The effect of the new standard gauge railway (SGR) on elephant movements in Tsavo Ecosystem, Kenya (March 2016 – March 2018)

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About this report: This report is an update of the 6-month and 1 year reports produced in October 2016 and July 2017 respectively. It documents findings made between March 2016 and March 2018 of 10 collared elephants in relation to the SGR and highway in Tsavo, and also observations before and after SGR completion on elephant utilization of underpasses. The findings are illustrated using maps, graphs, tables and photos.

Cover photo: The standard gauge railway and Maungu rail crossing bridge; an underpass utilized by elephants to cross the SGR but is being encroached by human settlement (Photo credit: Richard Moller, Tsavo Trust)

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Table of Contents

Summary

In 2014, the Government of Kenya initiated construction of the Standard Gauge Railway (SGR) linking Kenya's largest port city, Mombasa, and her capital city, Nairobi. The construction of the Mombasa – Nairobi SGR was completed and officially launched for use in June 2017. The SGR cuts through the 23,000 Km^2 Tsavo National Parks comprising Tsavo East and Tsavo West National Parks, and is home to the largest single elephant population in Kenya, numbering approximately 13,000 animals (2017 total aerial count) as well as other mammalian species.

Save The Elephants (STE) in partnership with Kenya Wildlife Service (KWS) fitted radio tracking collars on ten Tsavo elephants in March 2016. The main objective of this project was to understand the potential impact of the new SGR and highways in Tsavo on elephant movement and the effectiveness of the mitigation measures put in place to maintain ecosystem connectivity. A further 20 radio tracking collars deployed in February 2018 is expected to enrich these data we are collecting. However, this report documents findings from the initial ten collars deployed in March 2016.

In this report, we explore movement patterns and hotspots of elephants' use in relation to the new SGR and the Voi – Taveta highway after two years of tracking. The home ranges of some elephants crossing the SGR extend from Yatta plateau in Tsavo East to beyond Mkomazi National Park in Tanzania.

Out of the eight elephants collared along the SGR; six of them (some with their families), have managed to cross the SGR during the two years of monitoring. The two most frequently used SGR crossing points for the tracked elephants in Tsavo were the Maungu corridor and at the Manyani corridor. The two corridors are one of six SGR underpasses designed specifically for wildlife use. The monitoring of wildlife utilization of SGR crossing underpasses by KWS patrols teams have shown that, through direct animal signs such as footprints and dung, elephants are learning relatively quicker to use the underpasses than other wildlife species.

Movement patterns of the collared elephants also show that the erection of double electric fence, SGR fence and David Sheldrick Wildlife Trust's fence at Ngutuni, has completely blocked elephant movements to the high-usage area between the SGR and the Mombasa highway. Elephants attempting to cross over the SGR and highway from Ngutuni Conservancy towards the Sagalla farms have also had their movements curtailed.

The monitoring of the SGR, on foot or by vehicle, for wildlife crossing shows that elephant movements have been greatly impacted by the fragmentation of the habitat and blocking of normal migration routes. Some of the tracked elephants spent more than a year moving up and down along the SGR, but were not able to cross it after two years. The analysis of the mean speed

in elephant tracking data indicates that elephants are slower crossing the existing Mombasa highway than the new raised SGR.

One of the major challenge facing the underpass utilization by wildlife is the proliferation of illegal human settlements along the SGR and near the main underpasses. This applies especially to the Voi – Bachuma section of the SGR, around Ndara and Maungu areas. The other notable threat to wildlife use of the SGR underpasses is the high influx of livestock recorded going into the park through those underpasses.

We also identified in this study that elephants are attracted to the borrow pits not completely filled after construction, along the SGR. The borrow pits collect and avail water to elephants and other wildlife species, but may expose them to potential train and vehicle accidents.

Introduction

In March 2016, satellite radio tracking collars were fitted on five adult males and five adult female elephants in Tsavo (Table 1). The 10 elephants were darted and collared within 20km on either side of the SGR and the Voi–Taveta highway (Okita et al 2016). This joint STE and KWS project aimed to collect data on elephant movements on the face of new infrastructural development through Tsavo's wildlife areas including information on how elephants are learning to cross the new SGR and highways. We aimed to understand the potential impact of the SGR on wildlife and assess the effectiveness of the underpasses along the SGR. These analyses are important to wildlife managers and conservationists in protecting and enhancing wildlife connectivity in Tsavo Conservation Area. This report documents the results of the elephant tracking and SGR monitoring project in Tsavo after two years (See Fig. 1). It supplements our 6-month and one year reports published in 2016 and 2017 respectively.

Table 1: summary of the details of the collared elephants in Tsavo East and Tsavo West National Parks

Date collared	Elephant name	Sex	Capture location	Family size	Remarks about the animal
15/03/2016	*Makitau*	Male	Makitau; in TWNP, 1km north of Voi - Taveta highway, northwest of Makitau town	1	Has crossed the Taveta highway 21 times. Possible crop-raider at north of Taveta
15/03/2016	*Murka*	Female	Murka; in TWNP, 300 meters north of the Voi – Taveta highway	18	Has crossed the Taveta highway 239 times
15/03/2016	*Maungu*	Female	Maungu; in TENP, 600 meters east of the SGR, approx. 1km north west of Maungu town	16	Has crossed the SGR 55 times, probably through the Maungu rail crossing bridge but not crossed the highway
15/03/2016	*Ndara*	Male	Ndara; in TENP, 600meters east of the SGR	5	Has never crossed the SGR and his range extends to Galana Ranch
16/03/2016	*Kenani*	Male	Kenani; in TENP, 3km east of the SGR, approx. 17Km north west of Tsavo River Bridge	1	Killed on July 2016, but had crossed the SGR 104 times
16/03/2016	*Kamboyo*	Female	Kamboyo; in TWNP, 20Km west of the SGR, approx. 16Km south west of Mtito Andei town	10	Has never crossed the SGR
16/03/2016	*Manyani*	Female	Manyani;in TENP 1km east of the SGR	4	Has crossed the SGR 7 times at Manyani
16/03/2016	*Tsavo Bull*	Male	Manyani; in TWNP, 800meters west of the SGR	1	Crosses the SGR mostly at Manyani corridor. He has crossed 22 times
17/03/2016	*Rukinga*	Male	*Rukinga* Ranch; south east of Maungu town , approx. 7km from the SGR	3	Has crossed the SGR 42 times and also was crop-raiding at Sagalla
17/03/2016	*Taita*	Female	*Taita* Ranch; south east of Maungu town, approx. 7km from the SGR	15	Has crossed the SGR 14 times and her range extends into Tanzania

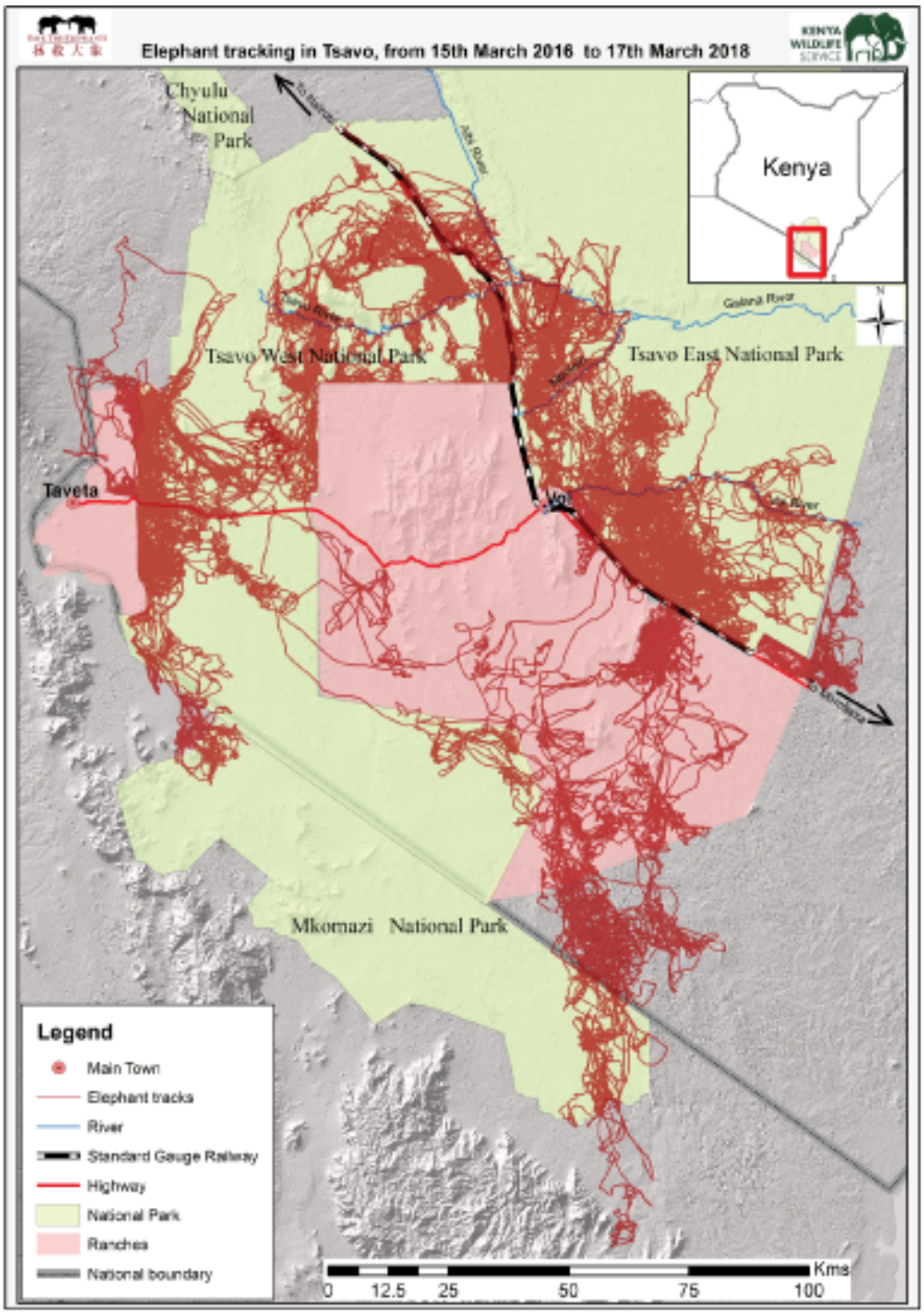

Figure 1: Elephant tracks for 10 elephants in Tsavo from 15th March 2016 to 17th March 2018. These 10 elephants were collared to study potential impacts of the SGR.

