A Case of First Canopy Bridges of Nepal at Banke National Park

Hariyo Ban Program

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Picture:

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Abbreviations and Acronyms

BaNP	Banke National Park
DNPWC	Department of National Parks and Wildlife Conservation
DoR	Department of Roads
GIS	Geographic Information System
GoN	Government of Nepal
IUCN	International Union for Conservation of Nature
LC	Least Concerned
m	meter
NP	National Park
RoW	Right of Way
TAL	Terai Arc Landscape
VWC	Vehicle Wildlife Collision

Summary

Haphazard development of large Infrastructure has not only increased risk to large mammals but also to small and medium sized mammals inhabiting in the area. This could pose serious threat on the ecosystem and biodiversity in the long run. Wildlife casualties due to vehicle accident is emerging as a serious threat due to roads traversing through protected and dense forest areas. There is a need for sustainable and wildlife friendly infrastructure development approach for balanced development and conservation activities to go hand in hand.

This study assesses the use and effectiveness of canopy bridges to minimize roadkill of arboreal species which is a very novel initiative in Nepal. Banke National Park where these bridges have been piloted records high number of roadkill including arboreal species.

Canopy bridges were regularly monitored using 9 remote camera traps for six months. 118 photographs of 4 different species were captured during the monitoring period of which the highest capture rate was that of the Indian Grey Langur (43.22 %) followed by Rhesus Macaque (30.51%) and Asian Palm Civet (25.42%). Out of the four monitoring periods/visits that was spread over a period of six months, maximum images have been detected during the third one (Dec to February) while the lowest was observed during the fourth one (Feb-March). In the five different locations where canopy bridges were installed, the highest number of images were captured in Muguwa area 2 with 91 counts. Images of four species were captured in all the canopy bridges. Images of the Indian Grey Langur, a native mammal species, was captured for 51 times with 14 independent detections contributing for highest count.

The study revealed that these types of simple bridges were frequently used by macaque and civet species and could be a potential mitigation measure to minimize roadkill to some extent. However, long-term monitoring and further research is essential to conclude its effectiveness and its potentiality.

Keywords:
conservation, infrastructure, arboreal species, Mammals, canopy bridge, roadkill

1. Introduction

1.1 Infrastructure Development Scenario and its impacts

The world spends about $2.5 trillion a year on the transportation, power, water, and telecom systems that underpin economic activity and provide essential services. But this has not been enough to avoid significant gaps, and investment needs are only growing steeper. It is estimated that investment needs to average $3.3 trillion annually through 2030 just to support current economic growth projections[1].

To achieve development goal of Government of Nepal (GoN) to graduate to middle income country by 2030, large investment in infrastructure development is an utmost requirement and has been a priority of GoN. Development of wide highways, expressways, railways, large irrigation canals have been planned and taking pace in the country. With increasing demand of these large linear infrastructure projects, their likely impacts to biodiversity are growing alongside.

Roads also have a much more direct impact on wildlife. Road mortality as a result of Vehicle-Wildlife Collisions. Besides the obvious impact to the individual animal, road mortality can also affect connectivity between populations on either side of the road, population size, population viability, and genetic variability, as well as representing a monetary loss (Huijser et al. 2009, Ascensao et al. 2013)[2].

