Kallar elephant corridor in the Western Ghats, India: trend of human interface vis-à-vis feasibility of wildlife-friendly flyover and land acquisition

Neha Midha, N. Krishna Kumar, D. Boominathan, Samuel Thomas and Chhavi Jain*

The present account from Kallar elephant corridor is a case-history which elucidates that delay in implementing management recommendations leads to unmanageable trends in land-use pattern, traffic intensity, human–elephant interface, and escalation of costs for management options like land acquisition and engineering structures as flyovers or 'elephant underpass'. Ultimately a situation may develop where elephants may take their own course of population reduction, fragmentation and shifting of problem to new areas.

Keywords: Elephant corridor, human-interface, traffic intensity, wildlife-friendly mitigation.

General problems in elephant habitats and corridors in India

WITH increasingly fragmented wildlife corridors, the existence and future of large home-range species like elephants are under threat in India[1–3]. The management of the resultant and increasing human–elephant conflict (HEC) warrants the use of innovative tools such as informed land-use planning and integrated conservation development projects, including wildlife-friendly engineering structures to alleviate the conflict, and achieve conservation goals along with economic development[4,5].

Conservation biology theory suggests that construction of linkage structures for wildlife between isolated habitat patches may increase or at least maintain gene flow[6], and possibly mitigate human–wildlife conflict[7]. World over, with the similar concern of impacts of fragmentation and losses due to conflict, crossing structures for wildlife are being incorporated into infrastructure projects as mitigation measures[6].

In the Indian context, a few such good recent examples are from Rajaji National Park (railways)[8], Assam (railways)[9], Nagarahole National Park (Mysore–Manathavadi road)[10], Lumding Reserve Forest (NH 54E)[11], Govindpur–Sahebganj highway[12], Indo-Nepal border road[13], NH 7 (ref. 14), and Wildlife Institute of India (WII)[15]. However, only in case of Chilla–Motichur corridor and NH 7, the recommendations have turned to reality; but till today the construction is not complete. Thus, it is evident that India lags behind in adopting these widely accepted mitigation measures.

One site where an engineering structure and land acquisition have been advocated by conservationists as a solution for conflict management for the last two decades is the Kallar elephant corridor in South India. This article discusses the magnitude and causes of conflict in this corridor and its development over time, focusing on elephant conservation and thereof suggested mitigation measures.

Elephant populations, habitats and corridors in South India

In southern India, elephants are patchily distributed across ranges. The Brahmagiri–Nilgiris–Eastern Ghats population range covers over 12,000 km^2, across Karnataka, Kerala and Tamil Nadu, and holds a minimum population of 6300 elephants. The Nilambur–Silent Valley–Coimbatore population range with an estimated population of 956 elephants is spread across Tamil Nadu and Kerala. This range still maintains tenuous links with the Brahmagiri–Nilgiris–Eastern Ghats population. The Anamalai–Parambikulam range is located in the south of the Palghat Gap, and extends over 5500 km^2 with an estimated population of 2500 elephants. The Periyar–Agasthyamalai range extends over 5600 km^2 and has an estimated population of 1800 elephants covering Tamil Nadu and Kerala[1,16].

For the long-term conservation of elephants across these ranges, a priority recommendation includes maintaining viable populations by protecting and strengthening

Neha Midha, N. Krishna Kumar, D. Boominathan, Samuel Thomas and Chhavi Jain are in the WWF-India, 172 B, Lodi Estate, New Delhi 110 003, India.
*For correspondence. (e-mail: nehamidha09@gmail.com)

