GIZ TraCS l Advancing Climate Strategies in Rapidly Motorising Countries

Characteristics of the in-service vehicle fleet in Kenya

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Authors:
Madara Ogot (University of Nairobi)
James Nyang'aya (University of Nairobi)
Rita Muriuki (University of Nairobi)

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

REPUBLIC OF KENYA
Ministry of Transport, Infrastructure, Housing and Urban Development
State Department of Transport

Project context

GIZ works on changing transport towards a sustainable pathway and facilitating climate actions in mobility. We support decision-makers in emerging and developing countries through training and consulting services, as well as by connecting stakeholders. Our ultimate goal is to keep global temperature change to below 2 degrees Celsius.

The Advancing Transport Climate Strategies (TraCS) project's objective in Kenya is to support Kenya's State Department for Transport to institutionalise climate change-related functions like designing and monitoring mitigation actions. In addition, the project closely coordinates with the Climate Change Directorate in the Ministry of Environment and Forestry to ensure coherence with the overarching framework of the Climate Change Act (2016). Under the framework of TraCS, the State Department for Transport and GIZ have cooperated to set up a climate change unit, which is now in charge of reporting on climate change-related activities of the state department and its state agencies, who are also represented in the unit.

In order to improve the transport database in Kenya to facilitate more accurate greenhouse gas emissions accounting in the sector, GIZ contracted a team at the University of Nairobi to estimate the in-use vehicle fleet for road transport in Kenya and collect data on average vehicle mileages. A database of all cumulative vehicle registrations exists at the National Transport and Safety Authority (NTSA), but information on which of these vehicles are still in use is not currently collected. There is also no official data on annual average mileages of different vehicle types. This study was conducted to fill this gap.

For more information, see: www.changing-transport.org/publications/?_sft_country=kenya

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Disclaimer

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Final Report

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List of abbreviations and acronyms

GHG	Greenhouse Gases
GPS	Global Positioning System
KNBS	Kenya National Bureau of Statistics
NCCAP	National Climate Change Action Plan
NTSA	National Transport Safety Authority
TraCS	Advancing Climate Strategies in Rapidly Motorising Countries
UNFCCC	United Nations Framework Convention on Climate Change
VKT	Vehicle Kilometres Travelled

1. Introduction

Determination of reasonably accurate greenhouse gas (GHG) emissions from road transport requires a good characterisation of the in-service vehicle fleet. Attributes include number of new vehicles imported/registered by year, as well as information on the existing fleet; vehicle fleet data differentiated by vehicle type, size, fuel type or drivetrain technology, age and emission concepts, where possible.

In Kenya aggregated data is available from Economic Surveys and from the National Transport Safety Authority (NTSA) for vehicle registrations. This data, however, does not account for the number of vehicles removed from service due to a myriad of reasons including mechanical problems, age, accidents, etc. Many official government reports including *Kenya: Second National Communication to the United Nations Framework Convention on Climate Change*[1] and *Kenya's Climate Change Action Plan: Mitigation,*[2] use a base number of 1,200,000 in 2010 citing Omwenga (2011)[3]. In his presentation, Omwenga simply states as a matter of fact, "the country had about 600,000 vehicle units in 2000, 950,000 in 2008 but this has risen to about 1.2 million in 2010/11" (p.4). There is no reference provided nor any indication on how these estimates were arrived at.

The Energy Regulatory Commission in *The Report on Global Fuel Economy Initiative (GFEI) Study in Kenya*[4] estimated, based on cumulative registration data from the Kenya Revenue Authority that there were a total of 1.5 million vehicles on Kenyan roads in 2009 (p.10). They projected using a linear model that by 2030, the total fleet will be about 5 million vehicles. In the report the vehicles are not split into categories. In addition, end of life is not factored into the model, therefore all registered vehicles are assumed to be active. This linear projection and assumption, will over time lead to significant over or under estimation of the vehicle population.

The University of California at Riverside did a study in Nairobi in March 2002 through a combination of videotaping vehicles on roads and randomly sampling parked vehicles at three locations: Central business district, Buru Buru and Muthaiga[5]. The process of videotaping enabled the study team to obtain information on several thousand vehicles. The taping was carried out for a period of 6 hours per day over six days at three locations: Buru Buru – low income area; Muthaiga – upper income area; and central business district – commercial area. Overall they found a vehicle distribution of passenger cars (89.37%), buses (6.03%), trucks (3.13%) and motorcycles (1.46%). As the study was done in Nairobi only, it may not be nationally representative. In addition, vehicle population distributions have significantly changed in the past 13 years since the study was carried out, especially for motorcycles that has seen a surge in the last few years.

Annual vehicle registration information, however, is available and compiled by the Kenya National Bureau of Statistics (KNBS) and made available annual through the Economic Surveys. Registration data is provided in several categories namely, Saloon Cars, Station Wagons, Vans/Pick-ups, Lorries/Trucks, Buses/Coaches, Mini Buses/Matatu, Special Purposes Vehicles, Trailers, Rollers/Graders/Cranes, Wheeled Tractors, Crawler Tractors, Motor and Auto Cycles, Three Wheelers, and Other Vehicles (all which do not fit into any of the previous categories). A summary of the annual registrations for these categories of vehicles from 1968-2017 is shown in Figure 1.1, and

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[1] NEMA (2015), *Kenya: Second National Communication to the United Nations Framework Convention on Climate Change*

[2] Stiebert, S. (2012), *Kenya Climate Change Action Plan: Mitigation, Chapter 2: Preliminary Greenhouse Gas Inventory,* Climate and Development Knowledge Network.

[3] Omwenga, M. (2011), "Integrated Transport System for Liveable City Environment: A Case Study of Nairobi, Kenya, 47th ISOCARP Congress.

[4] Energy Regulatory Commission, *Report on Global Fuel Economy Initiative Study in Kenya (GFEI)*, April 2015.

[5] Global Sustainable Systems Research, *Nairobi, Kenya Vehicle Activity Study,* University of California, Riverside (2002)

tabulated in Appendix A, Table A.1. From the figure, it is evident there has been a rapid increase in new registrations since 2007, especially for station wagons and motorcycles.

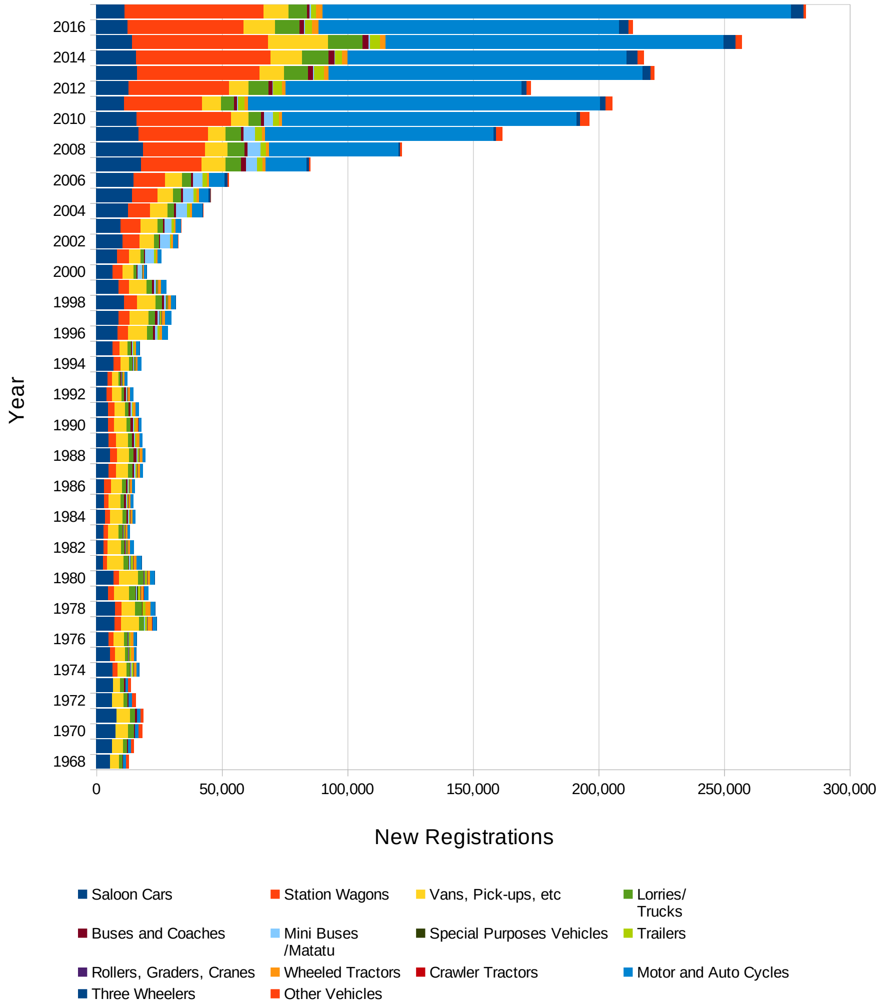


Figure 1.1: Summary of new vehicle registrations, 1968-2017

2. Age, In-Service Vehicle Population and Characteristics: Approach

2.1 Theoretical Background

The *survival rate* for a vehicle category is defined as the proportion of the number of vehicles registered in a particular year still being in service at a specified base year. The survival rate can be modelled using the modified Weibull distribution[6, 7](Equation 2.1):

$$S^{w}_{v,age} = \exp\left[-\left(\frac{Age + a_v}{T_v}\right) bv\right] \tag{2.1}$$

where *T* is the characteristic service life of the vehicle category, *v;* and *a/b* is the failure steepness. Two scenarios (not know in advance) can be modelled. For a high survival rate, the parameter a=0, and for low survival rate, a=b. The true rate is probably somewhere in between. Typically, shorter life (lower survival rates) may be due to heavier usage, higher accident rates or poor road conditions, all leading to higher wear and breakdowns (Baidya and Borken-Kleefeld, 2009)[8]. The latter conditions are common in a developing country such as Kenya.