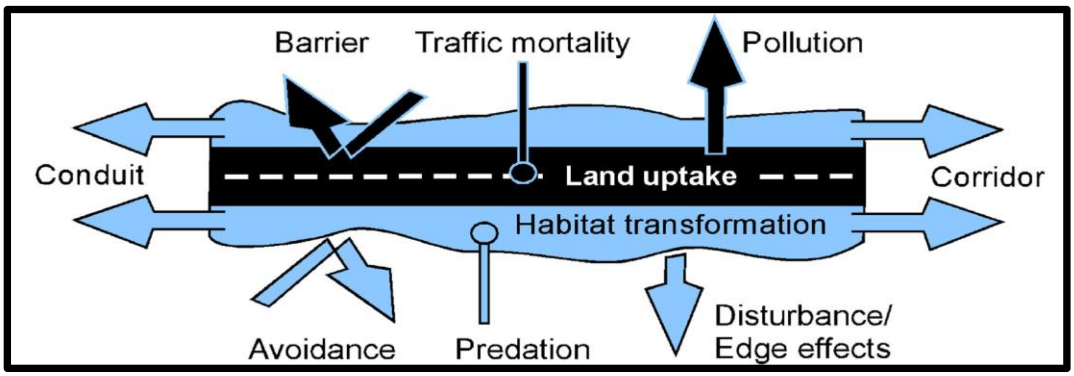

Figure 1: Various barriers to Wildlife due to Road

Source: Seiler 2001[3]

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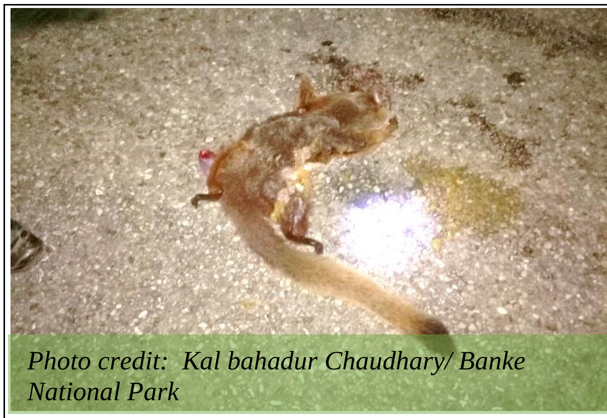
[1] *Bridging Global Infrastructure Gaps Reports, June 2016; Mckinsey Global Institute*

[2] *Huijser, M. P., Duffield, J. W., Clevenger, A. P., Ament, R. J., & P.T. McGowen. 2009. Cost–benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada: a decision support tool. Ecology and Society 14(2), 15.*

3 Seiler, A. 2001. "Ecological Effects of Roads: A Review." Department of Conservation Biology, Swedish University of Agricultural Sciences, Uppsala. Seiler, A., and L. Folkeson, eds. 2006. Habitat Fragmentation due to Transportation Infrastructure. COST 341:

Most of the under construction, planned mega projects of Nepal traverse through protected areas and critical forest area of corridors of Terai Arc Landscapes (TAL). This has not only increased the risk to large mammals but even small-and-medium sized mammals inhabiting in the area. Haphazard development of those linear Infrastructure projects could pose serious threats on ecosystem and biodiversity in long run.

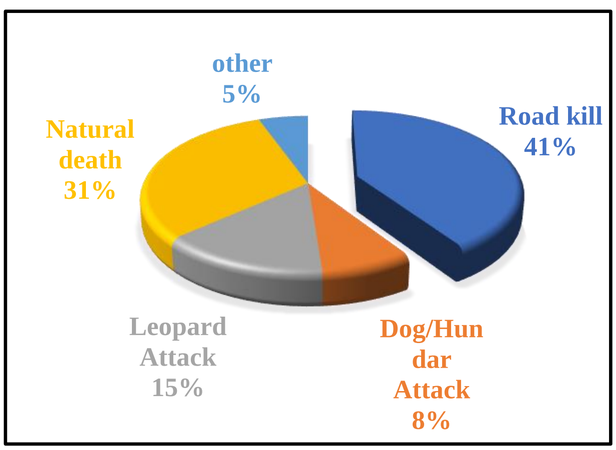


Common Palm Civet killed by vehicle at Banke National park

Group of Macaque species crossing busy Highway traversing through Banke National Park

1.2 Status of Vehicle Wildlife Collision (VWC) in Nepal

Department of National Park and Wildlife Conservation (DNPWC) is keeping record of wildlife causalities in and around core areas of National parks and conservation area of Nepal and as per their record of fiscal year 2017/18, a total of 326 wildlife causalities has been recorded. Among them, roadkill alone counts 41 % of total casualties, which is much higher than natural death (31 %). Most of the roadkill is recorded in Bardia National Park and Banke National Park (BaNP) alone (Figure 2), among which Spotted Deer (*Chittal*), Wild Boar, and Macaque are major species.



