment. Best management practice in the construction phase until the execution of the project would significantly lessen the detrimental effect on the environment. Thus, could reduce the human-animal conflict as the green structure could assimilate as a part of the urban forest and can be replaced as habitat or niche for these animals (Ahmad Zafir and Magintan, 2016).

1.2 Significant of Study
This research paper is to highlight the problem faced by wildlife because Malaysia's road and transportation development have endangered them. However, the efforts from the Malaysian government for the development of transportation infrastructure need to be praised. The problem is that the way of doing it is less sustainable. Easy excess from the construction of road and highways are giving benefits to human and society. Unfortunately, this situation creates losses in wildlife in many ways. This structure would demolish the habitat of wildlife and forced them to migrate from one place to another for survival.

1.3 Aim and Objective
The aim of this research is focused on wildlife roadkill as each wildlife species has its price value in the ecosystem services, which can be regarded as an asset to Malaysia. Here, the review wildlife roadkill data from PERHILITAN has been arranged into its groups of species. Then the selection of one species and their number of collisions are determined in the price of monies, Ringgit Malaysia (RM). Later, the long-term mitigation method was suggested.

2.0 Literature Review
There is an existence of illegal trade and poaching involving wildlife due to the value of these animals such as Malay Tiger, Elephant, Tapir and many more are achieving millions of Ringgit Malaysia in higher demand. This problem has already caused the extinction of these species (WWF, 2018; Brown, 2017). The situation between humans and wildlife is an imbalance where we are enjoying the road facilities, but other creatures are suffering due to their habitat loss. A further difficulty arises facing the wildlife due to fragmentation of forest, ecosystem disturbance and species extinction. Here, the problem of animal roadkill is neglected as too many loopholes in the issue of their necessities. The death of animals due to road accidents is a significant loss to the country. The mistakes are lying at how the development process had being carried out. In getting the balance of human and wildlife needs, the change of methods in carrying out the development process would be necessary from a conventional system to a more sustainable approach.

2.1 Wildlife Crossings in Malaysia
The fragmentation of Peninsular Malaysia Tropical Forest from 1900 to 1990 due to urbanization has created diversity in animals' populations and habitats (UNDP, 2013). An experimental approach to road mitigation that maximizes inferential power is essential to ensure that mitigation is both ecologically successful and cost-effective (Rytwinski et al., 2015). In Malaysia, several initiatives from the

Malaysian government has been apprehended to mitigate the issues of wildlife. Several wildlife crossings have been considered and built, as shown in Table 1. This wildlife crossing is to reduce road and highway implications and facilitating the migration of these animals.

Here, eco-viaduct no.3 at Sungai Yu is the most extended (900m long) wildlife crossing structure ever built in Malaysia and South East Asia (JKR, 2015). The Malaysia Public Work Department built three eco-viaducts with the Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN) in the two corridor locations at Sungai Deka, Terengganu, and Sungai Yu, Pahang. The third eco-viaduct was built at Gerik, Perak, on Corridor Ecology of Central Forest Spine (CFS) built by Empayar Kukuh Sdn Bhd (Contractor), Perunding HJRS Sdn Bhd (Consultant) and Forestry Department Peninsular Malaysia (Client) (DURA Technology Sdn Bhd, 2014).