Alternatively, Goel et al. (2014)[9], in their study of vehicle and passenger travel characteristics in Delhi (India) found that a log-logistic survival function (Equation 2.2) gave a better fit to their data.

$$S^{l}_{v,age} = \exp\left[1+\left(\frac{Age}{a_v}\right) bv\right] -1 \tag{2.2}$$

where a_v and b_v are the distribution parameters for the vehicle type, *v*. For this study all three models were used and comparisons made.

In order to determine the *survival rate,* first let n_b, n_k, r_b and r_k be the number of vehicles in the survey in the base year, in the survey with age *k*, the number of vehicles registered in the base year and the number vehicle registered *k* years earlier, respectively. The ratio n_k/n_b represents the proportion of vehicles in the survey sample with age k, with respect to those in the base year. The ratio r_k/r_b is the expected proportion of vehicles based on registration data with age *k*, and with respect to those in the base year, *b,* assuming all registered vehicles are still on the road. Dividing the survey sample ratio by the registration ratio yields the estimated survival rate for vehicle type *v,* with age, *k*. This is expressed in Equation 2.3 as:

$$S^{s}_{v,age} = \left(\frac{n_k\ r_b}{n_b\ r_k}\right) \tag{2.3}$$

To determine the model parameters in Equations (2.1) and (2.2), a solver can be used to estimate the parameters by minimizing the square of the difference between the observed (from the survey) survival rate as defined by Equation 2.3, and the modelled survival rates as defined by Equations 2.1 and 2.2, as shown in Equation 2.4:

[6] Zachariadis, T., Samaras, Z., Zierock, K.H., 1995. Dynamic modeling of vehicle populations: an engineering approach for emissions calculations. *Technol. Forecasting Social Change* 50 (2), 135–149; Zachariadis, T., 2006. On the baseline evolution of automobile fuel economy in Europe. *Energy Policy* 34, 1773–1785.

[7] Baidya, S. and Borken-Kleefeld, J. (2009) "Atmospheric emissions from road transportation in India", *Energy Policy,* 37(10), 3812-3822.

[8] Ibid.

[9] Goel, R., Guttikunda, S.K., Mohan, D., Tiwari, G., (2015) "Benchmarking vehicle and passenger travel characteristics in Delhi for on road emissions analysis", *Travel Behaviour and Society,* 2(2), 88-101.

$$\text{Min} \sum_{k=0}^{T} (S^{s}_{v,age} - S^{w}_{v,age})^2 \quad (2.4)$$

The number of in-service vehicles, N_s, can be therefore be estimated by multiplying the survival rates from the Weibull or Log-logistic models (Equations 2.1 and 2.2) and with the annual the new vehicle registration information from each year, r_k. Summation of the individual products (Equation 2.5) yields the estimated in-service vehicle population for the period under review:

$$N_s = \sum_{k=0}^{T} r_k \; S^{w}_{v,k} \quad (2.5)$$

with the estimated number of vehicles for each age group, N_k estimated from Equation 2.6:

$$N_k = r_k \times S^{w}_{v,k} \quad (2.6)$$

Next, the average annual vehicle kilometres travelled, VKT_a, was calculated from Equation 2.7:

$$VKT_a = \frac{1}{n} \sum_{k=0}^{n} Od/(2017\text{-}Yr_m+0.5) \quad (2.7)$$

where is n, Od and Yr_m is the number of vehicles surveyed, odometer reading and year of manufacture, respectively. The survey was conducted at the end of 2017, and thus serves as the reference year. It was assumed that an equal number of registrations occur each month throughout the year. Annual VKT calculation therefore assumed that all vehicles were registered in the middle of the year, hence the 0.5 in the formula. So, for example, odometer readings for a 2016 registered vehicles were divided by 1.5, to account for those that were registered in January 2016, and therefore have been on the road for about 2 years by the end of 2017, and on the other extreme, those registered in December 2016, which would have been on the road for about a year. A similar approach was used by Baidya and Borken-Kleefeld, 2009.[10]

2.2 Cross-sectional survey

A series of surveys were performed at busy fuel stations in urban areas across 3 major cities (Nairobi, Mombasa, Kisumu) and 19 towns in Kenya (Thika, Athi River, Kitengela, Ongata Rongai, Limuru, Mombasa mainland, Changamwe, Mtwapa Ukunda, Nyali, Nakuru, Eldoret, Kisii, Kakamega, Kericho, Machakos, Nanyuki, Isiolo and Meru). In each city and town, respondents in four different fuel stations were interviewed. Due to the larger market

[10] Op. Cit.

in Nairobi, a total of 16 petrol stations where covered for one week each during the survey period. The target population for this survey were motorists of both public, commercial and private vehicles at the fuel stations.

The respondents had a 3 item survey questions asking about their vehicle odometer reading, their estimated monthly fuel expenditure and where their vehicle was mainly used, whether in town, rural area or highway. The study was conducted at varied time periods from 8 am to 5 pm shifts seven days of the week from the 20th November 2017 to 17th December 2017. Enumerators spent a full week at each petrol station before moving to the next. Efforts were made to ensure the retailers where all different at each successive station to avoid vendor bias.

3. Age, In-Service Vehicle Population and Characteristics: Motor Cycles

This section covers vehicles categorised by NTSA as *Motor and Auto Cycles* which is also how the data is presented in the KNBS Economic Surveys.

3.1 Age Profile

There were a total of 639 motorcycle respondents in the survey. After the data was cleaned, a total sample of 570 remained. Age profiles were calculated both from the date of registration in Kenya (difference in the year of registration in Kenya, and the year of the survey, 2017) and from date of manufacture (difference in the year of manufacture, and the year of the survey). These are presented in Table 3.1 and 3.2, respectively. A year wise distribution of the age profile is presented in Figure 3.1 based on year of manufacture. Based on age from year of manufacture, the average age was found to be 9.83 years. From the analysis, 24.6% of the motorcycles were between 0-5 years, with the majority, 30% between 6-10years. This is in tandem with the surge in motorcycle registrations since 2005. What is surprising is the difference in proportion between age based on year of manufacture, and age based on registration. Although it is not common to import second-hand motorcycles, the lag between registration and year of manufacture may be due to countries of origin which is primarily China and India exporting to Kenya excess stocks of older models.

Table 3.1: Motor cycle age profile from survey data based on year of registration

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	291	177	57	22	23	570
Percent in each category	0.511	0.311	0.100	0.039	0.040	1

Source: Compiled from December 2017 Survey

Table 3.2: Motor cycle age profile from survey data based on year of manufacture

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	153	187	127	101	55	623
Percent in each category	0.246	0.300	0.204	0.162	0.088	1

Source: Compiled from December 2017 Survey

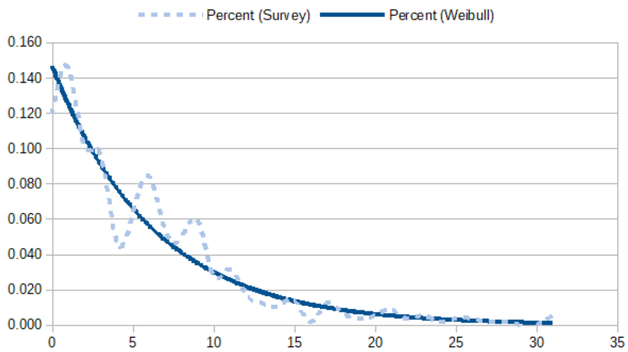
3.2 Estimation of in-service motorcycle fleet

The registration of new motorcycles underwent a significant increase between 2007 and 2010, rising from 16,293 in 2007 to 51,412 in 2008, 91,151 in 2009 and 117,266 in 2010. From 2010, the annual registration rates have ranged between a low of 93,970 in 2012 to a high of 134,645 in 2015. From 2009-2016, a total of 933,153 motorcycles were registered compared to 110,890 between 1985 and 2008, or approximately 10.6%. Coupled with the reasonable assumption that a significant number of those registered prior to 2009 are off the road, strongly reduces the importance of older motorcycles.

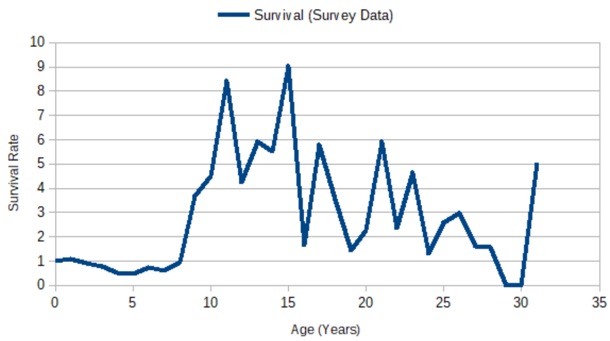
In addition, there would be statistical challenges in modelling data across the two periods whose characteristics are fundamentally different as evidenced in the estimates of the survival rate calculated from the survey data (Equation 2.4). The estimates before 2008 (equivalent to age 8 years and above) is very noisy and inconsistent with estimates based on years 2009-2016 or age 7 years and below (Figure 3.1(b).) This studies analysis, therefore, was restricted to the period 2009-2016.

Using 2016 as the base year and the approach defined by Equations 2.1-2.6, survival rate models based on Weibull Low, Weibull High and Log-logistic are presented in Figures 3.1(c) and 3.1(d). The parameter values for the models are presented in Table 3.2. For the log-logistic model, values from a study conducted in Delhi in 2012 are provided for comparison.

The estimated number of in-service vehicles for each age group between 2009-2016 using all three models is presented in Table B.1 in Appendix B. Due to the high registration numbers in recent years, the Weibull high and low estimates are expected to be and are close. A similar conclusion was reached by Baidya and Borken-Kleefeld (2009) in Delhi. From the three models, it was estimated that the in-service motorcycles range from 659,492 – 738,501 corresponding to 63.2% - 70.7% of total registered motorcycles of 1,044,043 during the same period. The models had goodness of fit for all models was poor, due to the wide variability in survival rates from year to year. However, they provide a starting point for making estimations.