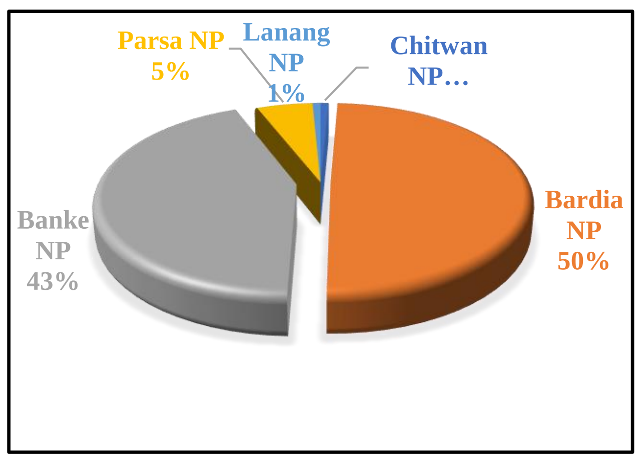


Figure 2: Cause of Wild animal casualties in various protected areas of Nepal

Source: DNPWC,2017/18

Table 1 below provides Year-wise roadkill data of BaNP:

Table 1: Roadkill data inside Banke National Park, 2019/20

S.N	Fiscal year	Roadkill inside BaNP	Remarks (Arboreal Species)
1	2014/15	24	
2	2015/16	50	Bandar- 1, Lokharke- 4, Nyari muso- 1, Gohoro- 1
3	2016/17	83	Bandar- 13, Gohoro-1
4	2017/18	72	Bandar- 7, Malsapro- 1, Gohoro- 5
5	2018/19	45	Bandar - 7, Lokharke- 1, Gohoro-1, Nyauri musa-1
6	2019/20	6	Bandar- 2, Lokharke-1, Gohoro -1, Nir biralo-1

Source: Banke National Park, 2019/20

To minimize potential roadkill incidents and promote wildlife friendly Infrastructure in Nepal, Department of Roads (DoR) has introduced its first Underpasses in Narayanghat- Mugling road section. With studies showing its use by several wild species, DoR has planned to construct various mitigation structures in other road projects as well.

1.3 Canopy Bridge - Introduction

Canopy Bridge is simple form of mitigating structure designed especially for arboreal animals to provide connectivity and to minimize impacts of habitat fragmentation where their movement along the roadside is frequent. Its design varies depending on the target species, topography and other factors. There are various designs of canopy bridges that are practiced around the world.

This type of mitigation practices is first initiation in Nepal. A simple design of such bridges is introduced for arboreal species.

Source: Ross L. Goldingay et al.2016: Targeted field testing of wildlife road-crossing structures: koalas and canopy rope-bridges

2. Objectives

Major objective of piloting the Canopy Bridge is to assess if it supports habitat connectivity of arboreal animal fragmented by linear Infrastructure development such as roads and to minimize the effects of linear barriers. As many wild animal casualties including arboreal animal are recorded along the highway traversing through dense and critical habitat area, the bridge aims to minimize roadkill and maintain canopy connectivity in long run.

3. Methodology

3.1 Location

Possible location for canopy bridge installation were identified based on various literature study and a series of walkover survey throughout the highways traversing through these park areas. Various stakeholder consultation with National Park Authority, Army personnel, District Road office, and key local informants were conducted to collect available information. Roadkill data from Banke National Park was very supportive in identifying feasible location for canopy bridge installation. Location of installed canopy bridges is shown in ***Figure 3***.