Table 1. Wildlife Crossings in Malaysia

No	Type	Name	Location	X Grid	Y Grid	Length (m)
1	Underpass Viaduct	1	Hulu Terengganu	502793	553193	245
2	Underpass Viaduct	2	Hulu Terengganu	504707	554963	140
3	Underpass Viaduct	3	Hulu Terengganu	507758	556506	245
4	Underpass Viaduct	Sg Yu 1	Kuala Lipis, Pahang	444022	505113	80
5	Underpass Viaduct	Sg Yu 2	Kuala Lipis, Pahang	443867	504679	250
6	Underpass Viaduct	Sg Yu 3	Kuala Lipis, Pahang	443705	502908	900
7	Underpass Viaduct	Belum	Hulu Perak, Perak	388060	618169	200
8	Overpass Crossing	N/A	Seremban, N9	436474	295033	N/A
9	Overpass Crossing	N/A	Port Dickson, N9	429862	278345	N/A
10	Underpass Crossing	M1	Hulu Perak, Perak	327169	610772	200
11	Underpass Crossing	M10	Hulu Perak, Perak	342843	605609	350
12	Underpass Crossing	M11	Hulu Perak, Perak	347069	603042	250
13	Underpass Crossing	M2	Hulu Perak, Perak	327721	609136	150
14	Underpass Crossing	M3	Hulu Perak, Perak	329637	608863	200
15	Underpass Crossing	M4	Hulu Perak, Perak	331463	608390	200
16	Underpass Crossing	M5	Hulu Perak, Perak	333346	609223	300
17	Underpass Crossing	M6	Hulu Perak, Perak	333738	609517	150
18	Underpass Crossing	M7	Hulu Perak, Perak	334218	609381	200
19	Underpass Crossing	M8	Hulu Perak, Perak	334954	608539	150
20	Underpass Crossing	M9	Hulu Perak, Perak	339403	608361	350

(Source: PERHILITAN, 2018)

2.2 Wildlife -Vehicle Collision

Despite the existence of wildlife crossing, cases of animal roadkill keep on increasing over the years. Data provided by PERHILITAN has shown that the death of animals recorded was 2,444 from the year 2012 until 2017. Table 2 listed the number of animals involved with the vehicle collision. The data collected from PERHILITAN can impose mitigation measures for the existing structures for further sustainability on ecosystem valuation. Besides, the analysis of data from animals' roadkill is determined quantitatively for further development of green structure in Malaysia.

Table 2. Wildlife Roadkill Data Recorded from 2012 to 2017

No	NDX	English Name	Scientific Name	Quantity
1	Mammals	Asiatic wild dog	Cuon alpinus	1
2	Mammals	Malayan Sun Bear	Helarctos malayanus	6
3	Mammals	Pig-tailed Macaque	Macaca nemestrina	9
4	Mammals	Binturong	Arctictis binturong	8
5	Mammals	Wild Boar	Sus scrofa	265
6	Mammals	Crab-eating Mongoose	Herpestes urva	21
		Small Indian Mongoose	Herpestes javanicus	2
7	Mammals	Asian Elephant	Elephas maximus	4
8	Mammals	Malayan Tiger	Panthera tigris	1
		Leopard	Phantera pardos	2
9	Mammals	Leopard Cat	Prionailurus bengalensis	88
10	Mammals	Serrow	Capricornis sumatraensis	2
11	Mammals	Long-tailed Macaque	Macaca fascicularis	439
12	Mammals	Slow Loris	Nycticebus coucang	1
13	Mammals	Malayan Porcupine	Hystrix brachyura	9
14	Mammals	Silvered Leaf Monkey	Presbytis cristatus	1
		Mitred Leaf Monkey	Presbytis melalophos	6
		Leaf-monkey	Presbytis sp.	1
		Silvered Leaf Monkey	Trachyopithecus cristatus	1
		Dusky Leaf Monkey	Trachypithecus obscurus	18
15	Mammals	Small-clawed otter	Aonyx cinerea	3
		Otter	Lutra spp.	11
		Hairy-nosed Otter	Lutra sumatrana	3
		Smooth Otter	Lutrogale perspicillata	5
16	Mammals	Yellow-throated Marten	Martes flavigula	1