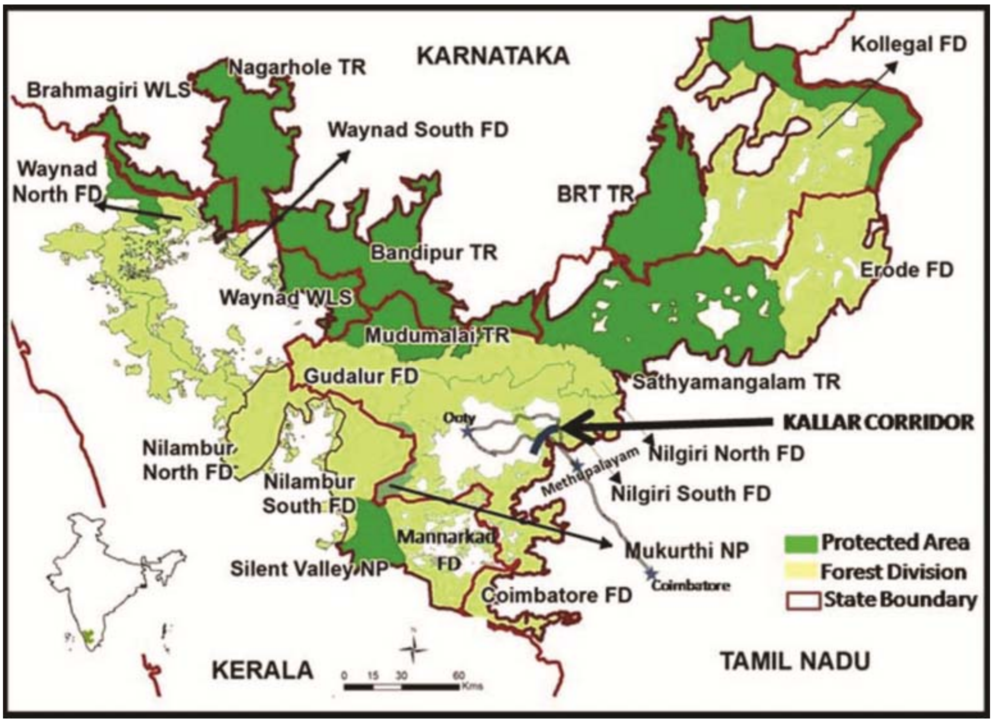

Figure 1. Location of Kallar elephant corridor in Nilgiri Eastern Ghats, southern India.

the existing corridors[1]. Ramkumar *et al.*[1] identified 28 such corridors in South India, Kallar elephant corridor is one such important connectivity.

Elephant population and significance of the Kallar corridor

The Kallar corridor connects the Brahmagiri–Nilgiris–Eastern Ghats elephant population range with Nilambur–Silent Valley–Coimbatore population range[1,17–19] facilitating genetic exchange, dispersal and access to a variety of seasonal foraging grounds[16]. This corridor seems to be the only possible transit route for large mammals to move between the forests of Silent Valley National Park, Mannarkad Forest Division (FD), and Palakkad FD towards Nilgiri North FD and Sathyamangalam Tiger Reserve through Coimbatore FD[20,21] (Figure 1). On an average, 80–100 elephants use this corridor annually for their seasonal movement (April–May)[18]. Recently, tigers have also been recorded using this corridor (WWF-India, unpublished report).

The conservation of the Kallar corridor is important with respect to long-term conservation of elephants in the Nilambur–Silent Valley–Coimbatore range. With a few hundred elephants in this range, their population is currently viable but only for a short term from the standpoint of demography and genetics[17]. The rule of thumb states that effective breeding individuals of 50 and 500 are required for the short- and long-term conservation of a population respectively[2]. The relatively low-density population of the Nilambur–Silent Valley–Coimbatore range is in danger of splitting into several completely isolated populations, if action is not taken to prevent further fragmentation. Considering this, protection of corridors and habitat consolidation is a high priority in this range, and existing links with the Brahmagiri–Nilgiris–Eastern Ghats population range should thus be maintained and strengthened where possible[1–3]; the Kallar corridor is one such crucial site.

Location and extent of the Kallar elephant corridor

The Kallar elephant corridor is located in the Mettupalayam range of Coimbatore FD in Tamil Nadu, India[17,18]. The area lies between latitude 11°20′ and 11°21′N, long. 76°51′ and 76°53′E (ref. 19). The corridor is a narrow strip of length 7 km and varies in width from 0.5 to 3 km; it is created due to steep escarpment of the Jaccanari Mountains to the north, and crop fields and developmental activities in the east[19] (Figure 2). The corridor begins at Kothagiri road and goes up to Kallar Reserve Forest along the foothills of the Jaccanari Mountain bisecting the Mettupalayam–Coonoor (NH 67) highway.