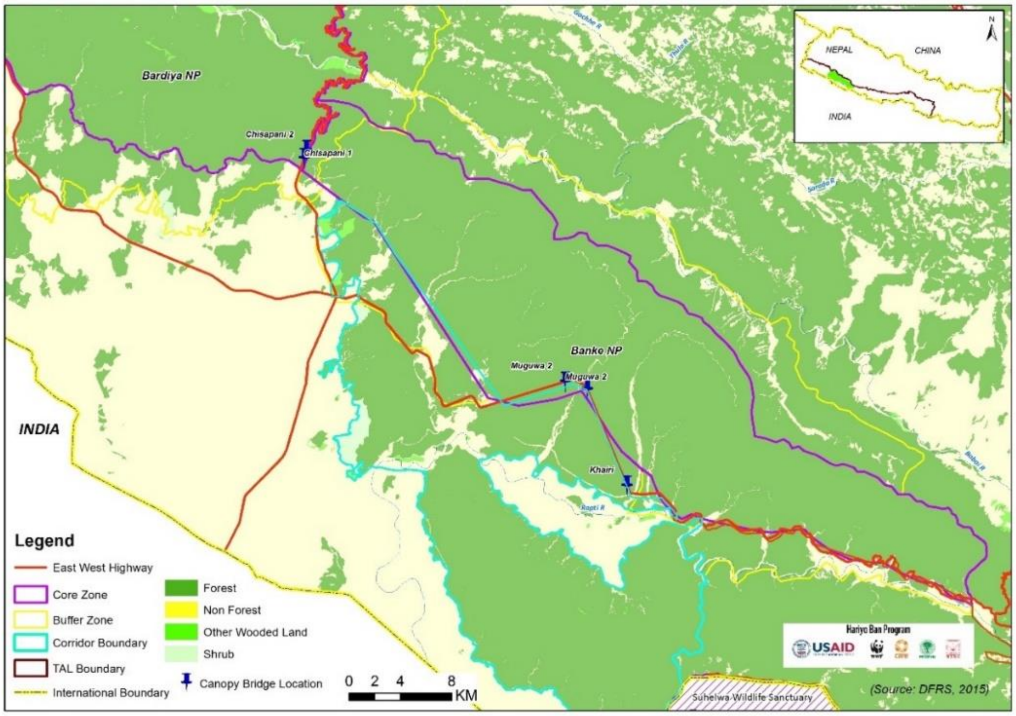


Figure 3: Location Map of Canopy bridge installation

3.2 Designing

As this is a pilot program and very first of its kind in Nepal, a simple design of bridge was adopted. A jute rope of 1 inch and silk rope of 0.5 inch in diameter along with small branches were used to prepare the canopy bridge. A net structure was prepared with jute and silk rope. A gap of 8 -9 inch was maintained in between two lateral ropes to make a net like design. At Muguwa site 2, two bridges were installed at location adjacent to each other to see variation of its design.

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3.3 Installation

All the installation work was done with support and close coordination with Banke National Park and Nepal Army personnel. Local people were hired for preparing and installing canopy bridge as per requirement. A standard installation procedure, which are appropriate to our country context was followed to the possible extent. Standard recommendations for placement of bridge as per international practice is highlighted in box below.

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Standard recommendations for placement of bridge as per international practice