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No	NDX	English Name	Scientific Name	Quantity
17	Mammals	Civet	Family Viverridea	2
		Common Palm Civet	Paradoxurus Hermaphroditus	418
		Malayan Civet	Viverra tangalunga	20
		Large Indian Civet	Viverra zibetha	6
18	Mammals	Sambar Deer	Rusa unicolor	1
19	Mammals	Malayan Tapir	Tapirus indicus	68
20	Mammals	Pangolin	Manis javanica	4
21	Mammals	Moonrat	Echinosorex gymnura	3
22	Mammals	Plantain Squirrel	Callosciurus notatus	3
		Oriental Tree Squirrels	Callosciurus prevostii	1
		Cream-coloured Giant Squirrel	Ratufa affinis	1
		Black Giant Squirrel	Ratufa bicolor	8
23	Reptile	Clouded Monitor	Varanus bengalensis	23
		Water Monitor Lizard	Varanus salvator	742
24	Reptile	Malayan Box Turtle	Cuora amboinensis	1
25	Reptile	Malayan pit viper	Calloselasma rhodostoma	7
		Viper	Viperidae	2
26	Reptile	Reticulated python	Python Reticulatus	59
		Blood Python	Python curtus	1
27	Reptile	King Cobra	Ophiophagus Hannah	16
28		Monocellate Cobra	Naja kaouthia	40
		Equatorial Spitting Cobra	Naja sumatrana	2
29	Reptile	Rat Snake	Ptyas spp.	4
		Indo-Chinese Rat snake	Pytas korros	1
30	Reptile	Dog-toothed Cat Snake	Boiga cynodon	2
Miscellaneous		Mangrove cat snake	Boiga dendrophila	1
Snakes		Malayan Krait	Bungarus candidus	3
		Common Malayan Racer	Coelognathus flavolineata	1
		Radiated Ratsnake	Coelognathus radiata	3
		Cave Dwelling Snake	Elaphe taeniura	2
		Snake	Suborder Serpentes	2
		Cave Racer	-	1
31	Bird	Red Junglefowl	Gallus gallus	12
32	Bird	Owl	Family Strigidae	3
		Barn Owl	Tyto alba	16
		Buffy Fish-owl	Ketupa ketupu	9
		Spotted Wood-Owl	Strix seloputo	2
33	Bird	Japanese Sparrowhawk	Accipiter gularis	1
		Eagle	-	3
34	Bird	White-breasted Waterhen	Amaurornis phoenicurus	19
35	Bird	Yellow bittern	-	1
Miscellaneous		Common Myna	Acridotheres tristis	7
Birds		Oriental Pied Hornbill	Anthracoceros albirostris	1
		Greater Coucal	Centropus sinensis	7
		Slaty-breasted Rail	Gallirallus striatus	1
		White-Throated Kingfisher	Halcyon smyrnensis	1
		Lesser Adjutant	Leptoptilos javanicus	1
		Black Naped Oriole	Oriolus chinensis	3
		Stork-billed Kingfisher	Pelargopsis capensis	1
		TOTAL		2444

(Source: PERHILITAN, 2018)

3.0 Methodology

Based on PERHILITAN data of the 2444 wildlife roadkill from the year 2012 to 2017, the result has been arranged for the quantity of roadkill for each species. The objective of this calculation is to select one species as a research primary subject. The selection depends on two criteria. The first criterion of roadkill quantity has been taken for consideration. The species with the highest roadkill quantities exhibited the most wildlife that prefers using this road to migrate from one place to another. Here, the species with the highest amount of roadkill is filtered out and shortlisted. The following criteria included the most endangered species (PERHILITAN, 2018). Among the shortlisted of the highest-ranking of roadkill's in Table 3, the species is then again chosen and clarified. Thus, the most endangered and extinct species were selected as a research primary subject. The selected species is the primary attention of this research study.

Table 3. The Highest Number of Animal-Vehicle Collision from 2012 to 2017

No	NDX	English Name	Scientific Name	Quantity
1	Mammals	Wild Boar	Sus scrofa	265
2	Mammals	Leopard Cat	Prionailurus bengalensis	88
3	Mammals	Malayan Tapir	Tapirus indicus	68
4	Mammals	Long-tailed Macaque	Macaca fascicularis	439
5	Mammals	Common Palm Civet	Paradoxurus hermaphroditus	418
6	Reptile	Water Monitor Lizard	Varanus salvator	742

3.1 Quantitative Data Analysis

Wildlife is Malaysia's valuable assets; some species could be found and available only in Malaysia. For example, Malayan Tapir and Malayan Tiger are considered valuable as these animals are originated from Malaysia (WWF, 2018). Hence, if the vehicles hit this nearly extinct species, their values of loss are believed to be more expensive due to the limited quantity of these animals. Furthermore, this threatened species is a favorite target of the poacher. As this animal's carcasses are valuable and have a high demand for illegal wildlife trade. Poachers have infiltrated in Malaysia Forest and plundered its wildlife, including tigers. Malaysia's wildlife is desired in the Asian market for use as folk medicine and as a sign of wealth (WWF, 2018).