The trend of land use

The major land use in the corridor are reserve forests and private land covered by forest, agricultural lands or settlements. Dry deciduous forest in the hill slopes and open

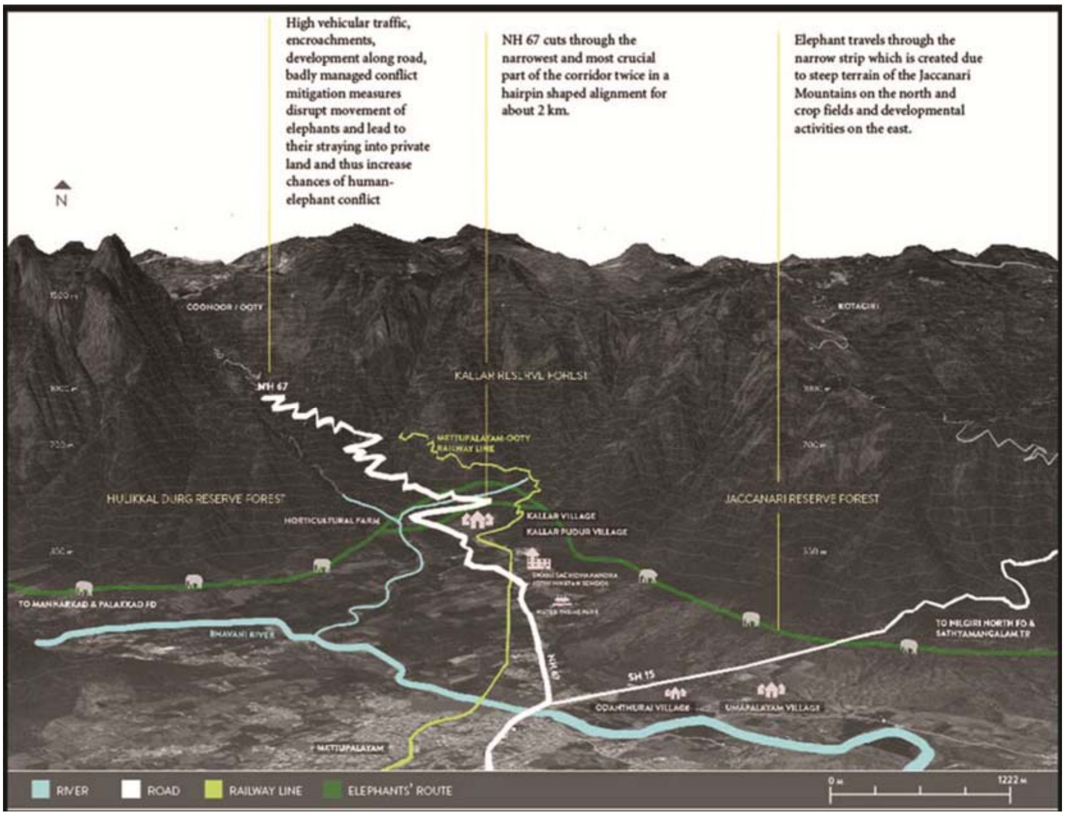

Figure 2. Three-dimensional representation of Kallar elephant corridor.

Figure 3. Camera-trapped photograph of elephant herd at Pulikuttai, Kallar corridor (Photograph courtesy: Tamil Nadu Forest Department).

scrub forests in the lowland areas dominate this corridor. The elephants use this corridor by moving through forests and scrub-covered reserve forests and private lands, arecanut farms, and croplands located at gentle contour lines and foothills. The availability of ecological resources makes it an important elephant habitat corridor (Figure 3)[18,23]. This existing connectivity is highly threatened by intense human land use, which has changed largely in last 15 years impeding the movement of elephants.