Elephant crossing points along the SGR

Two bulls and three females collared along the SGR have been recorded to cross the new railway line either over the SGR embankment or through the available underpasses. The animals who have crossed include: *Tsavo Bull*, *Rukinga*, *Manyani*, *Taita* and *Maungu.*

One of the major SGR crossing points for the tracked elephants in Tsavo is around or through Maungu corridor as shown in Fig. 2. Previously, elephants (specifically *Rukinga)* were crossing over the SGR and through culverts in Ngutuni area. However, this movement from Ngutuni Conservancy to the bushlands between the SGR and the highway has now been blocked by the erection of two electric fences (SGR fence and David Sheldrick Wildlife Trust's fence). The crossing over the SGR and highway to the Sagalla farms has also been curtailed (see Fig. 2).

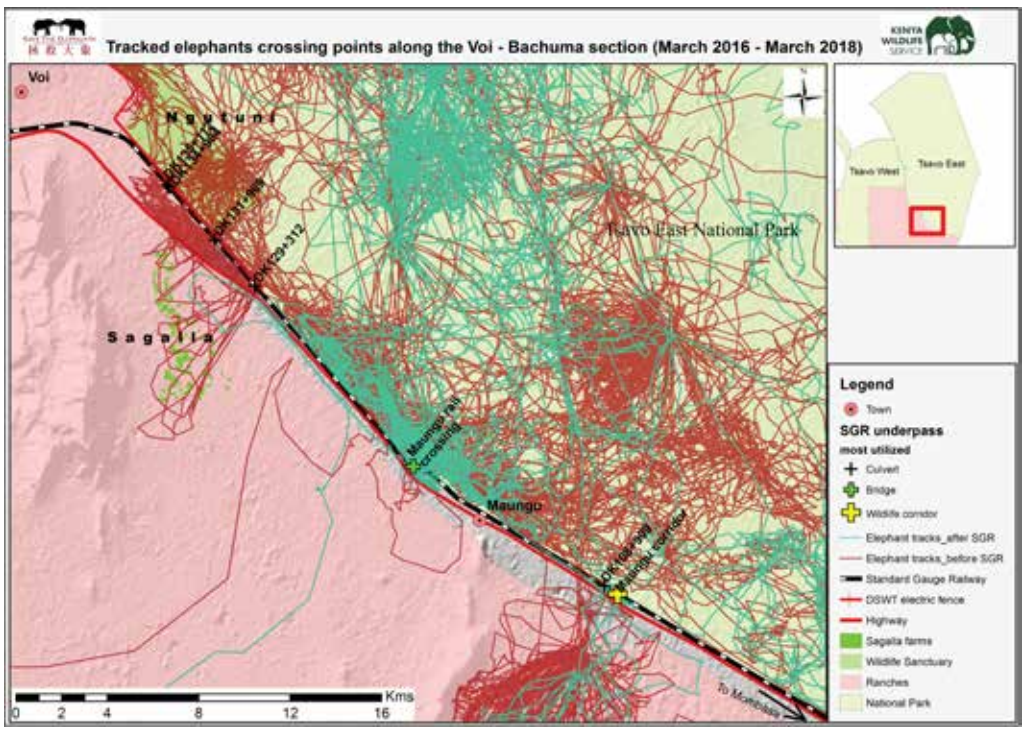

Figure 2: Elephant crossing points from tracking in Maungu area, before and after the SGR completion

The crossing near or through the underpasses have steadily increased over the 2-year period. *Maungu* who had never crossed the SGR after the first year, has now crossed the highest number of times (see Table 2), most probably through the Maungu rail crossing bridge.

However, she has not been able to cross the Nairobi – Mombasa Highway from the Park to the Taita Ranches.

The other major SGR crossing area for the elephants, apart from Maungu corridor and Maungu rail crossing bridge, is Manyani corridor. *Tsavo Bull* has crossed 22 times most likely through the Manyani corridor.

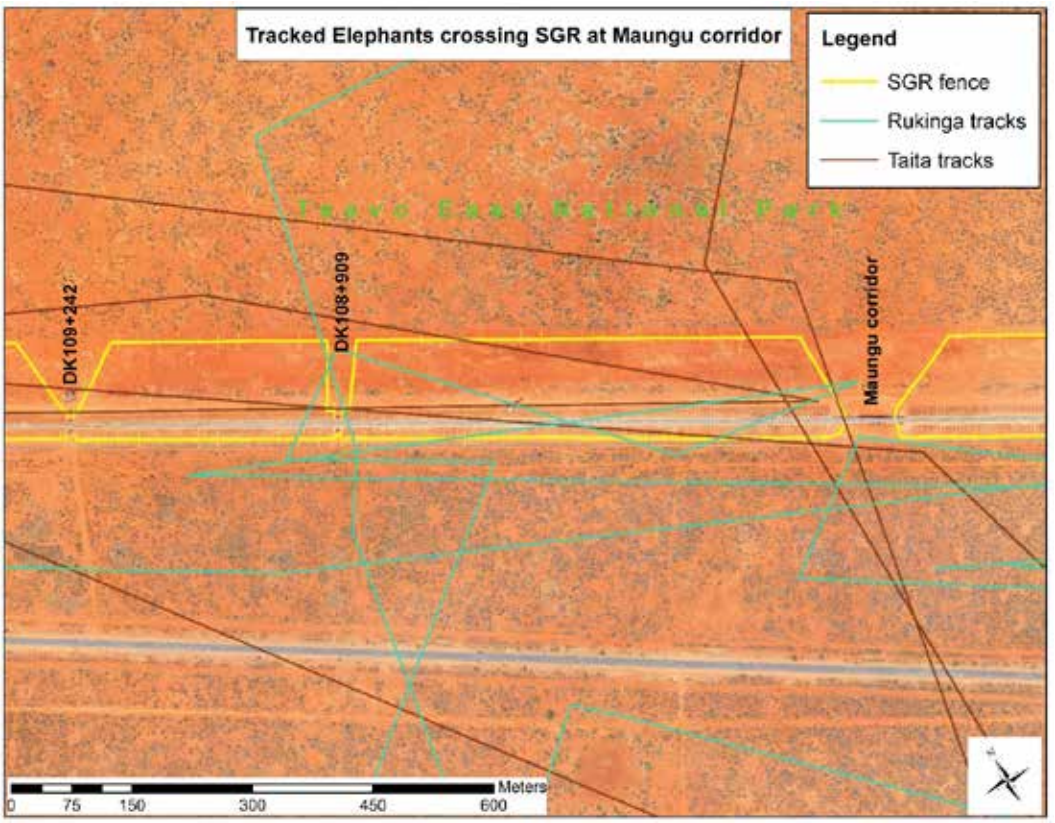

Figure 3: Tracked elephants using Maungu corridor and a culvert to cross the SGR on an aerial image taken in 2017

Out of the eight elephants collared along the SGR; six of them have managed to cross the SGR in the two years that we have been tracking them. One female and one male, *Kamboyo* and *Ndara*, have never crossed the new SGR railway and one female, *Maungu* has crossed the SGR but failed to cross the highway and consequently has not been able to cross from Tsavo East National Park into the Taita Ranches. Two other two animals, *Murka* and *Makitau*, were collared away from SGR in order to help us understand if the new Voi-Taveta highway was going to affect elephant crossings. These two have crossed the Voi – Taveta highway multiple

times and suggests that the Voi-Taveta highway forms no physical barrier to elephants (also refer to Figure 4c).

Table 2: SGR, highway crossings and use of the underpasses by the radio tracked elephants

Elephant Name	Total SGR crossings	Underpass use* of the total crossings	Percentage of crossings in the underpasses(2nd year)	Percentage of crossings in the underpasses(after 1st year)	Total Highway crossing
Tsavo Bull	22	16	72.7%	50%	459
Manyani	7	1	14.3%	14%	43
Rukinga	42	22	52.4%	43%	36
Taita	14	7	50.0%	18%	18
Maungu	55	24	43.6%		0
Total	140	70	**46.6(average)**	**31(average)**	556

*Any crossing within 100 meters of an underpass was assumed to represent use of an underpass. The assumption is in consideration of the GPS precisions and the settings for the frequency of data transmission by the radio transmitters.

Percentage of crossings in the underpasses refers to the number of times an individual crossed through an underpass out of the total times the individual has crossed the SGR.

From Table 2, it is clear that most of the individual elephants have crossed the Nairobi – Mombasa highway more times than they crossed the SGR. This suggests the difficulty that the elephants are having in crossing both the new railway and the existing highway. For instance, *Tsavo Bull* has crossed the highway 459 times but has crossed the SGR immediately next to the highway 22 times. We frequently observed from the tracking data that after crossing the highway the elephants will move up and down, between the highway and SGR, looking for a safe and easier point to cross the SGR. They may fail in their attempt to cross the SGR, presumably because they are stopped by the SGR fence and are yet to learn to use the underpasses.

We do note with interest that elephants have steadily learnt to utilize the SGR underpasses more with time. The inferred average use of underpasses in the first year for four animals was 31% compared to 46.6% for five animals after the second year of monitoring (See Table 2). We also learnt that 50% of the SGR crossings by elephants has been through the underpasses, with assumption that any crossing recorded within a hundred meters of an underpass is actually through that structure. The other 50% of the SGR crossing have been most likely those that climbed over the embankment.

In this report, we compare movement speed of each elephant while (a) crossing over the SGR, (b) crossing through an underpass and (c) crossing on the highway.

Table 3: Mean speed (Km/hr.) of tracked elephants crossing over the SGR, through the underpass and on the Voi – Taveta Highway

Elephant Name	Mean speed through the underpass	Mean speed over the SGR	Mean speed on the highway	Mean speed for all the tracks
Tsavo Bull	0.54	1.15	0.42	0.33
Manyani		0.96	0.55	0.29
Rukinga	0.86	1.74	1.41	0.44
Taita	1.38	1.53	0.85	0.50
Maungu	0.71	0.84		0.41
(**Average)**	**0.87**	**1.24**	**0.81**	**0.39**

Table 3 shows the mean speeds from hourly movement segments of an individual crossing through an underpass, over the SGR and on the highway. *Manyani* has probably crossed through an underpass only once, therefore her data is omitted from the mean speeds through an underpass. From Table 3, we can infer that elephants cross over the SGR faster than through an underpass or on the highway. This finding implies that crossing over the top of the SGR (presumably breaking the fence) is conducted at higher speeds so that the elephant can remove themselves quicker from the stress of clearing the obstacle. Elephants use slower speeds crossing the highway and using the underpasses perhaps suggesting that they feel safer than when crossing over the SGR embankment.