This process only involves the species mainly selected as primary research subjects. It is advisable for the value of the species is compared according to their standard maximum fine stated in Malaysia Act 716, 2010 (Government of Malaysia, 2010). At the end of this process, the total value of the loss is the total of the roadkill's of selected species multiply by the per-unit price of the species (PERHILITAN, 2018).

3.2 Value of Killed Wildlife in Ringgit Malaysia (RM)

The selection of one species and their number of collisions were determined in the value of monies, Ringgit Malaysia (RM). The application of an ecosystem valuation concept (Australian Government, 2010). Here, this concept valued the ecosystem in monetary value (Australian Government, 2010). For example, a recent study by the Western Transportation Institute calculated the average total costs associated with an animal-vehicle collision for three species: $7,890 per collision for deer, $17,100 for elk and $28,100 for moose (Trombulak and Frissell, 2000; Huijser et al., 2009). The animal-vehicle collision is a lesson learned for people and young generation to appreciate the ecosystem services.

3.3 The Approximate Distance between the Wildlife Roadkill Location and Eco-viaduct

The quantitative analysis for this research was inducted to evaluate the existence of the eco-viaduct at the roadkill location of the selected wildlife dedicated as research primary subject. Here, a simple calculation was done to determine the approximate distance in kilometre between the eco-viaduct and the primary subject's roadkill locations. Here, Equation 1 is a basic trigonometry formula in getting the approximate distance between the eco-viaducts and the roadkill locations. In the wildlife roadkill data and list of eco-viaducts provided by PERHILITAN, all locations are given in grid coordinates with the result in metre (m) (PERHILITAN, 2018). This formula is divided by one thousand for unit conversion in kilometre (km). The data of the wildlife roadkill shows that these animals did not pass by the eco-viaduct. This calculation is purposely to determine locations that need eco-viaduct or animal crossings when the distance was found to be too far for migration. After the total locations were acquired, the cost-benefit analysis for the eco-viaduct is calculated.

(1)

$$Dis \tan ce = \frac{\sqrt{(x_2 - x_1)^2} + \sqrt{(y_2 - y_1)^2}}{1000}$$

4.0 Results and Discussion

In the selection of primary research subject, Table 1 indicated the species with the highest amount of roadkill would be filtered out and shortlisted. Among the shortlisted of the highest-ranking of roadkill's, one species is choose based on second criteria, the most endangered species (PERHILITAN, 2018). Based on Table 2, there are six (6) animals that considered the highest species being killed in roadkill from the year 2012 to 2017. According to PERHILITAN, Malayan Tapir is the most endangered and extinct species in recent times. Malayan Tapir is a fully protected wildlife in Malaysia (Government of Malaysia, 2010). Thus, to fulfill the second criteria, Malayan Tapir (Tapirus Indicus) has been selected as the primary research subject (PERHILITAN, 2018).

4.1 The value of the killed wildlife in Ringgit Malaysia (RM)

The value of the killed wildlife can be calculated in Ringgit Malaysia (RM) for each species for losses due to animals-vehicle collision (PERHILITAN, 2018). In this paper, Malayan Tapir's value of life was based on the maximum fine stated in Malaysia (Government of Malaysia, 2010). It can be considered that; wildlife species are precious. Therefore, this animal has become a victim of the illegal trafficking business. This wildlife sometimes not sold in one full item, but their body parts were sold separately (Brown, 2017). It has been revealed that Malaysia has become one of the transit points for illegal wildlife trade before heading elsewhere in Asia (Brown, 2017).