Till 1990s, there were no major settlements in the corridor other than the Government horticultural farm and a few hutments amid arecanut and banana plantations. The setting up of the Satchidananda Jothi Niketan School in mid-1990s (Figure 2) and subsequent development in the area changed the scene[18,22]. According to Johnsingh and Williams[22], construction of the school led to loss in area of 17.4 ha and reduced the corridor considerably. Additionally, solar-powered fencing along the boundary of the school left a narrow passage for the movement of elephants[18]. Moreover, Hill Area Conservation Authority violation was also recorded in the construction of the school[18,22,24]. This was followed by the setting-up of a water-themed amusement park on 70 acres of land in the early years of 2000s at the fringe of the corridor. Although the corridor width has not been affected, noise pollution and littering by tourists may impact wild animals[18].

Soon after the setting up of the school and theme park, encroachment and development started all along stretch of NH 67. The Kallarpudur and Kallar villages, settlements adjacent to the Kallar railway crossing expanded indiscriminately. These settlements were established after the tribal resettlement initiative in the year 2000 and have now grown from a few households to about 400 (ref. 25).

Furthermore, on either side of the highway shops were opened to cater to increased tourist activity, which has further reduced the width of the corridor[26,27]. The study of Yoganand *et al.*[28] endorses this theory as they have documented that the time period between 1991 and 2006 saw an increase in the built-up area (27.18 ha), conversion of forest to cropland (17.95 ha), and degradation of dense scrub to open scrub (38.50 ha) in the Kallar corridor. These detrimental changes occurred mostly along the highway, near Kallarpudur village, along forest peripheries and in private forest lands.

Trend of traffic intensity

NH 67 also known as the 'ghat road' connects Mettupalayam to Ooty via Coonoor[26]. The highway presently cuts through the narrowest and most crucial part of the Kallar elephant corridor twice in a hairpin-shaped alignment for about 2 km (ref. 29). Elephants cannot use higher elevation for movement because of road cuttings, revetments and steepness of the slopes, and passage is only possible at the start of the ascent and between the bends[26] (Figure 4). A study by the WWF[29] found signs of elephant crossings on 22 occasions at NH 67, while surveying 99 times during July 2008 to January 2009. While family herds interestingly always crossed the corridor (five times) through the reserve forest and above the first hairpin bend, solitary males crossed 17 times through private lands below the first hairpin bend and caused considerable crop damage.

As the elephant movement is largely confined to a narrow strip along the foothills, the increasing vehicular traffic, road dividers, protection wall and large hoardings for advertisements on both sides of the first hairpin bend further disrupt free movement of these animals[18,25,26,29].

Over the past decade, traffic intensity has increased by 15% on NH 67 (WWF-India unpublished data), especially during the dry season which overlaps with elephant movement[29]. According to a WWF survey in 2015, 7019 vehicles drove through NH 67 daily in May, whereas in 2007 the number was 6083. In the evening and night, when the elephants are likely to cross, 2622 vehicles passed through the road, i.e. roughly 2 per minute (Figure 5). This frequency coupled with traffic speed is a serious deterrent for elephants while crossing the highway.

Figure 4. An elephant crossing NH 67 near the first hairpin bend in the Kallar corridor (photograph courtesy: Rubesh Durai).

HEC in the context of the Kallar corridor

The available data between 1994 and 2016 (till April) on the status of HEC in Mettupalayam and adjacent Sirumugai ranges of the Coimbatore FD reveal that the conflict has increased from 1999 onwards (Figure 6). This coincides with initiation of development activities in this area as discussed above. Since 1994, 15 elephants have died of electrocution and 33 people have lost their lives due to conflict with elephants. It is believed that changes in land use over the last two decades have created disconnections and bottlenecks forcing elephants to stray into private forest and agricultural lands, and adjacent ranges of Coimbatore FD and thus increased chances of conflict with humans[18].

Trend of management recommendations and their implementation

The conservation importance of Kallar corridor, HEC and possible solutions has been discussed since 1970. Late Davidar *et al.*[26] described Kallar as a functional elephant corridor and pointed out obstructions in the movement of elephants. They recommended the acquisition of private land for setting up an elephant corridor of about 100–150 m in width at and immediately below the first hairpin bend to connect the reserve forests on either side[26].