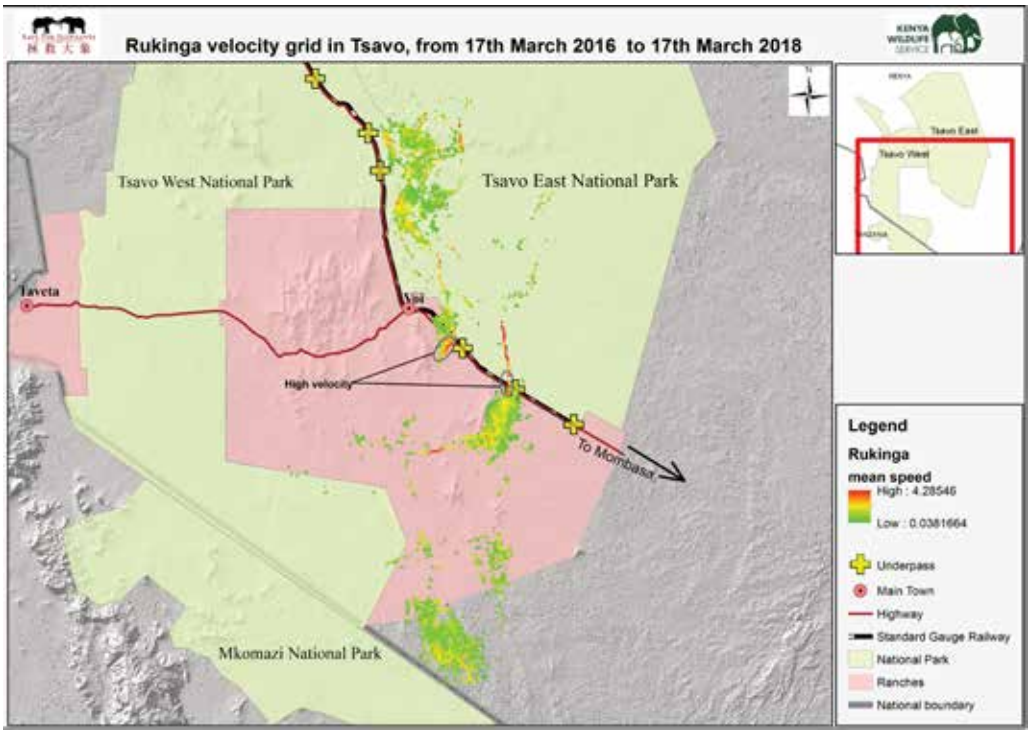

Figure 4: *Rukinga* movement velocity grid in two years of tracking this bull

The velocity grid for *Rukinga* in Fig. 4, summarizes the elephant movement dataset and mean speed in Tsavo within the two years of tracking. The red areas of the grid shows high speed or streaking while the green areas depicts low speed areas. In Fig. 4, the relatively high-speed areas has been identified in the Sagalla farmlands and across the SGR and highway.

Elephant movement hotspots

The following density maps of elephant movements by Kernel Density Estimator (KDE) method (Wall, 2014) show where the tracked animals spent most of their time in the 2 years of tracking (See Figures 5a, 5b & 5c). The kernel densities were done separately for northern, southern and western section of study area. The red areas show the highest concentration areas of elephant usage while the green areas show the lowest concentration of elephant usage. High concentration on one side of the SGR/highway could be interpreted to mean the infrastructure obstructed free elephant movement (Okita-Ouma et al, 2017). On the other hand, where the high concentration extends to both sides of the SGR/highway; the elephants have been able to cross the SGR. In Fig. 5a, the tracked elephants are more confined to the western side of Mombasa highway than the eastern side in the KWS Manyani Training School area where there are water holes and, presumably, good security. *Tsavo Bull* and *Manyani* are two elephants that are heavily utilizing the area around the Manyani Maximum Prison and the KWS Field Training School. Fig. 5b highlights that the collared elephants may have been restricted by the railway & highway by remaining mostly inside Tsavo East with less time spent in the Taita Taveta Ranches on the west.

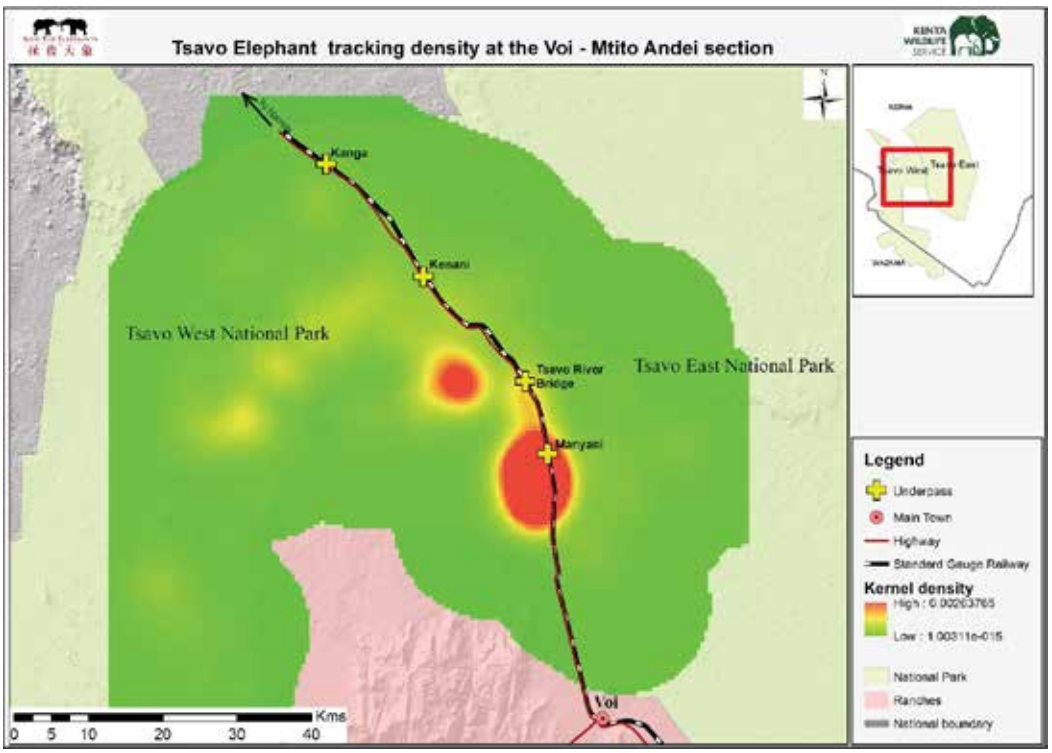

Figure 5a: Elephant movements density at the Voi – Mtito Andei northern section of the study area. The locations of the main underpasses are also shown.

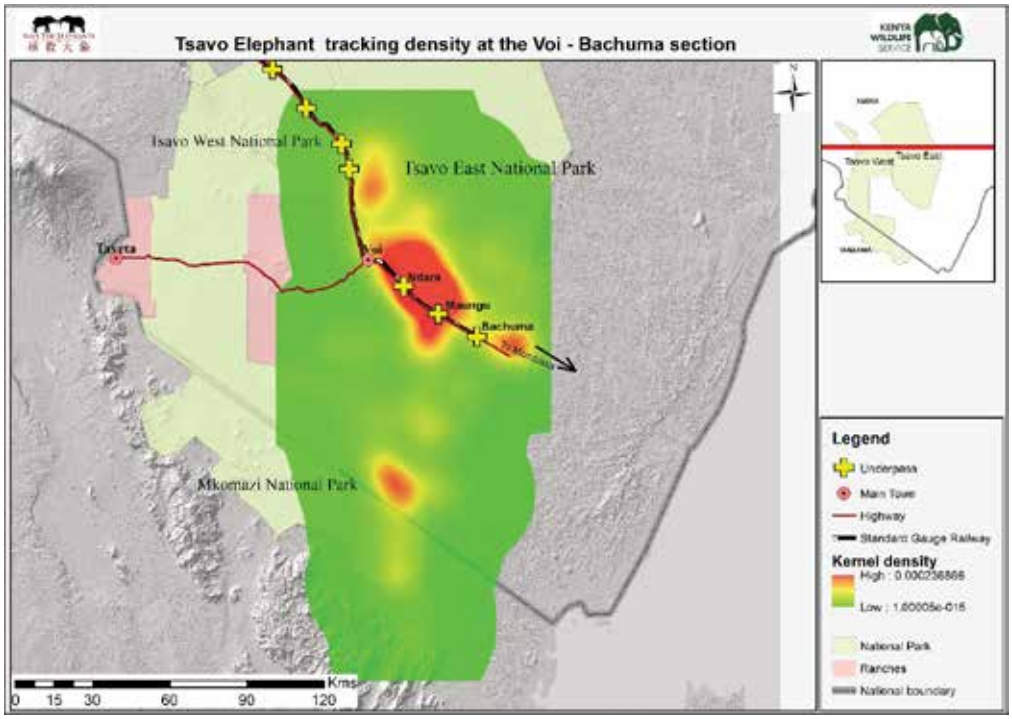

Figure 5b: Elephant movements density at the Voi – Bachuma southern section of the study area. The locations of the main underpasses are also shown.

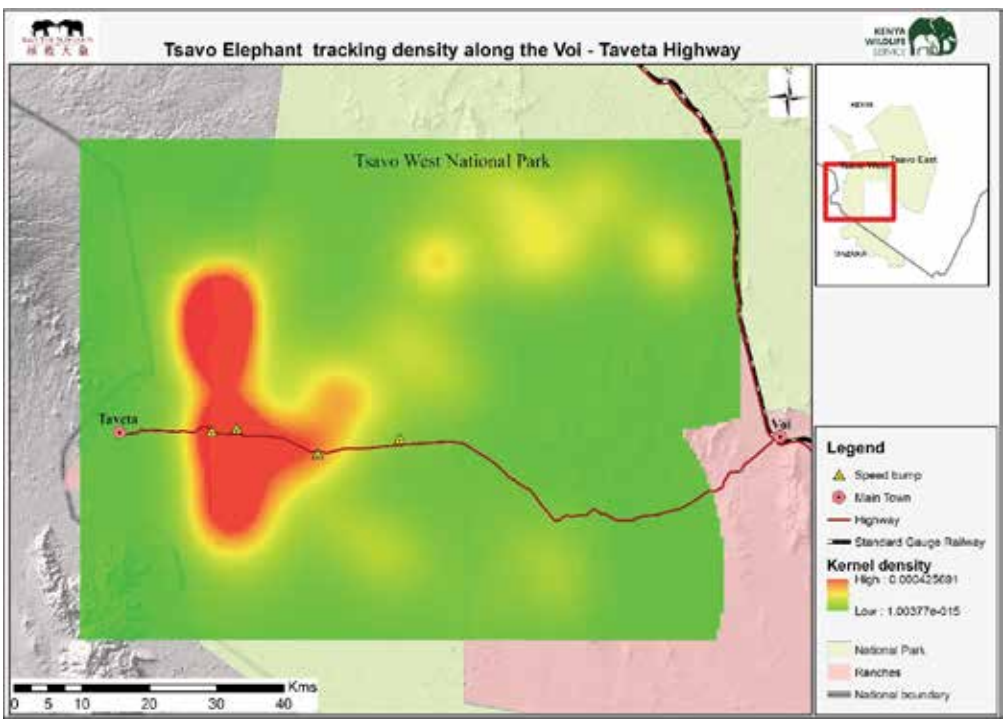

Figure 5c: Elephant movements density at the Voi - Taveta, the western section of the study area. The locations of speed bumps along the Voi - Taveta highway are also shown.