Based on the maximum fine, the life value of Malayan Tapir is RM100,000 per unit (PERHILITAN, 2018). The total value of the loss is the total of the roadkill's of selected species multiply by the per-unit price of the species. As a result, the total value of the loss is sixty-eight (68) Malayan Tapir roadkill's multiply by RM100,000 per unit price gives the total loss of RM6,800,000 or RM6.8 million in 5 years. It can be stated that the Laws of Malaysia International Trade in Endangered Species Act 686 and Wildlife Conservation Act 716 are the two (2) prevailing laws related to wildlife (Government of Malaysia, 2010). Most of the fine stated in this Acts is one hundred thousand

ringgits. That amount is higher than the price of a unit asset, which is reasonable for any wildlife misconduct (Government of Malaysia, 2010).

4.2 Result from the Approximate Distance between the Wildlife Roadkill Location and Eco-viaduct
Malayan Tapir is on the brink of extinction, being a victim in the roadkill has worsened the problem. The quantities of sixty-eight (68) Malayan Tapirs killed to prove that these species prefer to use the road for crossing. From this result, we can evaluate the distance of the eco-viaduct where the roadkill happened. The distance between the roadkill location and nearest eco-viaduct calculated was using Equation 1.

From the results obtained, for the nearest distance of roadkill with eco-viaduct for every 68 Malayan Tapirs killed, Terengganu, which owns three eco-viaducts, has the highest Malayan Tapir road killed. Pahang, which owns three eco-viaducts, is the second rank of the most road-killed of Malayan Tapir. Negeri Sembilan owns two eco-viaducts is in the third rank. The first three are the states that have more than one eco-viaduct, but the roadkill still happened. The last three are Johor, Kelantan and Selangor, the states that do not have eco-viaducts with average Malayan Tapir road killed. Pahang is the longest distance between the roadkill locations and the nearest eco-viaduct (208.07 km), and Negeri Sembilan is the shortest one. The results were not disclosed herein in the research paper.

However, Table 4 shows the simplified version of the Malayan Tapir road-killed in the states that have eco-viaducts. Terengganu, Pahang, and Negeri Sembilan. The average amount of Malayan Tapir road-killed found in the states that do not have eco-viaducts, Johor, Kelantan, and Terengganu. The states that have eco-viaducts need to have improvement plans to reduce the roadkill numbers. Meanwhile, the states that do not have the eco-viaduct may need to consider constructing a new eco-viaduct. The shortest distance found in Negeri Sembilan approximately 15.29km and the longest one in Pahang, which is about 208.07km. It can be observed that Malayan Tapir average distance to travel as far as 88.78km per month.

The shortest distance may be related to eco-viaduct effectiveness. Due to the lack of efficiency of these wildlife crossings, those animals did not feel attracted to use it. The roadkill happens at Kg Bukit Tangga, Kuala Pilah, Negeri Sembilan, and the nearest eco-viaducts were at Seremban, 37.3m Height Overpass (result not shown here). Improvement needs to be done on the design, and the tropical forest elements should be added more for this case. An improvement needed for the crossing structure or eco-viaduct, i.e., landscape maintenance, plants, salt licks and added fence. The research on wildlife behavior is recommended to identify the needs and majority of species living in this place.

Table 4 Malayan Tapirs Roadkill Range of Distances by State

No	State	Roadkill	Range of Approximate Distance (km)	No. of ecoviaduct	Value of Loss (RM100,000 per unit) (Act 716, 2010)
1	Terengganu	30	38.71 – 135.14	3	3,000,000
2	Pahang	13	139.62 - 208.07	3	1,300,000
3	N. Sembilan	6	15.29 – 45.04	2	600,000
4	Johor	13	N/A	No ecoviaduct	1,300,000
5	Kelantan	4	N/A	No ecoviaduct	400,000
6	Selangor	2	N/A	No ecoviaduct	200,000
	Total	**68**			**RM6,800,000**

4.3 Parameter of Consideration
Salt lick is used to attract the animals towards the eco-viaduct instead of using the road or highways for crossing. There are ten salt licks provided. The salt that is used is the same type used for cooking (PERHILITAN, 2016). Based on (Magintan et al., 2015), the definition of salt lick refers to any mineral spring or ground containing salt or any other mineral of which the consumption is conducive to the health or well-being of wildlife (Government of Malaysia, 2010; Magintan et al., 2015). Several preliminary observation of salt licks has been done with a total of 30 salt licks recorded at the protected area developed from the year 2011 to 2012 (Magintan et al., 2015).