(a) Age profile for motorcycles (R^2=0.922)



(b) Survival rates with respect to base year (2016)

Figure 3.1 Survival curve for motorcycles

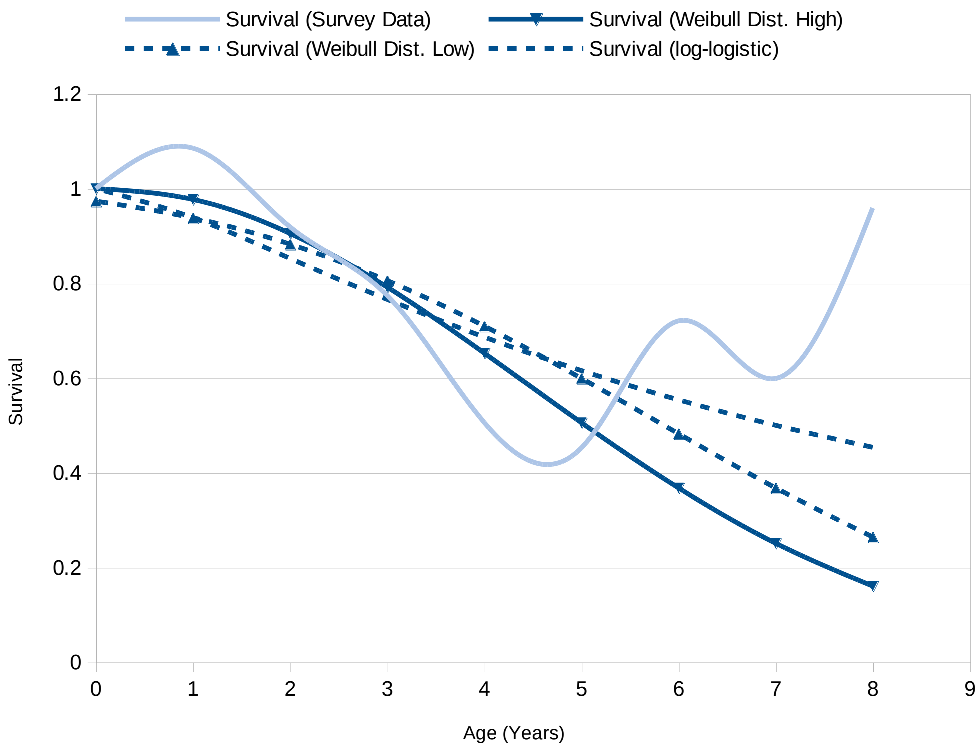


Figure 3.2 Motor cycle survival rate (based on registration year 0-8 only) estimates with Weibull function high (R^2=0.202), low (R^2=0.154) and log-log (R^2=0.294)

Table 3.2: Motor cycle survival rate models parameters

Weibull	Weibull (High)	Weibull (Low)	Log-Logistic	This Study	Goel et al (2014)[11]
b	1.27	1.08	**a**	1.4	3.2
T	12.33	10.27	**b**	7	7.5
	Baidya et al. (2009)[12]				
b	1.99	2.55			
T	15.83	18.23			

3.3 Annual on road vehicle kilometres travelled

On road activity was defined as annual vehicle kilometres travelled. This was determined using the odometer readings from the fuel station surveys, and are provided with confidence intervals at 95%. As above data used was restricted to the registration years 2007-2016. As the survey was conducted in December 2017, a full year had not passed and therefore the data set would be incomplete. In addition, it was assumed that an equal number of registrations occur each month throughout the year, thus for purposes of determining annual VKT is was taken as all vehicles registered in the middle of the year. So, for example for odometer readings for 2016 registered vehicles were divided by 1.5, to account for those that were registered in January 2016, and therefore have been

[11]Goel, R., Guttikunda, S.K., Mohan, D., Tiwari, G., (2015) "Benchmarking vehicle and passenger travel characteristics in Delhi for on-road emissions analysis", Travel Behaviour and Society, 2(2), 88-101.

[12]Baidya, S. and Borken-Kleefeld, J. (2009) "Atmospheric emissions from road transportation in India", Energy Policy, 37(10), 3812-3822.

on the road for about 2 years by the end of 2017, and on the other extreme, those registered in December 2016, which would have been on the road for about a year. The overall average was found to be 17,807 ± 3,519 km. The average annual VKTs for registration years between 2007 and 2016 is presented in Figure 3.2.

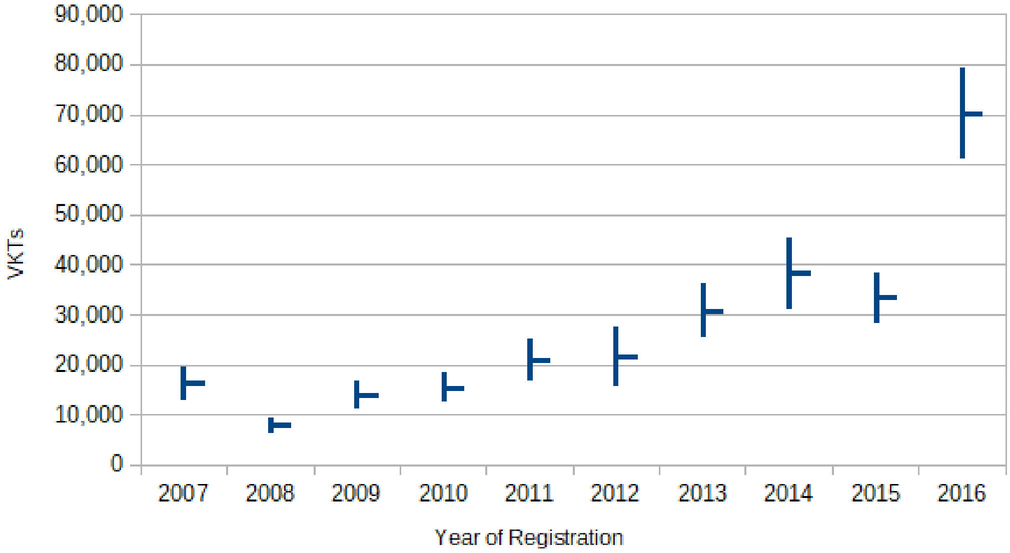


Figure 3.2 Trend in vehicle kilometres travelled and year of registration for motorcycles (2007-2016)

4. Age, In-Service Vehicle Population and Characteristics: Three Wheelers

This section covers vehicles categorised by NTSA as *three wheelers*, which is also how the data is presented in the KNBS Economic Surveys.

Figure 4.1 – Three-wheeler (*tuk-tuks*) primarily used for public transport

4.1 Age Profile

There were a total of 221 three-wheeler (popularly known in Kenya as *tuk-tuks)* respondents in the survey. After the data was cleaned, 197 valid respondents remained. Within this dataset, the earliest year of registration was 1985. The grouped age distributions based on year of registration and year of manufacture are presented in Table 4.1 and 4.2, with a year wise distribution of the age profile based on year of manufacture presented in Figure 4.2(a). The average age based on year of manufacture was 12.16 years. Based on year of manufacture, the largest proportion, 32.5%, were in the 6-10 age bracket, with 10.2% over 20 years old. As for motorcycles, three-wheelers are typically purchased new. The age lag between registration and date of manufacture may also be due to export to Kenya of excess older stocks from Asian manufactures.

Table 4.1: Three-wheeler age profile from survey data based on year registration (1985-2016)

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	81	65	26	14	4	190
Percent in each category	42.6	34.2	13.7	7.4	2.1	1

Source: Compiled from December 2017 Survey Data

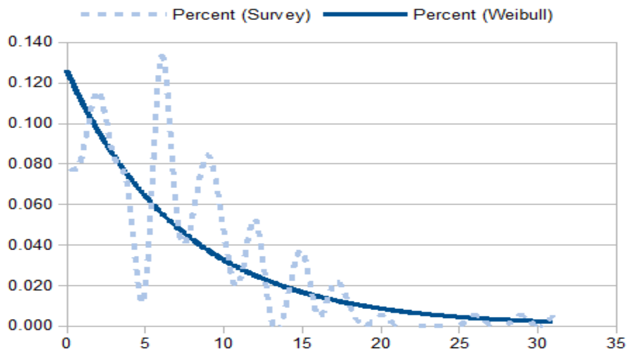
Table 4.2: Three-wheeler age profile from survey data based on year of manufacture (full sample)

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	17	64	48	48	20	197
Percent in each category	8.6	32.5	24.4	24.4	10.2	1

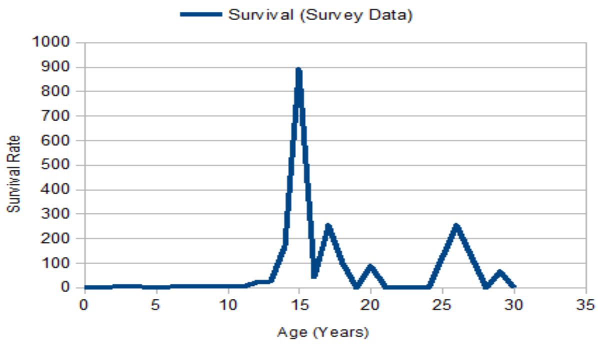
Source: Compiled from December 2017 Survey Data