1) Consider placing canopy bridges in *all* linear infrastructure projects (pipelines, roads, power lines, etc.). Our data suggest that a wide diversity of mammals benefit from their presence.
2) Include bridges in the design of the project as early as possible when studies are carried out for the EIA. Bridges can be established with the least interruptions to construction activities and least cost if they are considered by the topography team when first selecting the route of the infrastructural element. If bridges are not considered at this early stage, it is much more difficult to accommodate bridge trees if they are not located directly on either side of the RoW.
3) Have a biologist accompany the topography team as they select the route for the RoW in order to identify the best bridge candidates. Before going into the field, the biologist should evaluate which arboreal mammal species are present in the area and likely to use bridges.
4) Select bridge locations that are not near slopes, on curves, or on ridges. Bridges are difficult to engineer in such locations and may not last in the long run. If possible, perform a GIS (Geographic Information Systems) analysis before going into the field to estimate the best potential areas for bridges.
5) Select trees that are between 12-16m apart, with a minimum of 8m. Most machinery cannot pass between trees that are less than 8m apart. the planned width of the RoW, and/or the machinery being used for construction.
6) Use a range finder to measure the height of the crossing point and ensure that it is over 6m. Machinery must be able to pass beneath the bridge on the RoW
7) Select bridges at a variety of crossing heights. If a bridge is outside of the range of the canopy levels used by a species, the bridge may not be useable. For example, some small primates use the low canopy (~10-15m) and may be reticent to use a 35m-high bridge.
8) Select large trees (diameter at breast height >50cm) that are in good health and have no broken branches or a damaged trunk. Ensure that the trees are protected throughout the construction project. Mark the trees with large "DO NOT CUT" signs so that all construction crews take care not to hit them. If the bark is damaged by machinery, the tree may die.
9) Avoid fast-growing, pioneer tree species (e.g., *Cecropia* spp. in the neotropics) for bridges since they may have little structural integrity and are prone to fall. Also avoid using palms (Arecaceae spp.) since they lose their fronds periodically, and a connection may be lost as the tree grows.
10) Consider both the connectivity of the branches above the RoW and the continued connectivity of the bridge trees to the rest of the canopy on either side of the RoW. A bridge with no "destination" in the broader canopy network is unlikely to be useful to animals.
11) Design a simple monitoring program to determine the effectiveness of the established bridges.

Source: Tremaine Gregory et al. 2013: Methods to Establish Canopy Bridges to Increase Natural Connectivity in Linear Infrastructure Development

Based on various roadkill data and consultation, total of 6 canopy bridges at five different locations were installed. Details of their location and dimensions are provided in ***Table 2***.

Table 2: Location of Installed Canopy Bridges at Banke National Park

S.N	Location	Dimension (L × B × H) meter	GPS point
1	Khairi area	25 × 0.45 × > 8	28° 3'50.94"N 81°55'13.62"E
2	Muguwa area 1	24 × 0.45 × > 8	28° 7'56.68"N 81°53'22.09"E
3	Muguwa area 2	22 × 0.45 × > 8	28° 8'15.94"N 81°52'19.13"E
4	Chisapani area 1	17 × 0.45 × > 8	28°17'46.79"N 81°39'55.80"E
5	Chisapani area 2	14 × 0.45 × > 8	28°18'7.16"N 81°40'3.72"E

3.4 Data Collection and Analysis


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9 Cuddeback Camera traps were used for effective monitoring purpose. Monitoring work were done for six months from the day of its installation in coordination with National Park Authority. Each camera trap was given a unique code and data were collected at an interval of every 45 days. However, weekly monitoring was also conducted to ensure that no damage was done to structure and they are safe enough for arboreal species. Camera traps were knotted at the tree stem and their height were maintained to capture movement of arboreal species that exist in the area. Every pictorial evidence was collected and recorded in each monitoring visit to avoid any loss of data. All the images captured from the camera traps were collected and analyzed. Species detections were considered independent if the time between consecutive photographs of the same species was taken at an interval of more than 30 minutes (O'Brien et al. 2003)[4].

4. Results

A total of 118 photographs were captured during the monitoring period of six months. 32 independent detections of four different species were captured from all camera traps installed. Among four species, highest capture rate was of Indian Grey Langur (43.22 %) followed by Rhesus Macaque (30.51%) and Asian Palm Civet (25.42%).

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[4] *O'Brien, T.G., Kinnaird, M.F. & Wibisono, H.T. 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. Animal Conservation. 6(2):131-139.*

Table 3: Species recorded in various canopy bridges

Common Name	Scientific Name	Total image(s) captured	Total independent capture(s)	IUCN category
Rat Species	-	1	1	
Asian Palm Civet	*Paradoxurus hermaphroditus*	30	11	Least Concerned (LC)
Indian grey Langur	*Semnopithecus hector*	51	14	LC
Rhesus macaque	*Macaca mulatta*	36	6	LC
Total		**118**	**32**	