Fig. 1: A photo of post-construction at East Coast Highway Underpass
(Source: PERHILITAN, 2018)

A 20km electrical fence has been installed along the way to block the animals from crossing the road. As for now, no animals reported dead due to the electrical fence (Kamarul Zaman, 2013). Several parameters for consideration on minimizing the wildlife roadkill are to have a lookout tower. Here, the function of a lookout tower is to monitor wildlife movement that passes through and within the area. Most of this lookout tower was built at the end of the eco-viaduct (Kamarul Zaman, 2013). However, frequent surveillance is needed in this facility to observe the animal's migration. Figure 1 showed the post-construction of East Coast Highway Underpass, and much need to be done to attract the animals for using this eco-viaduct.

More advanced technology, such as using a camera, is one of the options to reduce animal-vehicle collision. These cameras were installed in a few points at the eco-viaduct to help in collecting data, recordings, and monitoring the species that used the eco-viaduct (Kamarul Zaman, 2013). Landscape at eco-viaduct was planted with *Trema Angustifolia* and *Napier* grass as the main attraction for the wildlife to move towards the eco-viaduct. The plants are the main dish for wildlife, such as elephants and deer's (Kamarul Zaman, 2013).

In the United States of America (USA) and European countries (Slovenia, Switzerland, Germany, France, and the Netherlands) are much more advanced in mitigating wildlife issues (see Figure 2). There are several kinds of research done in improving the design of wildlife crossings (Rytwinski et al., 2015). Some mitigation measures include animal detection systems, wildlife warning signs, changes in road-verge management, measures to reduce traffic volume, speed and noise. Several alleviations such as temporary road closure, wildlife crossing structures, wildlife fences (e.g., barrier fencing or exclusion fencing) can be considered.

(a)   (b)
Fig. 2: (a) The animal bridge, USA; (b) The green bridge, Germany
(Source: Rytwinski et al., 2015)

Some of the methods are used to prevent wildlife from assessing the road which used funnel fencing that is built along with the wildlife crossing structures and avoid the wildlife from assessing the road. Hence, the wildlife reflectors, wildlife repellents and modified road designs for eco-viaducts and lighting is installed in bridges were also an approach to prevent the wildlife from crossing the road (Ford et al., 2010; Huijser et al., 2009)

This wildlife crossing structure (e.g., under or overpasses: amphibian tunnels, badger pipes, ledges in culverts, land bridges, rope bridges, glider, poles) combined with fencing to prevent mortality and funnel wildlife towards the crossing structures. This structure has gained considerable attention from transportation agencies (Van der Grift et al., 2013). Green landscapes and vegetation also need to be embedded in this crossing structure to attract wildlife in using this facility.

5.0 Conclusion

In conclusion, it can be observed from the research study an amount of sixty-eight (68) Malayan Tapir (as the primary research subject) has been killed due to vehicle collision in Peninsular Malaysia from the year 2012 to 2017. This Malayan Tapir's value of life is RM100,000 per unit price, given the total loss of RM6,800,000 or RM6.8million in 5 years. It can be noticed that several parameters need to be considered when building a wildlife crossing. This structure of eco-viaduct or eco-bridge can be designed creatively and more sustainable to suit requirement and necessities of the wildlife. Furthermore, several methods and mitigation measures to stabilize their ecology, nature and habitat need to be implemented. However, there are several recommendations to further extend the research in wildlife behavior. This task would take a lot of work and effort as it is essential to conserve our wildlife. Better understandings in wildlife behavior and necessities are needed as the appropriate design of the eco-viaduct can be established to suit the purpose of this structure.

Acknowledgements

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