4.2 Estimation of in-service three-wheeler fleet

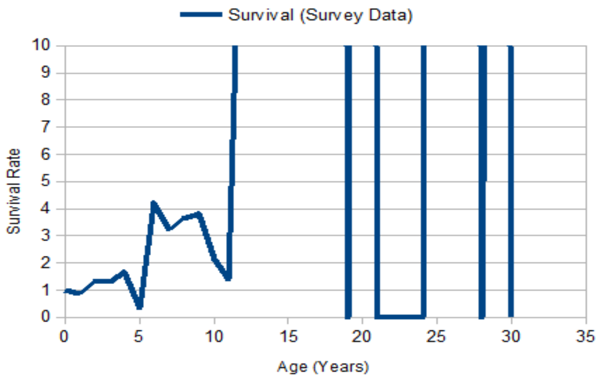
The registration of new three-wheelers between 1968 and 2003, was negligible. The however rose from 134 in 2004, to 1075 in 2006, with significant increases from 2010 at 1,521 to a peak of 4,775 in 2015, with a minor reduction to 3,815 in 2016. From 2010-2016, a total of 21,526 three wheelers were registered compared to 4,636 between 1985 and 2009, or approximately 17.8%. The estimates of the survival rates based on survey data for the period 1985-2016 (based on Equation 2.1-2.2) are shown in Figure 3.1(b, c). As can be seen, the data is too noisy for modelling the survival rates based on the approach in Equations 2.1-2.6. For this case, in-service vehicles would best be estimated using the Weibull age profile model (Table 4.2), where it is estimated that 75% to 77% of the motorcycles registered between 2009-2016 are still in-service. During the period 1985 to 2016, a total of 26,162 three wheelers were registered, yielding an estimate population of 19,621 – 20,113



(a) Age profile for motorcycles (R^2=0.922)



(b) Survival rates with respect to base year (2016)



(c) Survival rates with respect to base year (2016) – scaled axis

Figure 4.2 Age profile and survival rates for three-wheelers

4.3 Annual on-road vehicle kilometres travelled

Annual vehicle kilometres travelled, was determined through the use of odometer readings from the fuel station surveys and calculated from Equation 2.7. The data used was restricted to the registration years 1985-2016 due to no *tuk-tuks* registered earlier. The average annual VKT was 40,829 ± 7,326 km at 95% confidence level. The average annual VKTs for registration years between 1985 and 2016 and their respective confidence intervals presented in Figure 4.3.

5. Age, In-Service Vehicle Population and Characteristics: Passenger Cars

This section covers vehicles categorised by NTSA as *Saloon* or *Station Wagons*, which is also how the data is presented in the KNBS Economic Surveys.

5.1 Age Profile

There were a total of 7,251 respondents in this category, with 6,589 remaining after the data was cleaned. Key reasons for exclusion was where data was incomplete or clearly erroneous. Age profiles were calculated both from the date of registration in Kenya (difference in the year of registration in Kenya, and the year of the survey, 2017) and from date of manufacture (difference in the year of manufacture, and the year of the survey). These are presented in Table 5.1 and 5.2, respectively. A year wise distribution of the age profile is presented in Figure 5.1 based on year of manufacture. Based on age from year of manufacture, the average age was 12.4 years. Not surprisingly, only 1% of the sampled population had an age between 0-5 years. This is because the bulk of passenger cars are imported second hand, within the eight-year maximum age limit. The largest proportion of vehicles as therefore in the 6-10 age bracket at 33%, with only 9% being over 20 years old.

Table 5.1: Passenger car age profile (by registration date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	3326	2212	684	275	192	6,589
Proportion in each category	0.505	0.321	0.104	0.042	0.029	1

Source: Compiled from December 2017 Survey

Table 5.2: Passenger car age profile (by manufacture date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	70	2204	2468	1268	590	6600
Percent in each category	0.01	0.33	0.37	0.19	0.09	100

Source: Compiled from December 2017 Survey

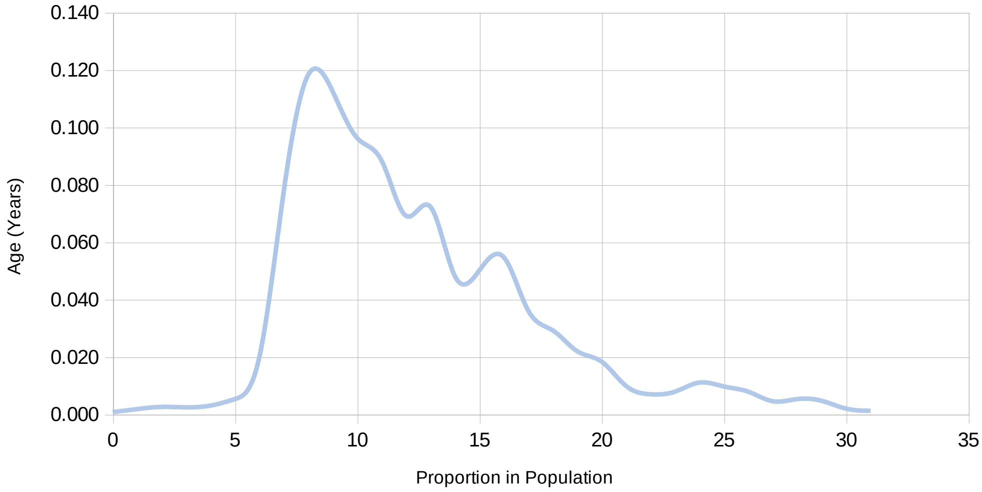


Figure 5.1 Passenger car population proportion by age based on 2017 survey

5.2 Estimation of in-service passenger car fleet

Estimation of the number of in-service passenger cars followed the approach defined by Equations 2.1-2.6. The base year was taken as 2016 as the survey was carried out in 2017, before the year had ended. Due to the significant time lag between year of manufacture and that of registration, the survival curves could not be based on manufacturing age. The age from registration in Kenya was therefore used. The calculated survival rate models based on Weibull Low, Weibull High and Log-logistic are presented in Figures 5.2. The parameter values for the models are presented in Table 5.3, where the goodness of fit as measured by R^2 were very good ranging from 0.9508 – 0.9526.

The estimated number of in-service vehicles for each age group between 1985 and 2016 based on each of the three models is presented in Appendix B, Table B.2. The number of in-service passenger cars is estimated between 591,019 and 616,709, against 808,965 new vehicle registrations of over the same period. This corresponds to an estimated 73.1 - 76.2% of vehicles registered between 1985 and 2016 still on the road.

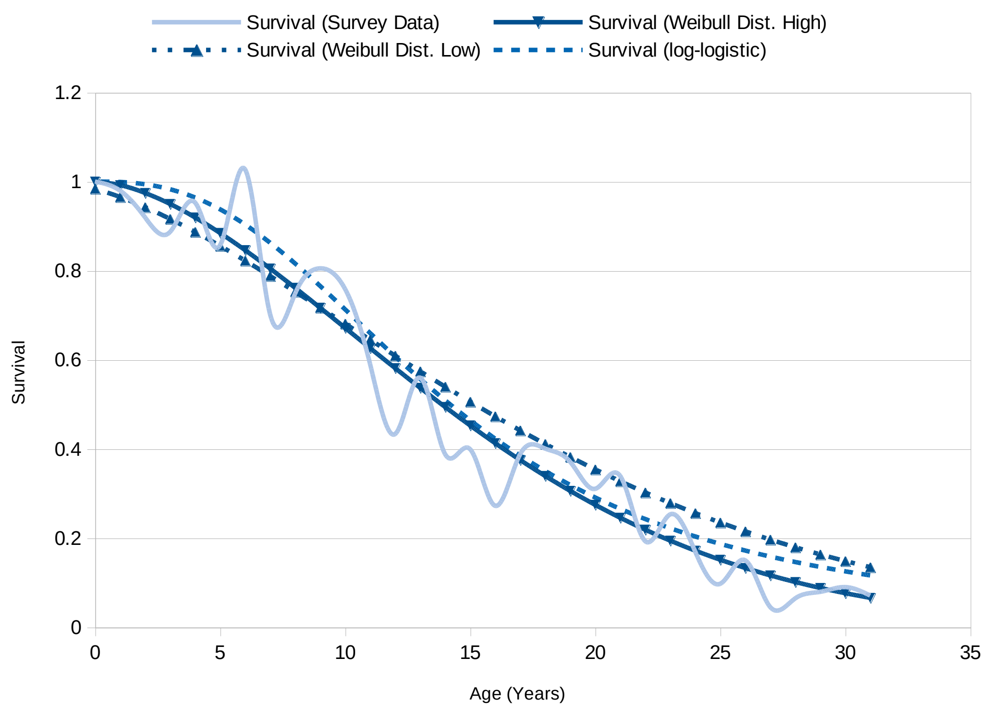


Figure 5.3 Passenger car survival rate estimates with Weibull function high (R^2=0.9529), low (R^2=0.9508) and log-log (R^2=0.9536)

Table 5.3: Passenger car survival rate models parameters

	This Study		Baidya et al (2014) (Petrol)	
Weibull	**High**	**Low**	**High**	**Low**
b	1.7	1.6	2.64	2.03
T	17.2	21.1	23.04	19.75
Log-Logistic				
a	2.6			
b	14.2			

Source: Developed from December 2017 Survey

5.3 Annual on road vehicle kilometres travelled

Annual vehicle kilometres travelled, was determined through the use of odometer readings from the fuel station surveys and calculated from Equation 2.7. The data used was restricted to the registration years 1985-2016 due to the negligible number of passenger cars registered earlier. The average annual VKT was 22,671 ± 2,496 km/annum at 95% confidence level. The average annual VKTs for registration years between 1985 and 2016, and their respective confidence intervals presented in Figure 5.4. A comparison was also done with VKT/annum for other studies as presented in Table 5.4. The results from this study appear on the high side of the range of VKTs similar to travel characteristics in certain cities in China.