Out of the four total monitoring periods/visits spread over six months, maximum images have been detected at third one (Dec to February). Total of 17 images were captured in the first monitoring period of bridge installation (Sep-Nov). Even though there was decline of total image captured in the second monitoring period (Nov -Dec), there was massive rise in third monitoring period (Dec-Feb). Total of 75 images were captured of which 13 independent detections were recorded in third monitoring period. Likewise, 12 images were captured in fourth monitoring period (Feb- March) with count of 7 independent species (***Figure 4).***

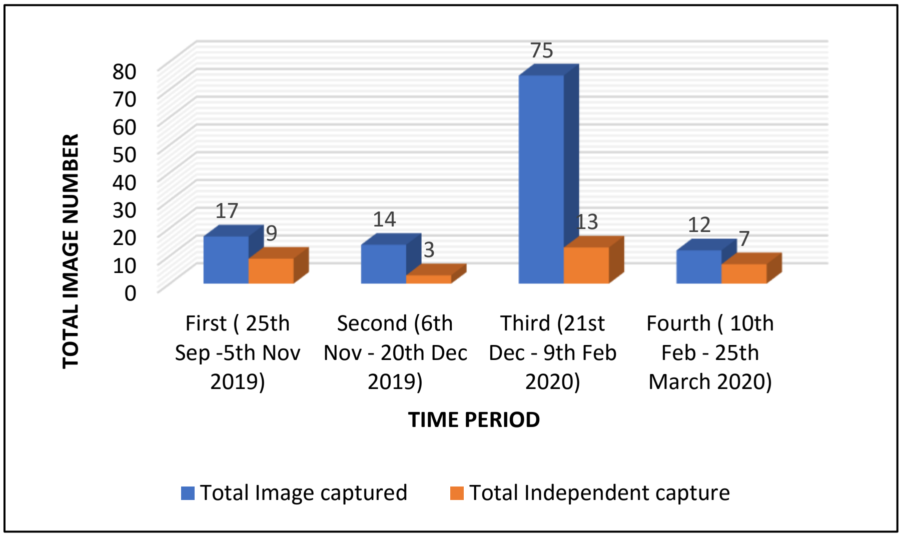

Figure 4: Monitoring wise total image captured and total independent captured

Canopy bridges installed at five different locations showed varied results in species capture pattern as shown in ***Figure 5***. Highest number of images were captured in Muguwa area 2 (91) followed by Chisapani area 2 (23) and Muguwa area 1 (4). No species was detected in Khairi area and Chisapani area 1. However, Muguwa area 2 is the only area where wider design has been installed i.e two bridges were installed adjoining to each other.