Exceptional movements of elephants

In this report, we also single out exceptional movements by two collared elephants, *Rukinga* (a bull) and *Taita* (a female). These movements are exceptional due to the extreme long distance covered in just two years and their apparent capability of crossing the SGR without any significant problems.

Table 4: Elephant cumulative track distance and Minimum Convex Polygon (MCP) area in two years

Elephant name	**Sex**	**Cumulative track distance(Km)**	**MCP range(**Km^2**)**
Makitau	Male	9181	9627
Murka	Female	8817	3359
Maungu	Female	7143	1327
Ndara	Male	7684	1827
Kamboyo	Female	5338	997
Manyani	Female	5022	227
Tsavo Bull	Male	5737	796
Rukinga	Male	8458	6933
Taita	Female	8677	7362

Table 4 shows the total approximate tracking distance per animal for the two years and the home range estimate using the minimum convex polygon technique. The MCP home range was calculated using 100% percentile of points (Wall, 2014).

Rukinga, a male elephant collared in March 2016 in Rukinga Ranch, south of Maungu town, has covered an approximate distance of 8,458Km within the two years of monitoring his tracking (See Table 4). His range extends from the Yatta plateau in Tsavo East southwards to the border of Kenya and Tanzania near Mkomazi National Park (See Fig. 6a).

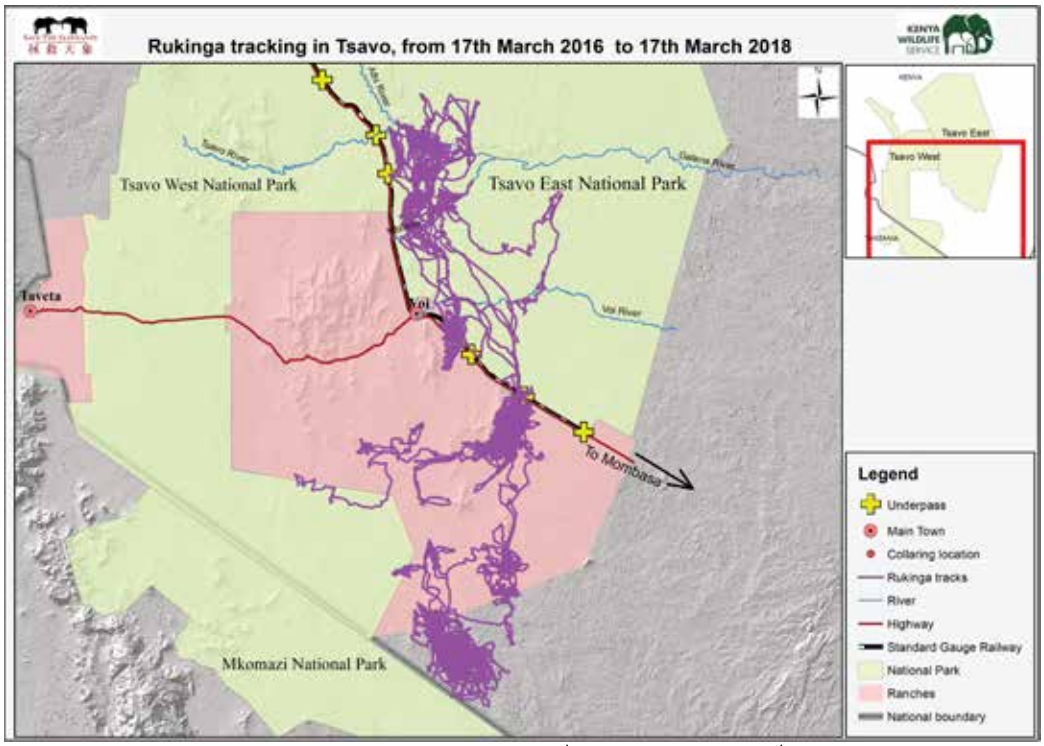

Figure 6a: *Rukinga*'s extensive movements from 17th March 2016 to 17th March 2018 showing a 6,933Km^2 range over a 2 year period

Taita, a female elephant, was collared in Taita Ranch southwest of Bachuma town in March 2016. Her range extends from the Galana River in Tsavo East to far south of Mkomazi National Park in Tanzania (See Fig. 6b). She has done a cumulative distance of approximately 8,673Km in two years.

Both animals moved back into Tsavo East from the Ranches after being collared in March 2016. *Rukinga* then spent April and May 2016 in Tsavo East and Ngutuni Conservancy while actively crop-raiding in Sagalla farms at night. *Taita* also spent significant time in Tsavo East and the Ngutuni Conservancy area but did not cross over to the Sagalla farms to crop-raid.

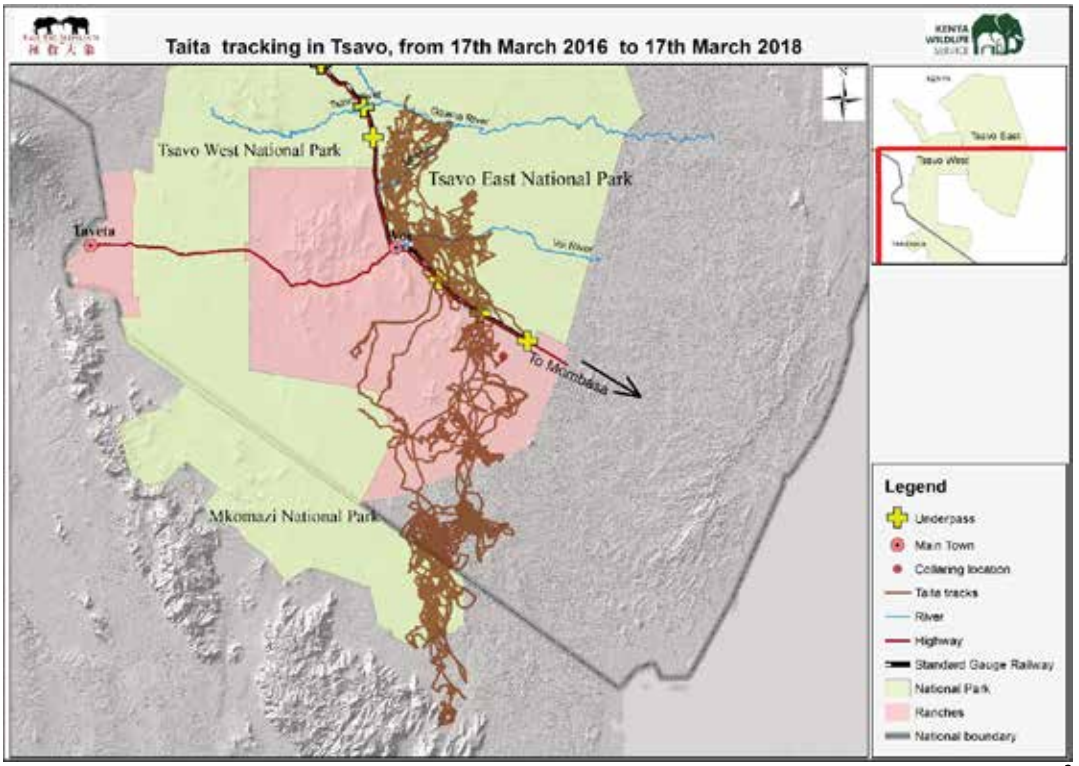

Figure 6b: *Taita*'s movements from 17th March 2016 to 17th March 2018 showing a 7362Km^2 range over a 2 year period

Table 5: Time spent (hours) by *Rukinga* and *Taita* in various conservation areas in Tsavo during the 2 years

	Total hourly fixes per individual animal for 2 years	
	Rukinga	***Taita***
Conservation Area		
Tsavo National Parks	5654	8098
Ngutuni Conservancy & Taita Ranches	11574	7167
Mkomazi National Park	0	1959
Total	**17228**	**17224**

Table 5 and Fig. 7 shows a summary of the cumulative amount of time spend by each of the two animals in three broad conservation areas.

While *Rukinga* has spent 67.18% and 32.82% of the two years in the Taita Ranches and Ngutuni Coservancy, and Tsavo National Parks respectively; *Taita* has spent 41.61% and 47.02% of her time in the Taita Ranches and Ngutuni Conservancy and Tsavo National Parks respectively (see Fig. 7). This shows the critical role played by conservancies and ranches in wildlife conservation.

Therefore, there is need to ensure that connectivity is maintained among Tsavo Conservation Areas.

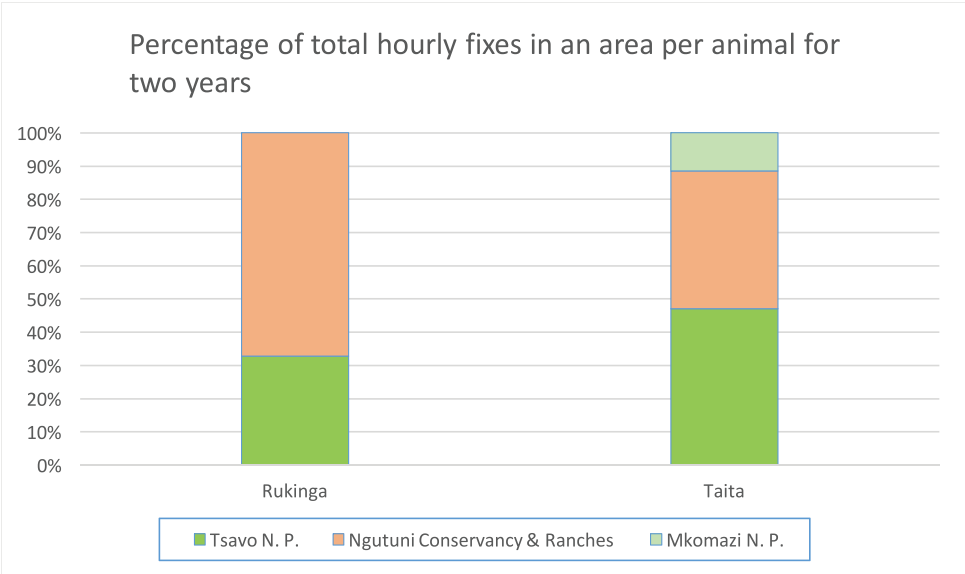

Figure 7: Time spent by *Rukinga* and *Taita* in various conservation areas in Tsavo during the 2 years

The movement of *Rukinga* and *Taita* seems similar in range and pattern. Both animals were in Tsavo East in January and February 2017; this is normally a dry season. Their movement data also shows that both were in and near Mkomazi National Park in May and June the same year after the short April rains. Between November 2017 and February 2018, *Rukinga* and *Taita* were both residing within Tsavo East National Park, after a limited November rainy season (rains were late and little). This may infer that they prefer spending time within the Park during the dry season, probably due to availability of permanent water sources. More research needs to be done to compare their tracking data with NDVI (Normalized Difference Vegetation Index; measures vegetation greenness) to see how rainfall influences movement decisions for these two elephants.