Table 5.4: Passenger car VKT/a comparison across various countries

Region	VKT/a	Year of Study	Source
Delhi, India	12,200	2012	Goel et al. (2015)[13]
Denmark	18,262	2005	Papagiannaki and Diakoulaki, (2009)[14]
Singapore	19,000	2010	LTA (2012)[15]
Foshan, China	22,000	2009	Huo et al. (2012)[16]
Yichang, China	25,200	2010	Huo et al. (2012)
Beijing, China	17,500	2008	Huo et al (2012)
Kenya	**22,671**	**2017**	**This study**

Source: Developed from December 2017 Survey

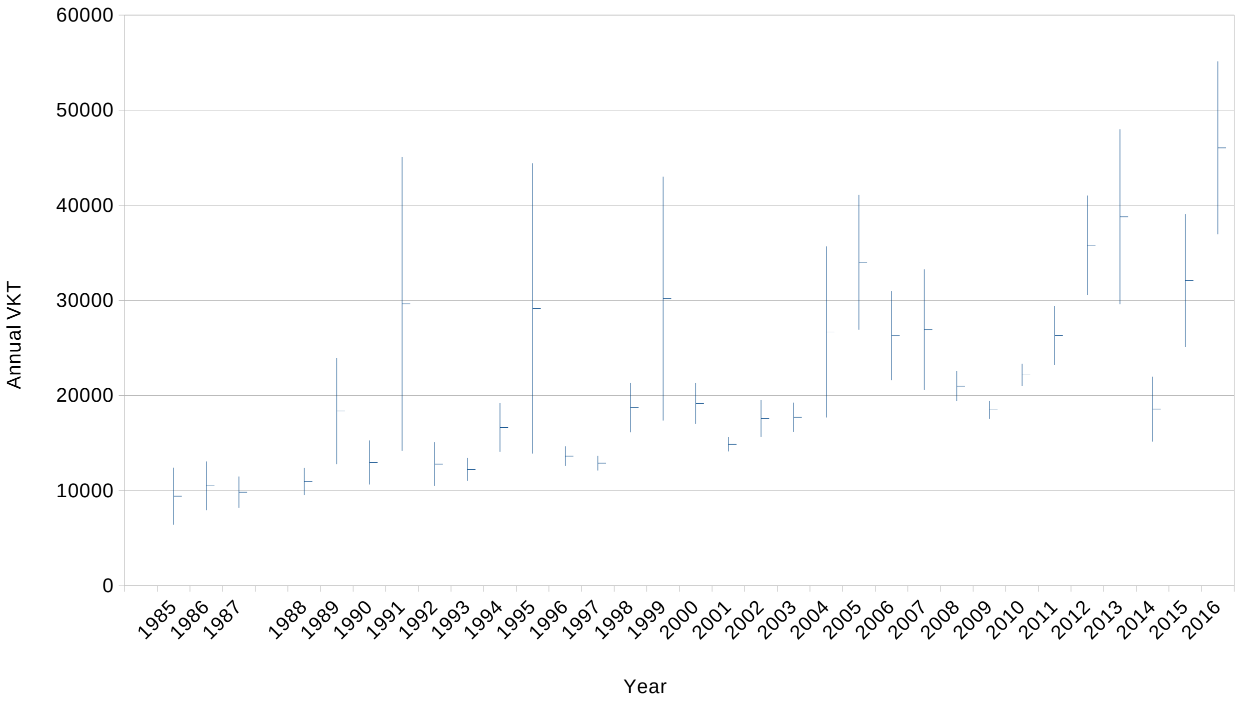


Figure 5.4 Trend in annual vehicle kilometres travelled and year of registration for passenger cars registered between 1985 and 2016

[13]Goel, R., Guttikunda, S.K., Mohan, D., Tiwari, G., (2015) "Benchmarking vehicle and passenger travel characteristics in Delhi for on-road emissions analysis", Travel Behaviour and Society, 2(2), 88-101.
[14]Papagiannaki, K., Diakoulaki, D., 2009. Decomposition analysis of CO2 emissions from passenger cars: the cases of Greece and Denmark. Energy Policy 37, 3259-3267.
[15]LTA, 2012. Singapore Land Transport Statistics in Brief 2012. Accessed online from Land Transport Authority, Singapore
[16]Huo, H., Zhang, Q., He, K., Yao, Z., Wang, M., 2012. Vehicle-use intensity in China: current status and future trend. Energy Policy 43, 6-16.

6. Age, In-Service Vehicle Population and Characteristics: LCVs

This section covers vehicles categorised by NTSA as *Vans, Pick-ups, etc.* category, which is also how the data is reported in the KNBS Economic Surveys.

6.1 Age Profile

There were a total of 619 respondents in this category. All the data remained after the clean-up exercise. The age profiles were calculated both from the date of registration in Kenya and from date of manufacture. These are presented in Table 6.1 and 6.2, respectively. A year wise distribution of the age profile is presented in Figure 6.1 based on year of manufacture. Based on age from year of manufacture, the average age was 8.96 years. As compared to passenger cars, a much larger proportion, 29% of the sampled population had an age between 0-5 years. The largest proportion of vehicles, as with passenger cars is still in the 6-10 age bracket at 37% due to import of second hand vehicles, with a significant 12% over 20 years old.

Table 6.1: LCV age profile (by registration date) from survey data

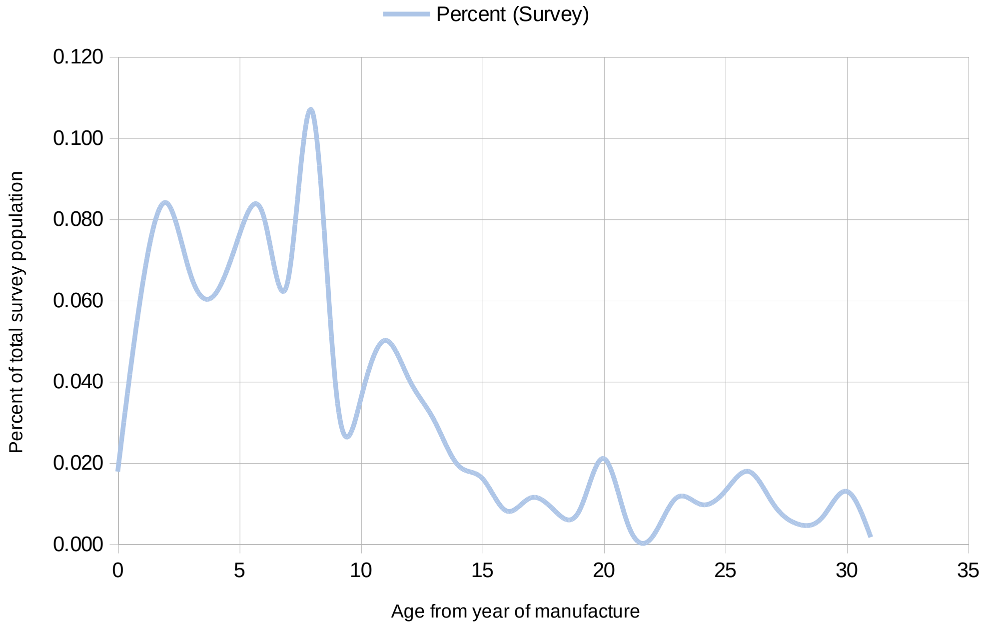
	0-5	6-10	11-15	16-20	21+	Total
Number in each category	282	191	68	23	38	602
Proportion in each category	0.47	0.32	0.11	0.04	0.06	1

Source: Compiled from December 2017 Survey

Table 6.2: LCV age profile (by manufacture date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	181	226	109	32	71	619
Percent in each category	0.29	0.37	0.18	0.05	0.12	1

Source: Compiled from December 2017 Survey



Source: Compiled from December 2017 Survey

Figure 6.1 LCV population proportion by age based on 2017 survey

6.2 Estimation of in-service LCV fleet

Estimation of the number of in-service LCVs followed the approach defined by Equations 2.1-2.6, with 2016 as the base year. Again the age from registration in Kenya was used. The calculated survival rate models based on Weibull Low, Weibull High and Log-logistic are presented in Figures 6.2. The parameter values for the models are presented in Table 6.3. Due to the wide fluctuation of the data from year-to-year the level of fit of the data to the models is moderate with a range of R^2 from 0.6994 to 0.7177. Part of this can also be attributed to the relatively small sample size.

The estimated number of in-service vehicles for each age group between 1985 and 2016 based on each of the three models is presented in Appendix B, Table B.3. The number of in-service LCVs is estimated between 113,971 and 130,230, against 223,836 new vehicle registrations over the same period. This corresponds to an estimated 50.9% - 58.2% of vehicles registered between 1985 and 2016 still on the road.

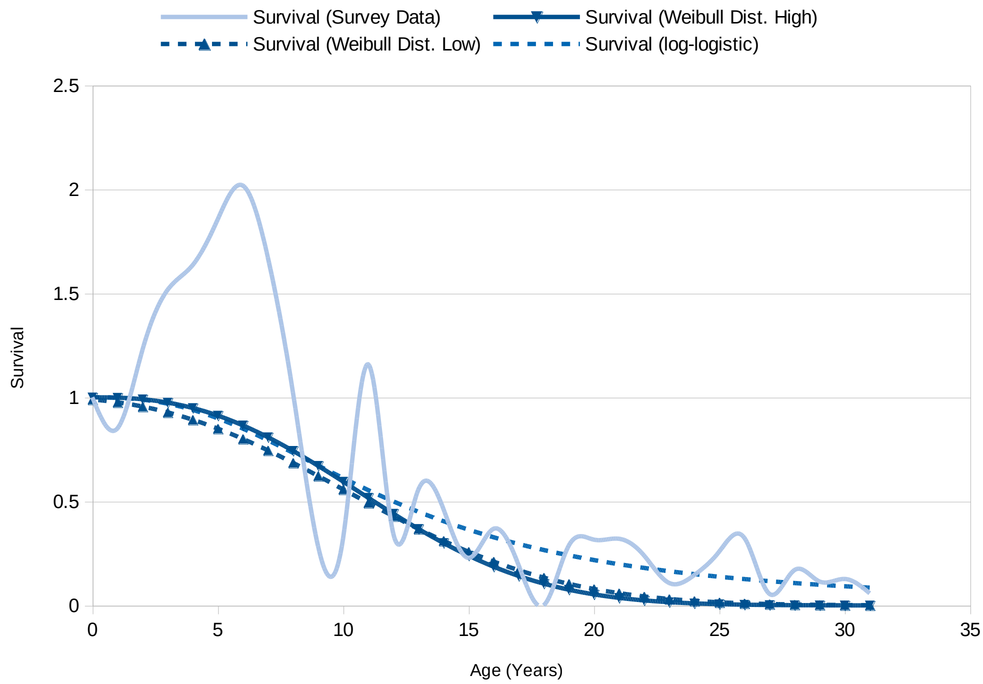


Figure 6.3 LCV survival rate estimates with Weibull function high (R^2=0.6994), low (R^2=0.7177) and log-log (R^2=0.7068)

Table 6.3: LCV survival rate models parameters

	This Study		Baidya and Borken-Kleefeld (2009)	
Weibull	**High**	**Low**	**High**	**Low**
b	2.5	2.5	1.99	1.99
T	13	21.1	18.67	20.54
Log-Logistic				
a	2.5			
b	12			

Source: Developed from December 2017 Survey

6.3 Annual on road vehicle kilometres travelled

Annual vehicle kilometres travelled were calculated using Equation 2.7 and are presented by vehicle registration year in Appendix A, Table A.4. The data used was restricted to the registration years 1985-2016. The average was found to be 30,811 ± 3,138 km/annum at 95% confidence level. This is similar to what Baidya and Borken-Kleefeld (2009) found in India with a range of 25.9-37.5 VKT/a.