Vermal *et al.*[19] stressed on the acquisition of part of a betel-nut plantation near Kallar village to maintain connectivity, prevention of encroachments on either side of the Ooty–Coimbatore road and restriction in the activities of the residential school and associated developments. Sukumar and Easa[17] also recommended that activities of

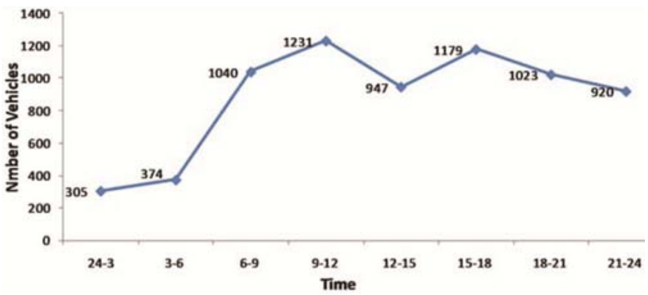

Figure 5. Vehicular intensity on NH-67 in the Kallar elephant corridor in a day during May 2015.

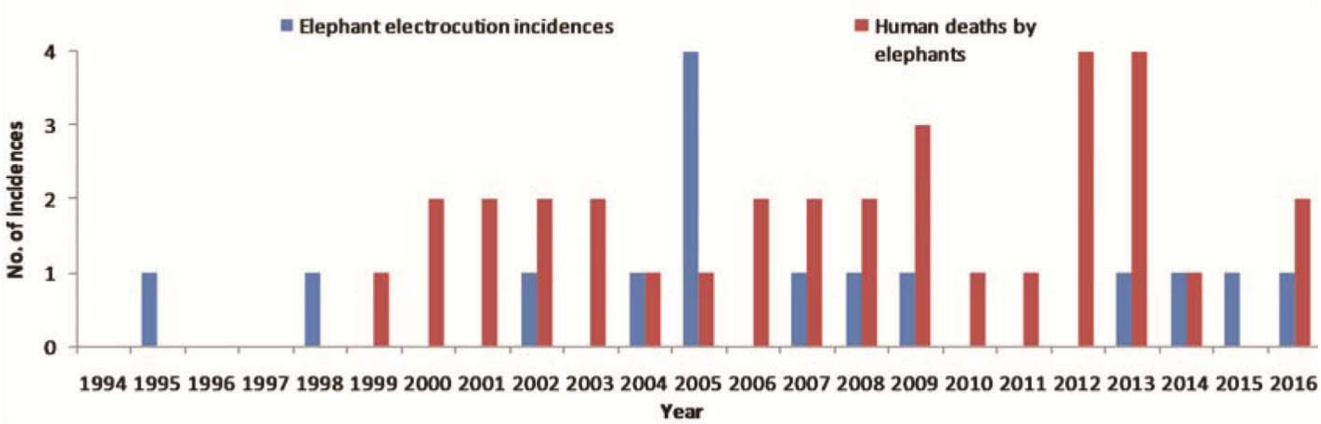

Figure 6. Status of human–elephant conflict in the Kallar corridor (Sirumugai and Mettupalayam ranges). (Source: Ramakrishnan and Ramkumar[18] and Tamil Nadu Forest Department).