Table 6 shows that *Taita* spent 100% of December and January in Tsavo East, while *Rukinga* spent 99% of December and January in the same area.

Table 6: Taita and Rukinga; monthly time spent in two years in five different areas

Taita

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mkomazi	0.0%	0.0%	0.0%	0.0%	5.2%	33.9%	49.9%	28.2%	17.2%	0.0%	0.0%	0.0%	**11.4%**
Ngutuni	0.0%	0.8%	8.1%	15.9%	24.4%	0.0%	0.0%	0.0%	1.3%	0.0%	0.0%	0.0%	**4.2%**
Ranches	0.0%	30.2%	39.2%	32.6%	52.1%	64.8%	49.8%	71.2%	34.9%	30.5%	42.6%	0.0%	**37.4%**
Tsavo East	100.0%	69.1%	51.5%	51.5%	18.3%	1.3%	0.0%	0.0%	46.7%	69.3%	57.4%	100.0%	**46.8%**
Tsavo West	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.3%	0.6%	0.0%	0.1%	0.0%	0.0%	**0.2%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Rukinga

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Ngutuni	0.0%	0.0%	0.0%	5.4%	3.5%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**1.0%**
Ranches	0.0%	27.9%	45.5%	66.3%	96.0%	92.1%	100.0%	100.0%	96.8%	100.0%	66.2%	0.0%	**66.2%**
Tsavo East	99.5%	72.1%	50.5%	28.3%	0.6%	5.0%	0.0%	0.0%	0.0%	0.0%	33.8%	99.8%	**32.1%**
Tsavo West	0.5%	0.0%	4.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%	0.0%	0.0%	0.2%	**0.7%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Elephant use of the underpasses

Monitoring the use of SGR underpasses and culverts by elephants and other wildlife species using their indirect signs such as foot prints along the SGR from Bachuma to Voi and from Ndii to Mtito Andei was conducted in July, August, September and partly October 2016 before the completion of the SGR. It was also done in July, August, September and October 2017 after the completion of the SGR. During the other months, monitoring was irregular due to logistical issues such field vehicle breakdowns. Monitoring was carried out for 3 alternating days per week culminating to a total of 12 days a month. Fence breakages or crossing the SGR over the embankments were recorded in addition to the different species signs.

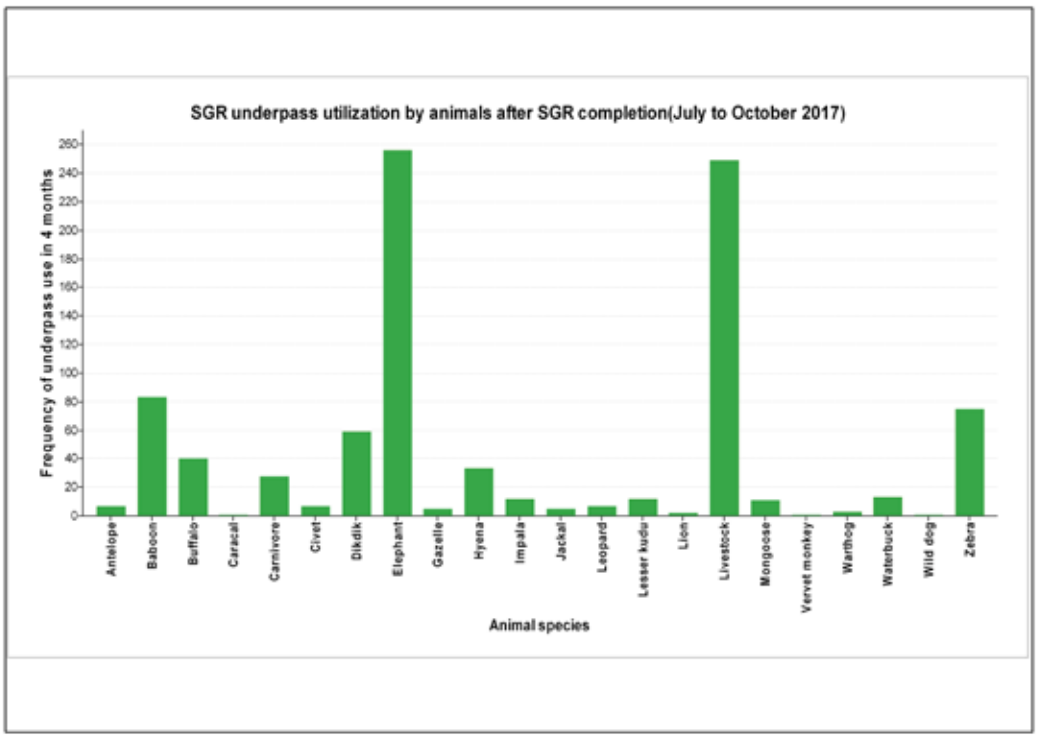

Figure 8: Underpass utilization per wildlife species between July and October 2017. Physical sighting, animal footprints, dung and pellets were used as sign of crossing the SGR through an underpass

The graph in Fig. 8 shows the frequency of underpass utilization per wildlife species four months after the SGR completion in June 2017. Different species of animals have been recorded to use the open underpasses. The underpasses include the wildlife corridors, bridges for different purposes and drainage culverts along the SGR. The main wildlife corridors constructed specifically for use by large mammals are six. These include Kanga, Kenani,

Manyani, Ndara, Maungu and Bachuma corridors. The wildlife corridors measures 60 - 70 meters in width and 5 – 7 meters in height. In addition, there are bridges important for large animals to use. These bridges include: Maungu rail crossing (180 x 7.3 meters), Kenani rail crossing (520 x 10 meters) and the longest bridge over the Tsavo River measuring approximately 1960 meters in width and 9 meters in height. There are also many other drainage bridges and culverts along the SGR of varying sizes. In this study, we are referring to the culverts by the chainage distance in kilometers (DK) from Mombasa i.e. culvert DK90+360 in Bachuma at the start of Tsavo East means it is 90.36 kilometers from Mombasa.

Fig. 8 shows that elephants and livestock appear to have the highest frequency of underpass utilization within the four month period. However, it is important to note that some animal species' signs are more noticeable than others. The finding shows the impact caused by habitat fragmentation to elephants who are being forced to use the underpasses to traverse between habitats, and the pervasive livestock incursion into parks which are freely utilizing the underpasses with no restrictions. The over-utilization of the underpasses by livestock into and out of the park suggest that there could be challenges in the future, as wildlife may start to feel less secure using those underpasses if they are frequently filled with cattle and herders. Camera traps and rangers/scouts could be deployed to deter herders from entering the park at these few sites and to record wildlife use of the underpasses during the day.

Voi – Bachuma section

This section of the SGR and highway is facing a massive upsurge of illegal human settlement forming in a ribbon along the new transport development route (See Fig. 10a). The western side of the SGR in the ranches also has human settlements that are gradually blocking the designated SGR underpasses. The high frequency of elephants crossing over the SGR embankment between July and October 2016 (Figure 9a) may indicate a greater need for the elephants to access the habitat on the other side of the SGR (Okita-Ouma et al, 2017) and not being restricted by the fences. This access between Tsavo East National Park and the Sagalla Ranches was completely blocked by the David Sheldrick's Wildlife Trust electric fences that was constructed in late 2016 (See Figure 2) and the SGR fence between Voi and Ndara area installed since October 2016. These two parallel fence lines were completed around October 2016 and February 2017 respectively, and may explain the observed decrease in the number of elephants who crossed the SGR via the embankment between the park and Sagalla. The double fencing at Ngutuni also completely blocked elephants from utilizing the culverts in this area. The animals seem to have shifted to use the previously underutilized Maungu water bridge 3, Maungu rail crossing and Maungu corridor (see Figures 9a& 9b). Ndara corridor is more underutilized than expected and is most likely due to the illegal settlements directly around the main Ndara elephant underpass (See Figure 10a and Plate 1). A significant presence of charcoal for sale has also been observed from these illegal road-side settlements suggesting that an increase in illegal settlements coincides with an increase in illegal tree felling.

Culvert number DK108+909, measuring 4 meters wide and 5 meters in height, was the most utilized culvert on the Bachuma – Voi section by elephants according to both the monitoring data and from the tracked elephant data (see Figure 3). This culvert is approximately 9 kilometers away from the Maungu corridor underpass which is also frequently utilized by elephants and should be prioritized for protection from illegal settlements.

Voi – Mtito Andei section

The Tsavo River Bridge was the most utilized underpass by elephants on this section four months after the SGR completion, and used most between July and October 2016. Ndii Water Bridge, Kenani rail crossing bridge and Manyani corridor were also frequently utilized by elephants. This shows how essential other bridges not originally meant for wildlife usage are in enhancing wildlife connectivity. Of all the main wildlife underpasses on this section, Kenani corridor was the least utilized. This is can be attributed to its proximity to the Kenani rail crossing which has high elephant usage. Culvert DK236+909 (5 meters wide, 5 meters high) is also frequently utilized by elephants, previously between July – October 2016, high number of elephants crossing over the SGR near this culvert was recorded as shown in Fig. 9c.

There was an exponential increase in the frequency of underpass usage between July – October 2017 compared to between July – October 2016 (See frequency of use of corridors in Figures 9c & 9d). We may infer that elephants adapted reasonably quickly to the underpasses and particularly after the SGR electric fence was erected. This inference is partly supported by the recorded decrease in the frequency of crossing over the SGR embankments in the same period.

Strikingly, the culverts between Kenani rail crossing and Manyani have not been utilized in both periods of monitoring (Figures 9c & 9d). This may be due to the high use of Kenani rail crossing and Tsavo River bridges. Animals may have preferred these two wide underpasses to the narrow culverts.