7. Age, In-Service Vehicle Population and Characteristics: Buses

This section covers vehicles categorised by NTSA as *Buses and Coaches*, which is also the manner in which the data is presented in the KNBS Economic Surveys.

7.1 Age Profile

There were a total of 207 respondents that fit into the above categories in the survey. All the data remained after the clean-up exercise. The age profile was calculated both from the date of registration in Kenya and from date of manufacture. These are presented in Table 7.1 and 7.2, respectively. A year wise distribution of the age profile is presented in Figure 7.1 based on manufacturing age. Based on age from year of manufacture, the average age was 5.3 years. Unlike passenger's cars and LCVs, most buses are assembled locally and bought new. As a result, 59.4% of the sampled population had an age between 0-5 years, with only an insignificant 3.9% being over 20 years old.

Table 7.1: Buses age profile (by registration date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	133	36	22	7	4	202
Proportion in each category	0.658	0.178	0.109	0.035	0.020	1

Source: Compiled from December 2017 Survey

Table 7.2: Buses age profile (by manufacture date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	123	48	22	6	8	207
Percent in each category	0.594	0.232	0.106	0.029	0.039	1

Source: Compiled from December 2017 Survey

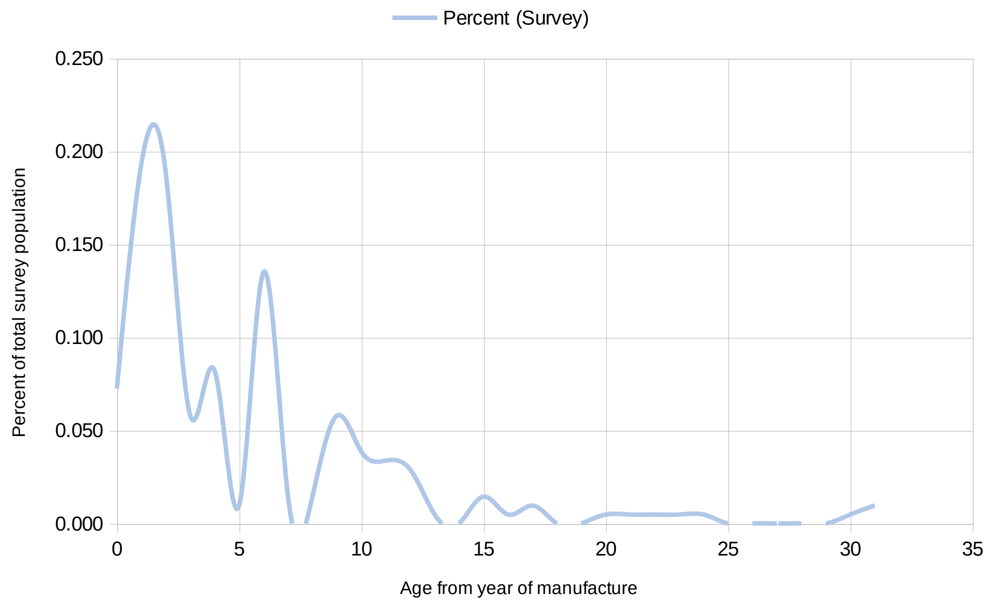


Figure 7.2 Bus population proportion by age based on 2017 survey

7.2 Estimation of in-service bus fleet

Estimation of the number of in-service passenger cars followed the approach defined by Equations 2.1-2.6. For consistency, the survival curves were based on the year of registration in Kenya. The calculated survival rate models based on Weibull Low, Weibull High and Log-logistic are presented in Figures 7.2. The parameter values for the models are presented in Table 7.3. Due to the wide fluctuation of the data from year-to-year the level of fit of the data to the models were moderate with R^2 ranging from 0.8020 to 0.8182. Part of this can also be attributed to the relatively small sample size.

The estimated number of in-service vehicles for each age group between 1985 and 2016 and using all three models is presented in Appendix B, Table B.4. From the models the number of in-service Buses is estimated at between 11,092 and 13,026, against a new vehicle registration of 32,780 over the same period. This corresponds to an estimate of between 33.8-39.7% of vehicles registered between 1985 and 2016 are still on the road.

Table 7.4: Bus survival rate models parameters

	This Study		Baidya and Borken-Kleefeld (2009)	
Weibull	**High**	**Low**	**High**	**Low**
b	1.08	1.1	3.21	2.29
T	7.4	8.3	17.37	18.28
Log-Logistic				
a	2			
b	5.8			

Source: Developed from December 2017 Survey

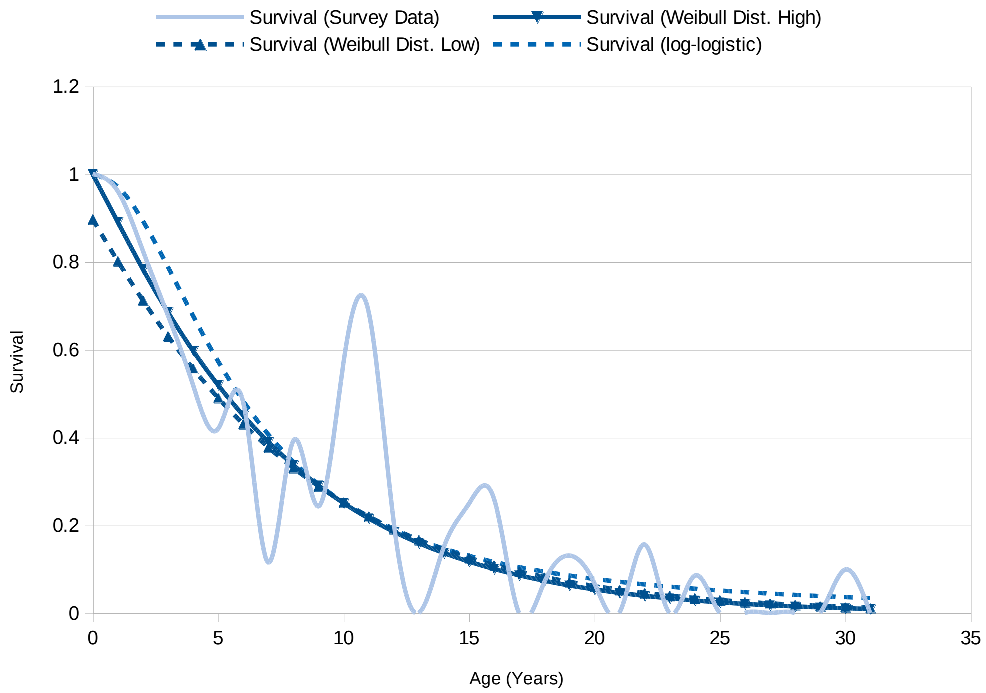


Figure 7.3: Bus survival rate estimates with Weibull function high (R^2=0.8167), low (R^2=0.8182) and log-log (R^2=0.8020)

Note that for the mitigation potential study (INFRAS, 2018), all buses were reassigned to the "Standard" size class (up to 18 t) instead of the "Midi Bus" (< 15t) size class. The authors of INFRAS (2018) know from their own observation in Kenya that many buses are in this size class. Furthermore, a quick web research confirmed this. A possible reason that this size class was not registered in the present study may be that the survey was conducted at public retail petrol stations, while buses may use company outlets.

7.3 Annual on road vehicle kilometres travelled

Annual vehicle kilometres travelled were calculated from Equation 2.7. The data used was restricted to the registration years 1985-2016. The overall average was found to be 43,815 ± 6,803 km/annum at 95% confidence level. These values are similar to 44,105 km/annum and 39.1-62.5 km/annum found in studies carried out in Nepal (2014)[17] and India (2008)[18].

[17]Bajracharya, I., & Bhattarai, N. (2016). Road Transportation Energy Demand and Environmental Emission: A Case of Kathmandu Valley. Hydro Nepal: Journal of Water, Energy & Environment, (18).

[18]Baidya, S. and Borken-Kleefeld, J. (2009) "Atmospheric emissions from road transportation in India", Energy Policy, 37(10), 3812-3822.

8. Age, In-Service Vehicle Population and Characteristics: *Matatus*

This section covers vehicles categorised by NTSA as *matatus*. These are the small minivans (14-seater) used for public transport.

Figure 8.1: *Matatus* awaiting passengers on the streets of Nairobi

8.1 Age Profile

There were a total of 930 respondents that fit into the above categories in the survey. After the clean-up exercise, 828 remained. The age profile was calculated both from the date of registration in Kenya and from date of manufacture. These are presented in Table 8.1 and 8.2, respectively. A year wise distribution of the age profile is presented in Figure 8.2 based on manufacturing age. Based on age from year of manufacture, the average age was 15.9 years. As similar to passenger cars, a negligible proportion, 1% of the sampled population, had an age between 0-5 years. The largest proportion of vehicles 52.3% were in the 16-20 age bracket, and a very significant 15.7% over 20 years old. When compared to year of registration, these proportions can be explained as follows. As the government seeks to phase out the 14-seater *matatus,* there has been a deliberate effort to restrict their registration, especially for sole use within urban areas[19], resulting in those registered in the last five years constituting 10.4% of the sample. Based on purchase of used vehicles, and the need to maintain older registered vehicles on the road for use in urban areas (as cannot be replaced by newer ones), registration age between 6-10 years was the largest proportion at 55.9%.