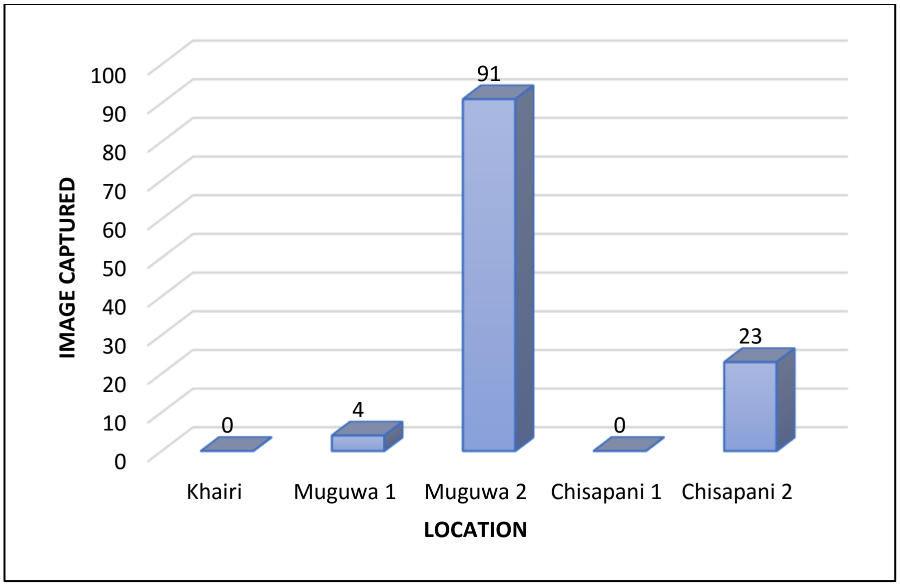

Figure 5: Location wise total image captured

Among four species' images captured in all canopy bridges, Indian Grey Langur, a native mammal species, had its images captured for 51 times with 14 independent detections contributing for highest count. Likewise, Rhesus Macaque had second highest count with 36 images and 6 independent detection. Asian Palm civet with 30 images with 11 independent detections contribute for 3rd highest count (***Figure 6***).

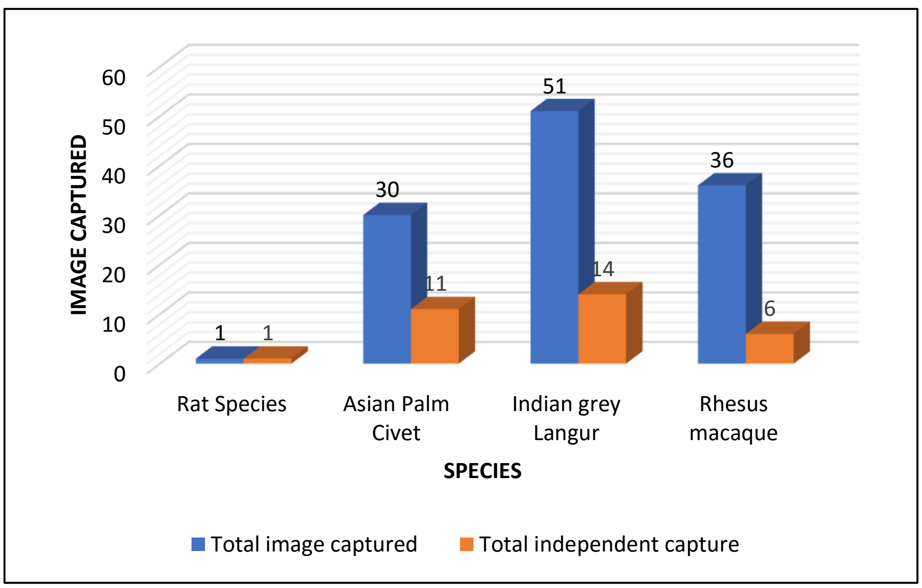

Figure 6: Species wise total image and Independent capture

5. Discussions and Conclusions

Roadkill issues are emerging worldwide due to growing economy and transport sector development. Banke and Bardia National Parks are among the protected areas of Nepal where major section of highway traverses through its core forest area. On one hand, Nepal is among few countries where achievements in conservation successes are taking pace. On the other hand, large infrastructure especially linear projects are emerging as threats to flagship species, their pray species and their habitat. Most of the under construction, planned mega projects of Nepal including wide highways, irrigation canal, transmission line, railways traverse through protected areas and critical corridors of TAL. This possesses high risk not only to large mammals, but even to small-to-medium sized mammals inhabiting in the area. Construction of Underpass/ Overpass, modified bridges, wide culverts, canopy bridges for medium-to-large size animals are widely practiced globally and this kind of mitigation practices shall be in place wherever required to minimize VWC and maintain connectivity.

When linear barriers such as roads inhibit faunal movements, subdivided populations may become increasingly prone to the loss of genetic variability and local extinction (Fahrig & Merriam 1985; Moritz et al. 1993; Simberloff 1993; Gerlach & Musolf 2000)[5]. In many developed countries, wildlife road-crossing structures are now commonly installed to reduce these impacts when major new roads are constructed (Taylor and Goldingay 2010; van der Grift et al. 2013)[6]. Arboreal species can be especially affected by roads because of their fidelity to canopies and naivety on the ground (Lancaster et al. 2011)[7].