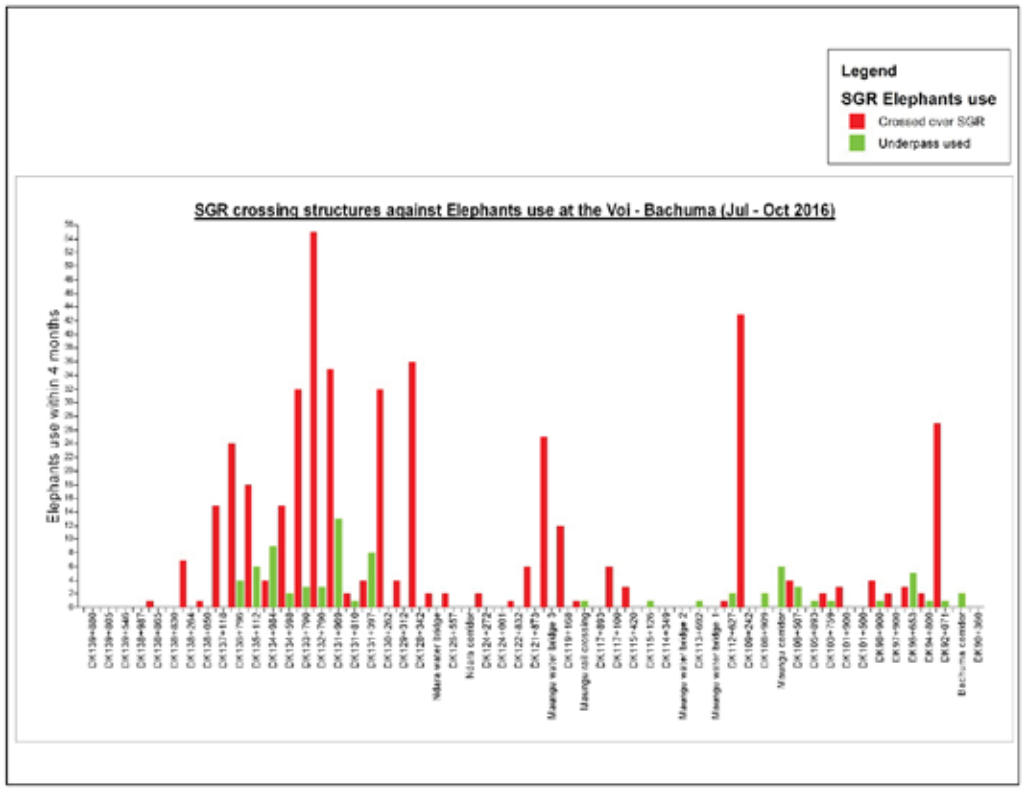

Figure 9a: Elephant – underpass utilization at the Voi – Bachuma, July – October 2016

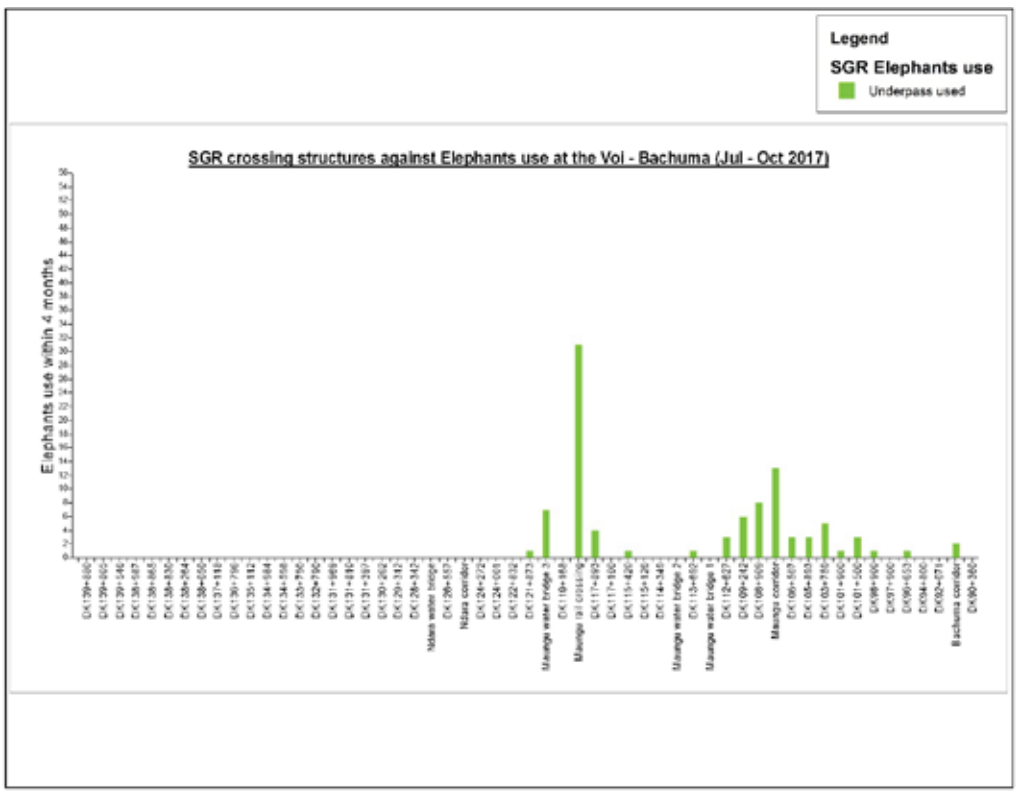

Figure 9b: Elephant – underpass utilization at the Voi – Bachuma, July – October 2017

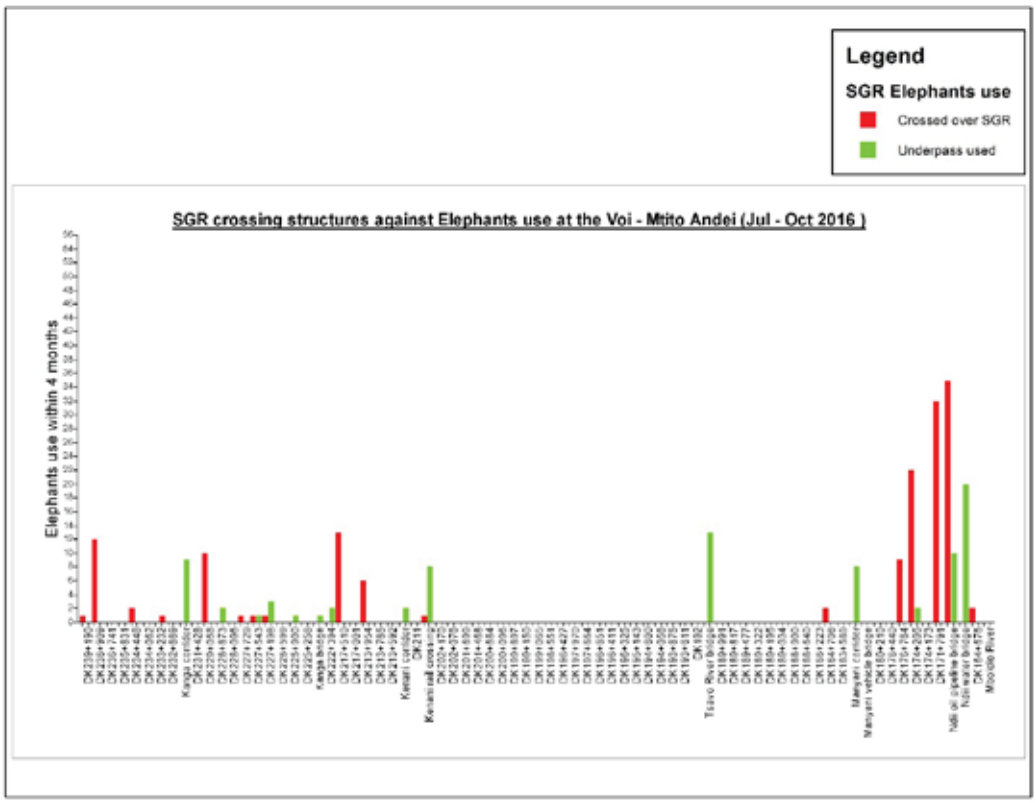

Figure 9c: Elephant – underpass utilization at the Voi – Mtito Andei, July – October 2016

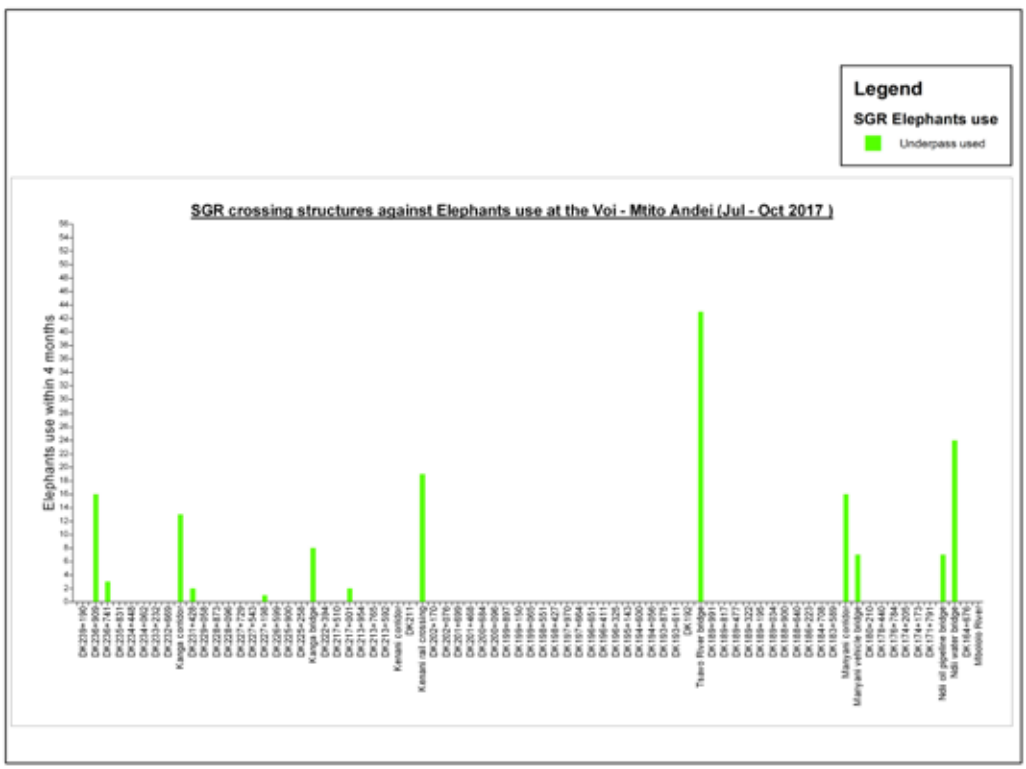

Figure 9d: Elephant – underpass utilization at the Voi – Mtito Andei, July – October 2017

Effect of human settlement on SGR underpass utilization by elephants

There is widespread human settlement on the railway, road and the park reserves between Ndara and Bachuma as shown in Fig. 10a. Some of the settlement are found right at the wildlife underpasses i.e. Ndara corridor (See Plate 1 and Plate 2). This seems to discourage wildlife from utilizing the underpass to cross the SGR and explains the low usage of Ndara corridor by elephants, both from ground monitoring and tracking data as shown in Fig. 10b.