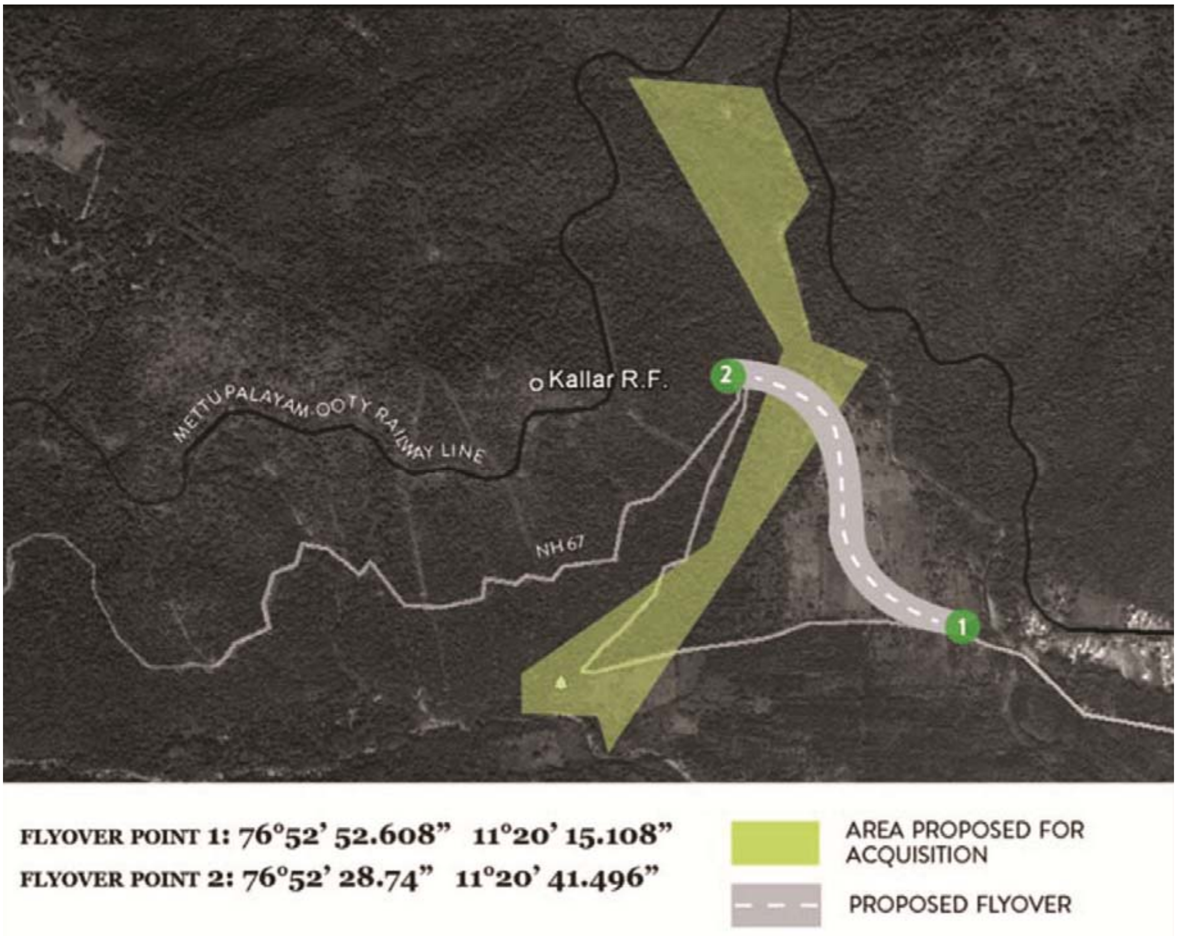

Figure 7. Location of proposed flyover and land for acquisition.

the residential school and other development activities should be monitored.

Yoganand *et al.*[28] recommended widening of the corridor to a minimum of 500 m by acquiring 346 acres of land at a cost of INR 38,573,878. They further suggested either realignment of highway or construction of flyover. Ramakrishnan and Ramkumar[18] found that 103.05 acres of land would have to be acquired at a cost of INR 136,500,000 for securing the corridor. WWF[29] identified the most critical area for acquisition and construction of the flyover. Johnsingh *et al.*[20] noted that the Tamil Nadu Forest Department plans to acquire agricultural land south of the corridor, but pointed out that an 800 m long flyover at the base of the hills for vehicles on both the highways is a must.

In 2015, in response to the efforts of FD, WWF and other stakeholders, officials of the Tamil Nadu State Government and National Highway Authority of India presented a budget of INR 160 crores for construction of a 1.6 km flyover from Kallar bridge to the second hairpin bend (Figure 7). On completion, the present road would be closed allowing elephants to cross from below the flyover. Unfortunately, the budget did not get the approval from the State Government and the project fizzled out due to elections in the State.