As per many studies done worldwide, Canopy bridge or other walkways are very useful to maintain connectivity of arboreal species when road is wide, and animals are not able to move from tree to tree. Even though these are simple structures, they can provide safe passages to many tree dwelling species to move from one tree canopy to others fragmented by linear infrastructure such as Road, Railway, irrigation canal, pipeline etc.

Many rope bridges, or canopy bridges, have been installed worldwide to mitigate negative impacts on arboreal species, including several opossum, monkey, dormouse and squirrel species (Norwood 1999, Teixeira et al. 2013, Sonoda 2014)[8]. Recent studies have drawn attention to the ability of canopy rope-bridges to encourage arboreal mammals to crossroads and other canopy gaps (Weston et al. 2011; Goldingay et al. 2013; Soanes et al. 2013, 2015)[9].

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[5] *Reference: Fahrig, L. & Merriam, G. 1985. Habitat patch connectivity and population survival. Ecology 66: 1762-1768*

[6] *Taylor, B. D., and Goldingay, R. L. (2013). Squirrel gliders use roadside glide poles to cross a road gap. Australian Mammalogy 35, 119–122.*

7 Lancaster ML, Taylor AC, Cooper SJB, Carthew SM (2011) Limited ecological connectivity of an arboreal marsupial across a forest/plantation landscape despite apparent resilience to fragmentation. Molecular Ecology 20: 2258–2271. doi: 10.1111/j.1365- 294X.2011.05072.x

8 Norwood C (1999) Linkages in the landscape: The role of corridors and connectivity in wildlife conservation [Book Review]. Pacific Conservation Biology 5: 158.

9 Weston, N., Goosem, M., Marsh, H., Cohen, M., and Wilson, R. (2011). Using canopy bridges to link habitat for arboreal mammals: successful trials in the Wet Tropics of Queensland. Australian ammalogy 33, 93–105. doi:10.1071/AM11003

During six months' monitoring, 4 different Arboreal species that exist in these areas were recorded. Animal using these bridges in very first month of installation are very encouraging results. Species like monkey, Langoor, Civet which are found abundantly in these areas where roadkill of these species are recorded high were captured using these bridges frequently. This indicates that canopy bridges in Banke NP are effective for arboreal species which can be a good mitigation measure for restoring connectivity of fragmented habitat. As these are very new initiatives in the country, further new designs, research activity ought to be explored. Long term study is required to identify how frequently these species are using the bridges and whether these are effective in minimizing mortality of arboreal species in long run.

The study showed frequent use of wider design canopy bridge installed at Muguwa area 2 compared to others. Around 77 percent of total captures were recorded there which helps derive the idea that Macaque species prefers wider design to cross from one canopy to another canopy of tree comparatively. However, long-term monitoring is essential to conclude on appropriate width required for arboreal species to cross between tree canopies. Further, variant designs of canopy bridges should be piloted in similar habitat to explore the appropriate design that species are comfortable to use.

As this was a piloting program initiative in Nepal, our results have shown potential and opportunity to initiate permanent structure in the areas which will eventually support to mitigate roadkill of arboreal species in long run and to maintain habitat connectivity to some extent. Further new design of canopy bridges, and research activities shall be explored. Long term study is required to know how frequently these species are using these bridges and whether they are effective in minimizing mortality of arboreal species in the long run. Results of this study are imperative to demonstrate the use of this type of structure by target species. The study concludes that these structures are important and have great potential in maintaining habitat connectivity fragmented by linear intrusions such as Roads, Irrigation canals, Railway line, pipeline, and offer a ray of hope to minimize roadkill of arboreal species to some extent.

Annex I – Pictorial Highlights

Images Captured by Camera traps

Indian Grey langoor

Asian Palm Civet

Rhesus Macaque

Rat Species

Other Photographs

Rhesus Macaque in Muguwa area

Langoors at Muguwa area

Rhesus macaque crossing roads at Muguwa area

Langoor crossing roads at Muguwa area

Team preparing canopy bridges