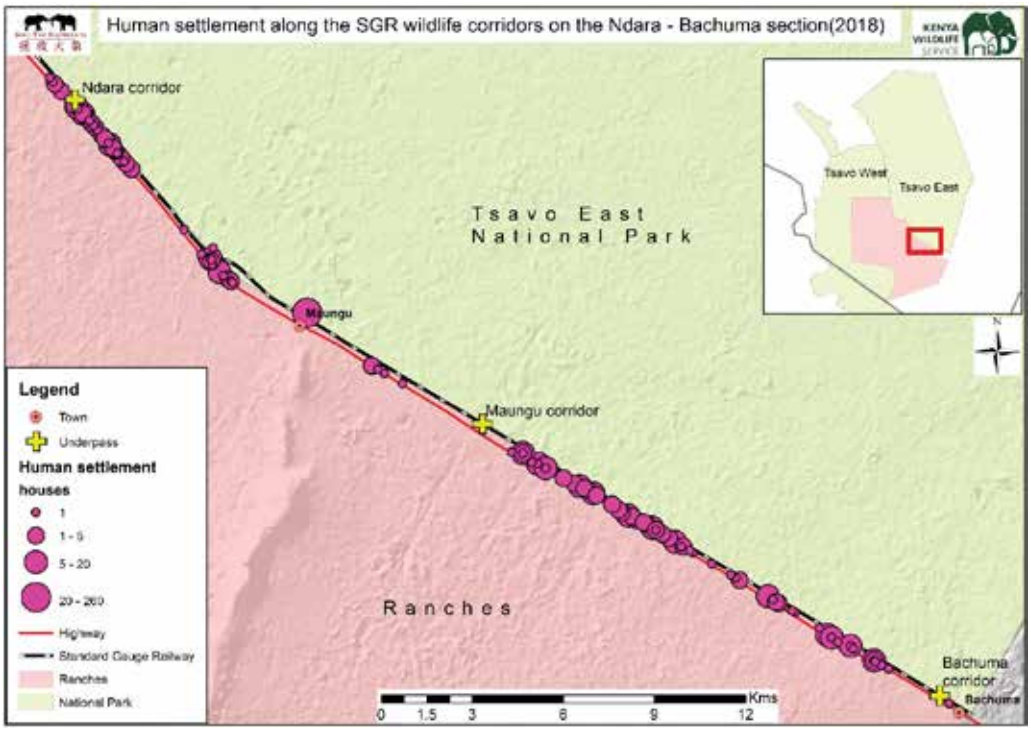

Figure 10a: Human settlement (houses) mapped along the railway, road and park reserves in May 2018 between Ndara and Bachuma

Plate 1: Illegal human settlement and charcoal kiln near Ndara corridor underpass at DK125

Plate 2: Illegal human settlement at Maungu rail crossing bridge at DK118, which is utilized by wildlife

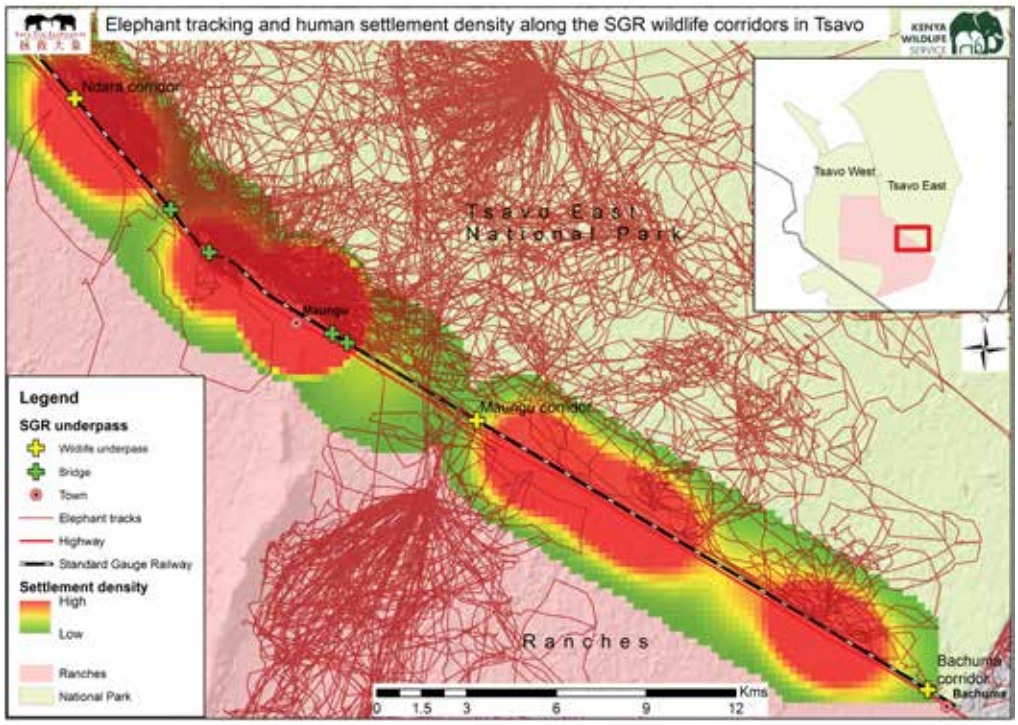

Figure 10b: Human settlement density along the railway, road and park reserves in May 2018 and elephant tracking between Ndara and Bachuma

Effect of SGR borrow pits on elephant movement

During the SGR construction, borrow pits in Tsavo were dug in the park to get soil for raising the SGR embankment. Some of these borrow pits were left open or not fully filled after construction was completed and naturally store surface water whenever it rains. The data from our elephant tracking shows that animals are attracted to these water points along SGR as shown in Fig. 11. Though these borrow pits increases water availability to wildlife, it endangers elephants and other wild animals by attracting them to the transport corridor and increasing their vulnerability to train and vehicle accidents.

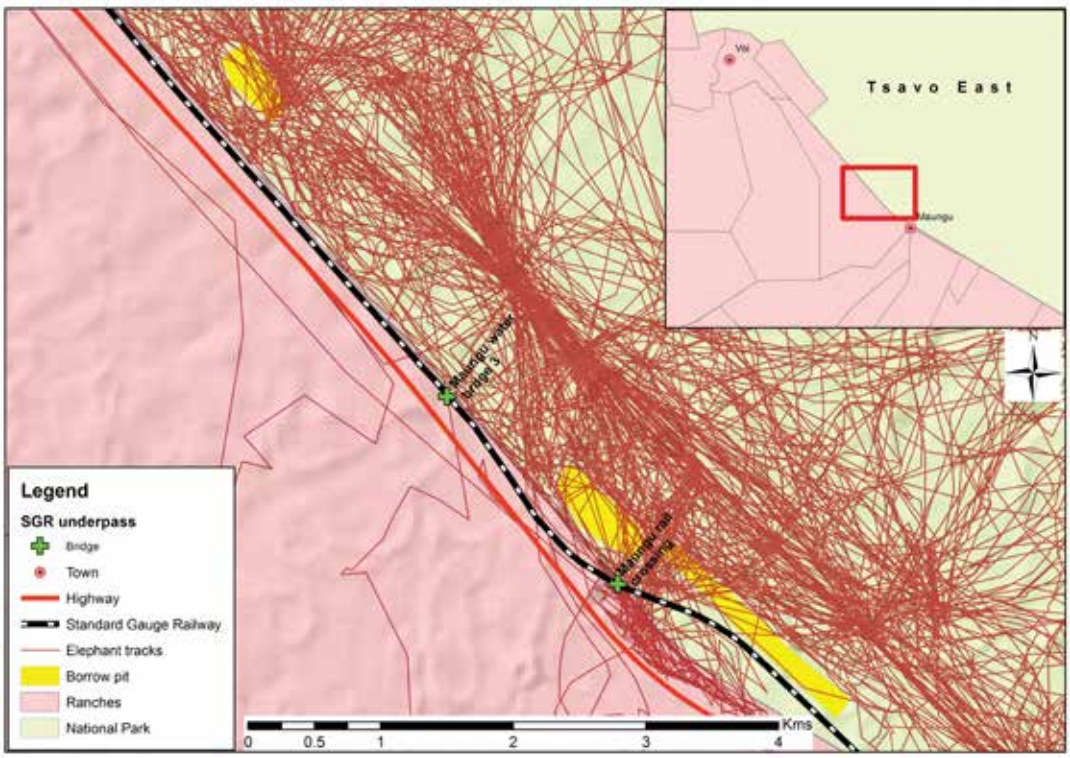

Figure 11: Tracked elephants movement to SGR borrow pits in Maungu. Most of these tracks are for one elephant; *Maungu*