The possible reasons for non-implementation of the recommendations till now are that most of the conflict-prone areas and bottlenecks are not under control of FP, and are owned by multiple entities. Ramakrishnan and Ramkumar[18] estimated that out of 103.05 acres of land that needs to be acquired, only 12 acres is under forest jurisdiction. Furthermore, there are multiple stakeholders, e.g. Government Horticulture Department, Satchidananda Foundation, and patta land owned by multiple private players and tribal families. Based on the extent of land to be acquired, availability of Government land; willingness of people, guidelines and market value, the study concluded that the feasibility of land acquisition in Kallar is low[18]. Moreover, there are no guidelines that provide permissible land-use change in corridors in India. The only mechanism to check development activities in Tamil Nadu is through Hill Area Conservation Authority, which unfortunately is not being enforced. A clear example is violation in construction of the Satchidananda residential school[18,22,24].

Literature review on wildlife-friendly flyover and private land conservation

Location and engineering structures

Table 1 presents the different types of engineering options used world over to enable wildlife crossing. Majority of the studies have proffered classifications based on major taxonomic groupings and body size as the primary determinants influencing wildlife crossing design[30,31] along with engineering constraints due to terrain, cost of construction, maintenance and highway safety[31].

Along with mitigation structures, other options are being explored world over for conservation of critical wildlife habitats on private land which include land which acquisition by Government or private organization; imposing regulations like eco-sensitive zones in India or habitat conservation plan in USA[34] and new and voluntary approaches like financial incentives for private landowners willing to set aside their land for conservation. Purchase of private land by large private conservation organizations to either self-manage, or donate to Government agencies for conservation purposes has been witnessed in Latin America, North America, Australia, Africa and Asia[34–36]. Similarly, the use of conservation easements in the form of tax benefits or other incentives are now being used in the US, Latin America, Africa, UK and Australia[35].

Species-specific mitigation measures

The scope of the present article allows the discussion to be focused on the connectivity for large mammals' functional group. WII[15] recommended that a raised linear infrastructure with pillars of minimum 8–10 m height above ground is the best solution in elephant landscape, but if the cost of these structures is high then an underpass of height 6–8 m, width 10–12 m, and minimum span of 50 m with isolated piers, or an overpass at least 10–12 m in width if the linear infrastructure is passing through steep terrain on both sides can be considered. On the other hand, Ruediger and DiGiorgio[31] recommended 3.6 m + height × 15 m + width open span bridges for large carnivores like grizzly bear and wolf. Florida, USA, has used 36 m bridges with 2.4 m height in the Big Cypress Preserve area for movement of Florida panther and black bear under I-75 (ref. 37).

Status of use of wildlife-friendly flyovers worldwide and in India

Viaducts have been extensively used in Europe, especially in areas with undulating terrain and over waterbodies as topographic relief sometimes make bridging necessary. These are usually not built exclusively for wildlife movement but if proper habitat connectivity is provided, the large span and vertical clearance allow it to be used by a wide range of wildlife. In Slovenia, three viaducts (593, 160, and 265 m long respectively) on the Ljubljana–Trieste Highway were built for human connectivity, wildlife and hydrology, and are known to be successfully used by brown bear, wolf and a number of ungulates[33]. Similarly, successful examples of open-span bridges for wildlife crossings have been reported in Banff National Park, Colorado, Montana, Idaho, and Arizona, USA[31].

Southeast Asia witnessed its first series wildlife viaducts in Malaysia since 2008 during highway development for Sg. Deka, Terengganu (three viaducts), Sg. Yu, Pahang (three viaducts), and Gerik, Perak (one viaduct) wildlife corridors to secure connectivity for large mammals, including elephants, tigers and prey species. In all the three cases, forests around the viaducts were also designated as 'reserve' to reduce further threat of habitat destruction. Despite, the positive effort, Clements *et al.*[38] revealed that 20 viaducts in Perak and Terengganu, Malaysia were 'effective' crossing structures for only two