Table 8.1: Matatus age profile (by registration date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	85	455	212	43	19	814
Proportion in each category	0.104	0.559	0.260	0.053	0.023	1

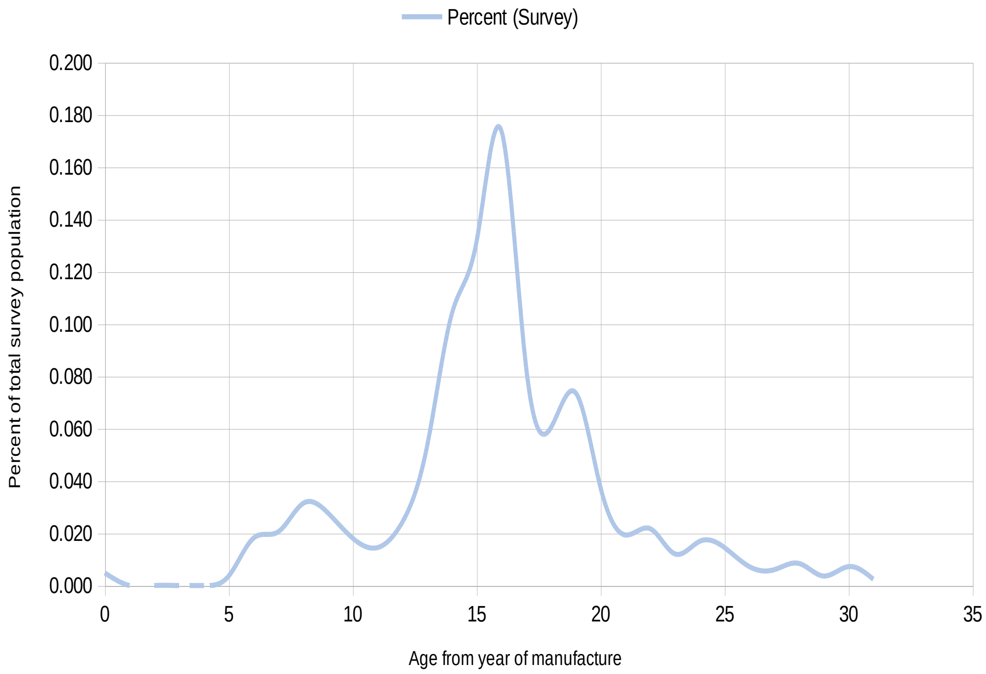
Source: Compiled from December 2017 Survey

[19]Uhuru limits planned ban on 14-seater *matatus*, *Daily Nation Newspaper,* 5 November 2014.

Table 8.2: Matatus car age profile (by manufacture date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	4	84	177	433	130	828
Percent in each category	0.005	0.101	0.214	0.523	0.157	1

Source: Compiled from December 2017 Survey



Source: Compiled from December 2017 Survey

Figure 8.2 Matatu population proportion by age based on 2017 survey

8.2 Estimation of in-service matatu fleet

Estimation of the number of in-service *matatus* followed the approach defined by Equations 2.1-2.6, with 2016 as the base year, and using the age from registration in Kenya. The calculated survival rate models based on Weibull Low, Weibull High and Log-logistic are presented in Figures 8.3. The parameter values for the models are presented in Table 8.3. Despite the wide fluctuation of the data from year-to-year the level of fit of the data to the models was still quite good, with R^2 ranging from 0.8001 to 0.8152. Part of this can also be attributed to the relatively small sample size.

The estimated number of in-service vehicles for each age group between 1985 and 2016 and using all three models is presented in Appendix B, Table B.5. From the models, the number of in-service *matatus* is estimated at between 11,056 and 14,789, against a new vehicle registration of 52,497 over the same period. This corresponds to an estimate of between 21.1-28.2% of vehicles registered between 1985 and 2016 are still on the road. This low proportion may be as a result of the on-going effort to phase out 14-seater *matatus* from use in urban areas. Traditionally, this is where the bulk of *matatus* operate.

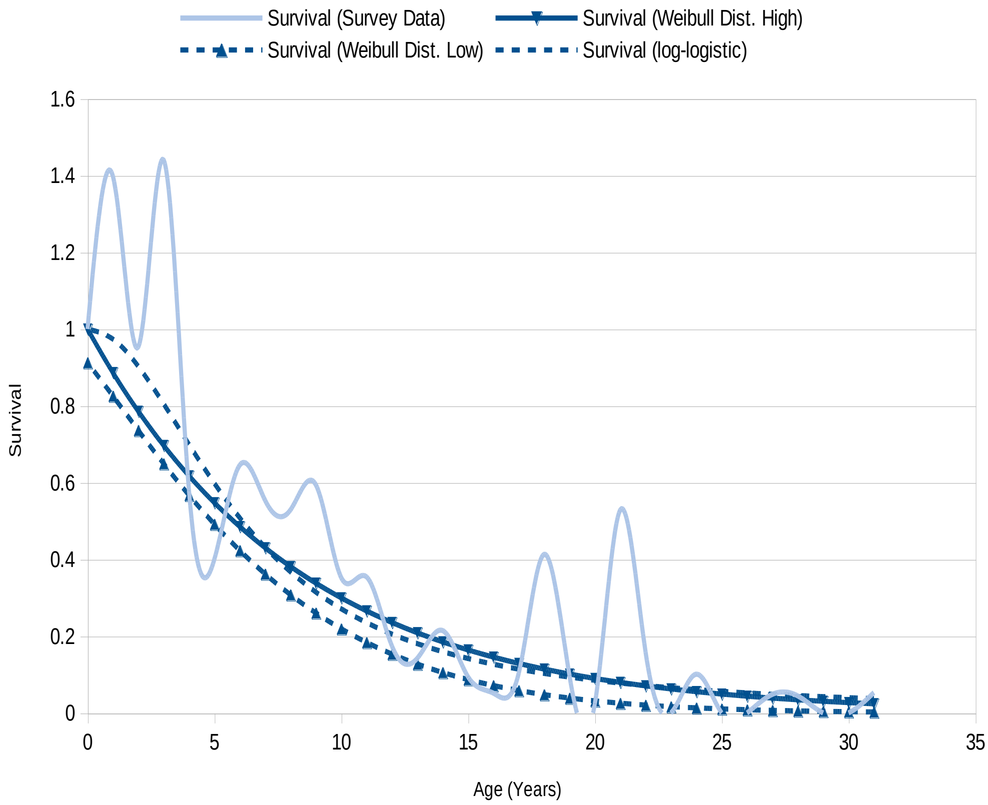


Figure 8.3: *Matatu* survival rate estimates with Weibull function high (R^2=0.8001), low (R^2=0.8043) and log-log (R^2=0.8152)

Table 8.4: Matatu survival rate models parameters

	This Study	
Weibull	**High**	**Low**
b	1	1.3
T	8.3	8.2
Log-Logistic		
a	2	
b	6.1	

Source: Developed from December 2017 Survey

8.3 Annual on road vehicle kilometres travelled

Annual vehicle kilometres travelled were calculated using Equation 2.7 and are presented by vehicle registration year in Appendix A, Table A.6. The data used was restricted to the registration years 1985-2016. The average was calculated as 22,356 ± 1,193 km/annum at 95% confidence level.

9. Age, In-Service Vehicle Population and Characteristics: HGVs

This section covers vehicles categorised by NTSA as *Lorries and trucks*, which is also the manner in which the data is presented in the KNBS Economic Surveys.

9.1 Age Profile

There were a total of 773 respondents that fit into the above categories in the survey. All the date remained after the clean-up exercise. The age profile was calculated both from the date of registration in Kenya and from date of manufacture. These are presented in Table 9.1 and 9.2, respectively. A year wise distribution of the age profile is presented in Figure 9.1 based on manufacturing age. Based on age from year of manufacture, the average age was 6.6 years. The largest proportion, 45.4% were between 0-5 years, with only 4.5% above 20 years. This implies a relatively young overall fleet.

Table 9.1: HGVs age profile (by registration date) from survey data

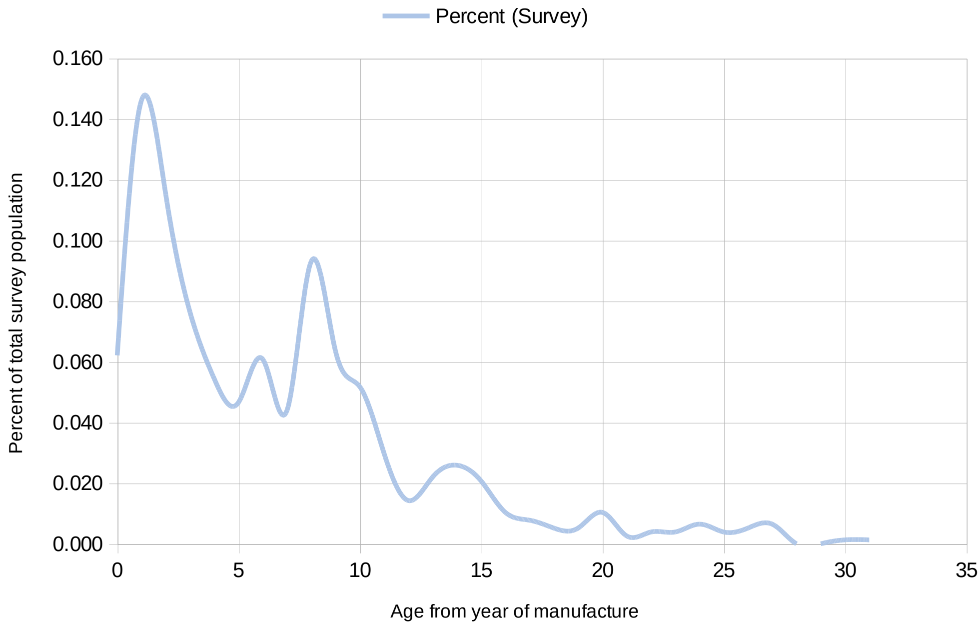
	0-5	6-10	11-15	16-20	21+	Total
Number in each category	471	192	33	17	25	738
Proportion in each category	0.638	0.260	0.045	0.023	0.034	1