Movement of translocated elephants and the SGR

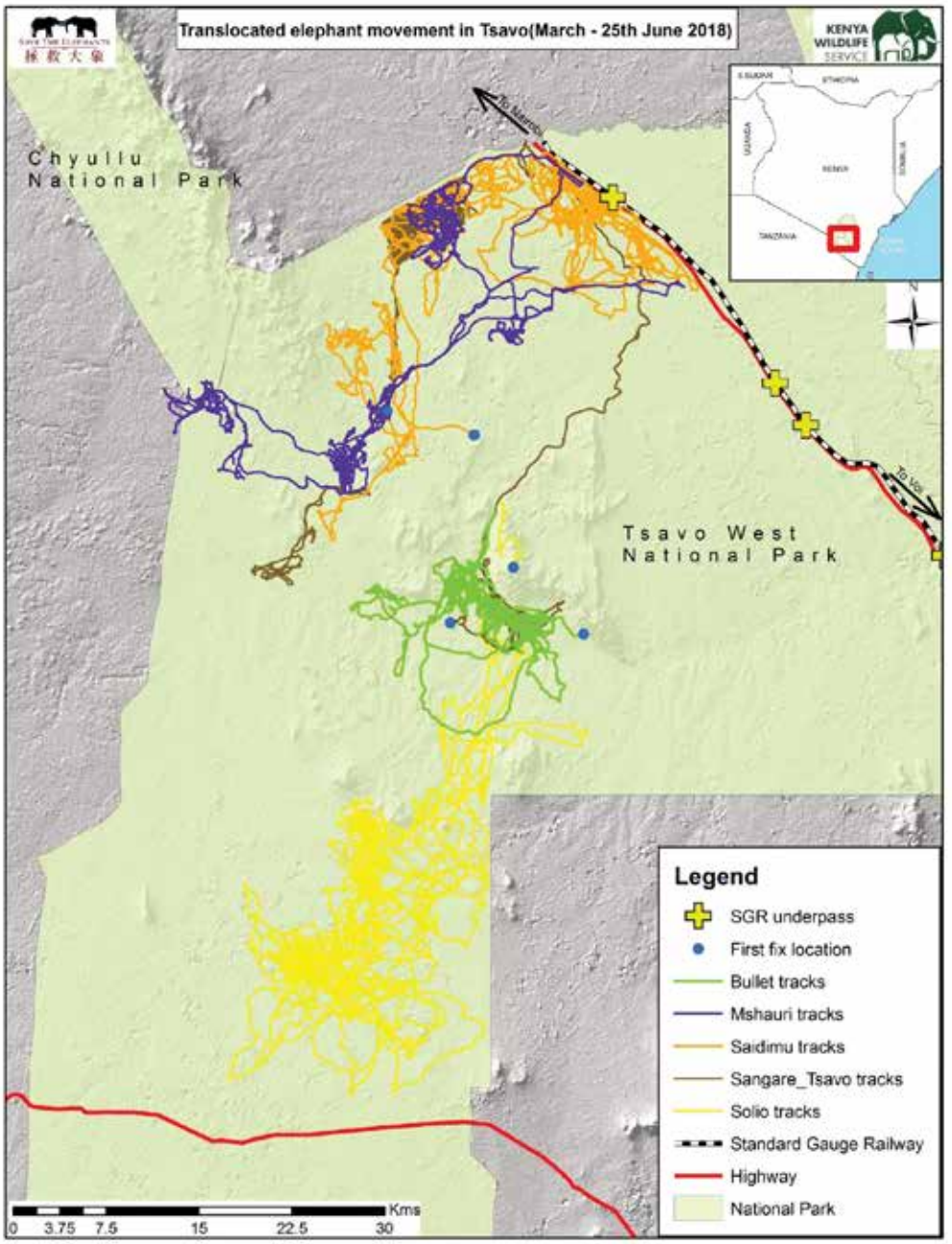

Figure 12: Movement of five elephant bulls translocated into Tsavo West National Park in March 2018

In March 2018, five elephant bulls were translocated by KWS from Laikipia to Tsavo West National Park. Their collars were initially set to transmit tracking data every ten minutes to provide high intensity details on their immediate movements after release. The translocated elephants were released inside Tsavo West but three of them (Sangare, Saidiumu and Mshauri) immediately moved north to/near the highway and SGR (see Figure 12). They all were blocked from travelling further north and seem to experience difficulty crossing the transport networks. Saidimu managed to cross the highway, but he was not successful at crossing the SGR.

Emerging issue: the proposed Nairobi – Mombasa Expressway (NME)

The Government of Kenya intends to construct a 473 kilometer expressway on a new route from Nairobi to Mombasa. This infrastructure is an important development project for Kenya in achieving her Vision 2030 goals, by increasing capacity to handle the volume of traffic from Kenya's capital city to her largest port and reduce congestion on the existing Nairobi – Mombasa Highway.

The NME has been proposed to pass through wildlife protected areas, as well as wildlife dispersal areas and wildlife corridors. The main wildlife areas expected to be affected by this project include: the Athi Kapiti plains, Kibwezi Forest, Chyullu National Park, Tsavo West National Park, Tsavo East National Park and Taita Ranches.

The construction of this six-lane expressway is expected to further fragment the Tsavo Conservation Area as shown in Fig. 13 and hinder wildlife connectivity between the important habitats unless carefully designed and placed wildlife underpasses that align with those along the SGR are put in place.

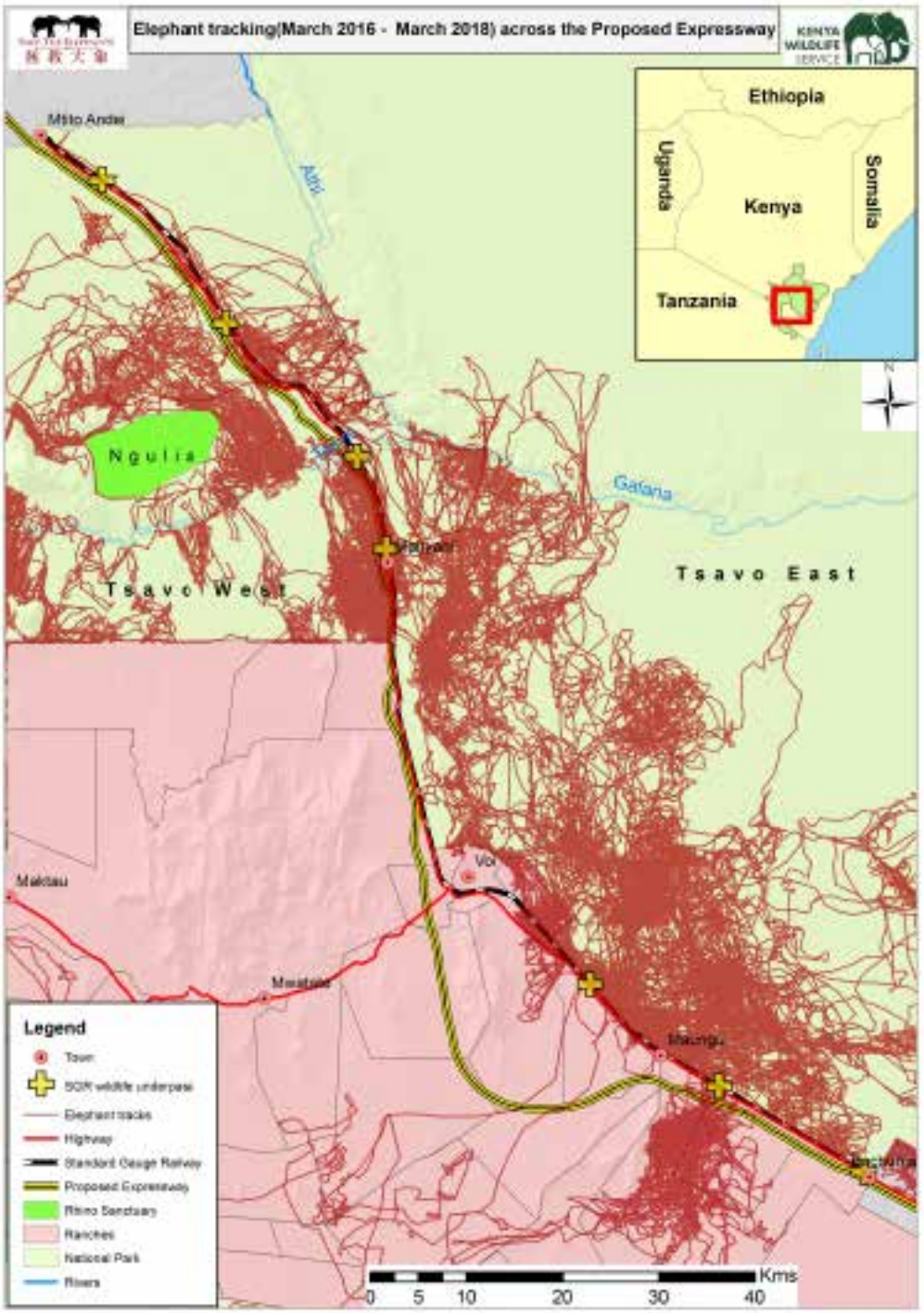

Figure 13: The proposed expressway route cutting through elephant corridors in Tsavo

Conclusions

There are few studies in Kenya on road ecology, and on the need to incorporate wildlife conservation in transport infrastructure planning. The development of the SGR in Kenya from Mombasa to Nairobi through wildlife conservation areas has brought to the fore, the gravity of linear infrastructure cutting through wildlife areas.

This study suggests that elephants are greatly impacted by habitat fragmentation because of their need for free movement and vast landscape. Elephants are calmer crossing the existing Mombasa highway than the new SGR which is raised and fenced. Elephants are also attracted to the borrow pits near and along the SGR left open during construction, because they hold rain water; and elephant free movement to other water points has been restricted by the new SGR. Though this phenomenon, readily avails water to elephants and other wildlife species, it may endanger wildlife by exposing them to potential train and vehicle accidents due to borrow pits' close proximity to the SGR. These sections of the SGR should be closely monitored.

There is need for more research and to develop policies on how transport managers and civil engineers can work with wildlife ecologists and conservationists to avoid and mitigate on the effects of habitat fragmentation.

There is also need to study what constitutes effective wildlife crossing structures in Tsavo and other regions where infrastructural development is being done in wildlife areas.

This report demonstrates that wildlife underpasses on the SGR can be effective in maintaining wildlife habitat connectivity. However, there is need to ensure that those underpasses are left open and free from obstructions.

Human settlements along the transport corridor and in the park discourage elephants and other animal species from utilizing some SGR underpasses. Therefore, illegal settlements on and around the main wildlife underpasses such as Ndara corridor and Maungu rail crossing bridge should be moved away and policed to stop any further illegal settlements from obstructing the free flow of wildlife between conservation areas.

We also indicate in this report that some SGR crossing structures meant for wildlife use are being misused by people to drive livestock into the National Parks. This may discourage wildlife from utilizing those underpasses in crossing the SGR. Camera traps (automated cameras) should be installed and it is proposed that rangers be deployed in those major underpasses to monitor and curtail livestock incursion into the park through the SGR underpasses.

There is need to continue monitoring how elephants and other species are utilizing the different SGR underpasses in Tsavo. This can be complimented by installation of digital motion detecting cameras in the underpasses, in order to understand what works and what doesn't work for effective wildlife underpasses. It will also give us a clue on how different wildlife species respond and interact while using underpasses to cross the new SGR.

Elephant radio tracking provides invaluable data for land-use planning and information on monitoring the impact of new transport infrastructure that can be fed back into management plans as Kenya continues to develop under its 2030 Vision goals.

References

Okita-Ouma B., Lala F., Moller R., Koskei M., Kiambi S., Dabellen D., Leadismo C., Mijele D., Poghon J., King L., Pope F., Wittemyer G., Wall J., Goss S., Obrien R. & Douglas-Hamilton I. Preliminary indications of the effect of infrastructure development on ecosystem connectivity in Tsavo National Parks, Kenya. Pachyderm, No. 57(2016).

Okita-Ouma B., Lala F., Koskei M., Mwazo A., Kibara D., King L., Kanga E. & Douglas-Hamilton I. 2016. Movements of satellite-linked collared elephants and other wildlife in relation to the Standard Gauge Railway (SGR) and highways in Tsavo Ecosystem, Kenya (March – September 2016). Pages 1-34. Save The Elephants and Kenya Wildlife Service, Nairobi.

Okita-Ouma B., Lala F., Koskei M., Mwazo A., Kibara D., King L., & Douglas-Hamilton I. 2017. Tracking and monitoring of elephant movements along the Standard Gauge Railway and highways in the Tsavo Ecosystem, Kenya (March 2016 – June 2017). Pages 1-28. Save The Elephants and Kenya Wildlife Service, Nairobi.

Wall, J. 2014. Movement Ecology Tools for ArcGIS (ArcMET) v.10.4.1 v1.

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