Table 1. Types of engineering options to enable wildlife crossing

Structure type	Definition	Wildlife functional groups and their preference of usage
Overpass	Allows passage of animals above the road	
Land bridge	A typically wide (30–70 m) bridge that extends over the road with soil and vegetation and other features (rocks, logs, etc.)[15,32].	Large carnivores, and herbivores; small and medium-sized mammals; reptiles and amphibians.
Canopy bridge	Rope and pole suspended on the road, either from vertical poles or from trees[32].	Small and medium-sized mammals.
Glide pole	Vertical poles placed in the centre median or on the road verge, which provide species that glide intermediate landing and launch opportunities[15,32].	Small and medium-sized mammals.
Underpass	Allows passage of animals below the road	
Bridge/viaduct/flyover	These maintain or elevate the grade of the road and are mainly useful in areas with undulating terrain and over waterbodies[32,33].	Large carnivores and herbivores; small and medium-sized mammals, and reptiles and amphibians.
Culvert	These are typically square, rectangular or half circle in shape. Primary purpose is fauna passage or drainage, or both[15,32].	Large carnivores[31], large herbivores (size requirement needs to be considered); small and medium-sized mammals; reptiles and amphibians.
Tunnel	Round pipes of small diameter (<1.5 m) made up of steel or corrugated metal. Primary purpose is to convey water under the road, while secondary purpose is wildlife passage[15].	Small mammals; reptiles and amphibians.

of six target mammal species, both of which were herbivores. Most importantly, viaducts were poorly used by all carnivores, including tigers.

In India, three flyovers are being constructed during upgradation of NH 58 and NH 72 which pass through three elephant corridors of Rajaji Tiger Reserve, Uttarakhand. The recommendations included flyovers of at least 6 m height each and width of 736 m on NH 58 which passes through Chilla Motichur corridor; 500 m on NH 72 through Badkot Kansaray corridor and 400 m on NH 72 through Teen Pani corridor[15]. Similarly, construction of flyovers as mitigation measures has also been recommended by management agencies in cases of upgradation of NH 7 (ref. 14), passing through Pench Tiger Reserve and Kanha–Pench tiger corridor; NH 37 close to Kaziranga Tiger Reserve and Kandi road cutting Corbett Tiger Reserve.

Along with mitigation structures, other models of private land conservation for securing the wildlife corridor have also started to evolve in India. Successful examples are Edayarhalli–Doddasampige in Karnataka and Thirunelli–Kudrakote in Kerala through private purchase model; Kaniyanpura–Moyar elephant corridor in Karnataka through Government securement model, and Siju–Rewak in Meghalaya through a community securement model[1].

Reasons for data deficiency

Despite mitigation measures been in existence around since 1950s in developed countries, the literature still lacks complete information on the use and extent of effectiveness of these structures in mitigating the barrier effect of roads, reducing vehicle–wildlife collision and potential to prevent the local extinction of populations. Corlatti *et al.*[6] reported that evidence of the effectiveness of wildlife crossings derived from long-term monitoring programmes is currently limited for most species. Clevenger and Waltho[39] reported that most monitoring efforts have been largely short term and aimed at single species. Further, monitoring is rarely conducted long enough to meet the adaptation period wildlife need to begin using crossings on a regular basis. A review by Van der Ree *et al.*[32] of 123 studies concluded that most of the mitigation measures were successful at the level of individual animals. However, their effectiveness at reducing the risk of population extinction remains unclear.

Recommendations for the Kallar corridor and conclusion

This study discusses the magnitude and causes of increased HEC in Kallar corridor located in South India and its development over time. It also highlights the management recommendations that have been made by the scientific community for the last two decades for land acquisition and construction of a wildlife-friendly flyover as a solution to manage conflict situation in the corridor.

Considering the rapid land use changes that have occurred in the corridor since mid-1990s, along with the present thrust on infrastructure development, urban expansion, growth in tourism, and forest resource use, further land-use changes are expected to occur in this corridor which can lead to an increase in the conflict and will ultimately threaten its use by elephants. Given the unavoidable development imperatives, the present study recommends that despite data deficiency on the use and extent of effectiveness of wildlife mitigating structures in alleviating the barrier effect of roads; and considering engineering constrain of undulating terrain in the present situation, construction of flyover and securing adjacent land to prevent further degradation seem to be the most viable options. Investing in such opportunities and gaining experience will help bridge the gap between our desire to conserve and our demand to grow economically.

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