Source: Compiled from December 2017 Survey

Table 9.2: HGVs car age profile (by manufacture date) from survey data

	0-5	6-10	11-15	16-20	21+	Total
Number in each category	351	238	111	38	35	773
Percent in each category	0.454	0.308	0.144	0.049	0.045	1

Source: Compiled from December 2017 Survey



Source: Compiled from December 2017 Survey

Figure 9.1 HGV population proportion by age based on 2017 survey

9.2 Estimation of in-service HGV fleet

Estimation of the number of in-service HGVs followed the approach defined by Equations 2.1-2.6, with 2016 as the base year, and using the age from registration in Kenya. The calculated survival rate models based on Weibull Low, Weibull High and Log-logistic are presented in Figures 9.2. The parameter values for the models are presented in Table 9.3. Despite the wide fluctuation of the data from year-to-year the level of fit of the data to the models was good, with R^2 ranging from 0.88514 to 0.8543, despite the relatively small sample size

The estimated number of in-service vehicles for each age group between 1985 and 2016 and using all three models is presented in Appendix B, Table B.6. From the models, the number of in-service HGVs is estimated at between 58,838 - 71,895, against a new vehicle registration of 121,551 over the same period. This corresponds to an estimate of between 48.5 – 59.1% of HGVs registered between 1985 and 2016 are still on the road.

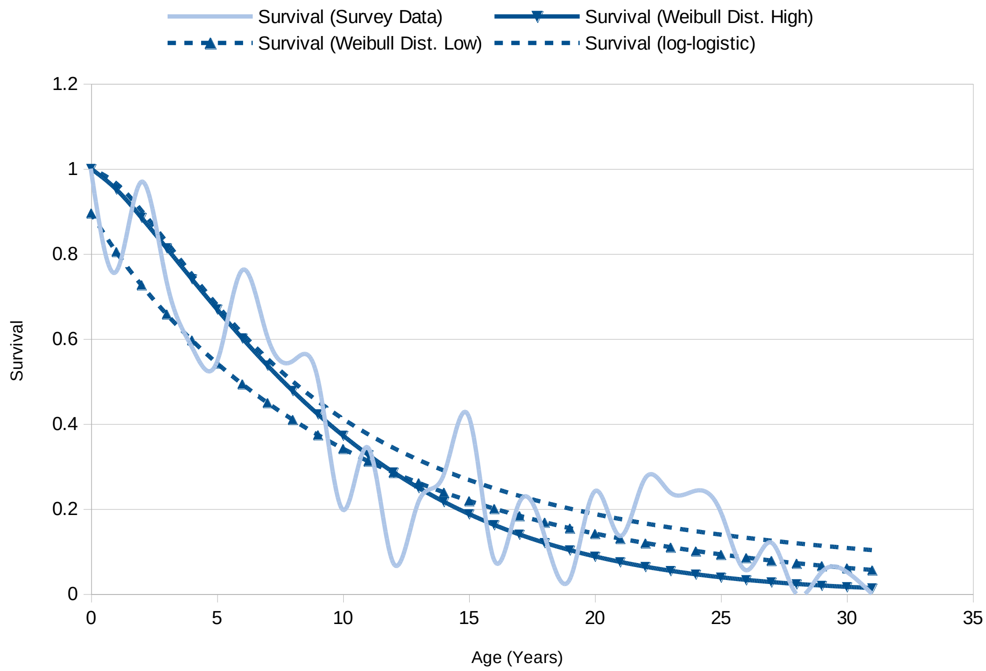


Figure 9.2: HGV survival rate estimates with Weibull function high (R^2=0.8526), low (R^2=0.8514) and log-log (R^2=0.8543)

Table 9.4: HGV survival rate models parameters

	This Study	
Weibull	**High**	**Low**
b	1.3	0.92
T	10.1	10.1
Log-Logistic		
a	1.6	
b	8	

Source: Developed from December 2017 Survey

Note that for the mitigation potential study (INFRAS, 2018), 20% of the total vehicle kilometres of trucks were reassigned to the size class 34-40 t. In the survey carried out for the present study, this size class did not occur. However, according to the JKUAT study (Abiero et al., 2015), this is the most frequent size class on the international freight corridors like Mombasa–Nairobi–Malaba or Nairobi–Namanga. A quick web research revealed images from weigh bridges and border crossings in Kenya that confirmed this finding. A possible reason that this size class was not registered in the present study may be that the survey was conducted at public retail petrol stations, while large trucks may use company outlets.

9.3 Annual on road vehicle kilometres travelled

Annual vehicle kilometres travelled were calculated using Equation 2.7 and are presented by vehicle registration year in Appendix A, Table A.7. The data used was restricted to the registration years 1985-2016. The overall average was found to be 63,205 ± 6,204 km/annum at 95% confidence level. This is similar to an Indian study whose VKT/annum ranged from 53.1-59.6 km/annum[20].

[20]Baidya, S. and Borken-Kleefeld, J. (2009) "Atmospheric emissions from road transportation in India", Energy Policy, 37(10), 3812-3822.

10. Conclusions and recommendations for future data collection

This study was a preliminary attempt to determine a few key characteristics for road transport in Kenya. Key among them was to develop models and estimate the number of in-service vehicles in the country. The results for all vehicle categories are summarised in Table 10.1. From the results, it is estimated that there are between 1.46 – 1.6 million vehicles on the road, accounting for between 63.4-69.4% of the 2.31 million new registrations over the period 1985-2016.

Table 10.1 Summary of estimate in-service vehicles by category in Kenya

Vehicle Category	Number Registrations (1985-2016)	Estimated In-Service (Lower bound)	Estimated In-Service (Upper bound)	In-Service Percent Range (%)
Motor cycles	1,044,043	659,492	738,501	63.2-70.7
Three Wheelers	26,162	19,621	20,113	75-77
Passenger cars	808,965	591,019	616,709	73.1-76.2
Buses	32,780	11,092	13,026	33.8-39.7
Matatus	52,497	11,056	14,789	21.1-28.2
LCVs	223,836	113,971	130,230	50.9-58.2
HGVs	121,551	58,838	71,895	48.5-59.1
Totals	**2,309,834**	**1,465,089**	**1,605,263**	**63.4-69.4**

As this as a preliminary study, the analysis still includes areas with significant uncertainties and gaps. A few general observations can be made:

1. For passenger cars, matatus, LCVs and HGVs, a majority of vehicles are imported second-hand, and therefore had a significant different "life" elsewhere with different survival rates and travel characteristics. This combined with their use in Kenya presents challenges to the typical analysis methods found in the literature. In addition, for motorcycles and three-wheelers, since these are typically bought new, the large variation in the registration age profile, and the date of manufacturing age profile suggests older unsold stock being exported from the source countries (mainly in Asia) to Kenya. As a result of these issues, all the survival rate curves were based on age from registration which yielded better useable results. VKT/annum were based on age of manufacture.
2. Odometer readings, especially for matatus and three wheelers may not be very reliable. A large number were not operational or had clearly been tampered with and were excluded from the analysis
3. The survey did not specifically target any vehicle category in the sample. As a result some segments, for example motorcycles, have small samples, as compared to their populations. Future studies should perform stratified sampling based on vehicle segments, taking into account each categories estimated population.

A summary of the most important uncertainties and gaps, and future data collection priorities, therefore, is provided in Table 10.2.

Table 10.2 Summary of Uncertainties and gaps with future data collection priorities

Type of Vehicle	Indicator	Comments on derived data	Uncertainty	Urgency of action to improve data	Potential for future improvements
Motor Cycle (2W)	▪ Age and Age Profile	▪ Registration has significantly risen since 2007 necessitating use of 2007-2016 registered vehicles for modelling	**Medium**	**High**	▪ At the rate of new registrations, it is estimated that the on-road 2W fleet will soon surpass those all other vehicles ▪ A larger survey should be carried out, purposefully targeting 2Ws to increase the sample size. This may allow further disaggregation into regions, providing further insights
	▪ Vehicle Kilometres travelled	▪ As above. ▪ Many 2Ws had non-function odometers, and were excluded from the analysis. ▪ Several had extreme values, showing clear tampering (values over 800,000) and were also excluded from analysis	**Medium**	**High**	▪ As above
Three-Wheeler (3W)	▪ Age and Age Profile	▪ Registration has significantly risen since 2007 necessitating use of 2007-2016 registered vehicles for modelling ▪ Overall number is low resulting in sample sizes when broken down per registration year that are well below recommended levels for analysis	**High**	**Medium**	▪ The overall population of 3Ws is small and thus their contribution to overall GHG is small. ▪ A larger survey should be carried out, purposefully targeting 3Ws to increase the sample size, and improve on the validity of the analyses
	▪ Vehicle Kilometres travelled	▪ As above. ▪ Many 3Ws had non-function odometers, and were excluded from the analysis. ▪ Several had extreme values, showing clear tampering (values over 800,000) and were also excluded from analysis	**High**	**Medium**	▪ As above

Type of Vehicle	Indicator	Comments on derived data	Uncertainty	Urgency of action to improve data	Potential for future improvements
Passenger Cars	▪ Age and Age Profile	▪ The sample size was sufficient to derive meaning estimates. ▪ The age profile clear shows a shift by 7 years due to the majority of vehicles imported as used vehicles exploiting the 8-year maximum age limit (older vehicles are cheaper). ▪ Survival curves therefore based on year of registration, and not manufacture as is typical to account for this	**Low**	**Low**	▪ A deliberate attempt was not made to target petrol and diesel vehicles. This can be done in future
	▪ Vehicle Kilometres travelled	▪ Fits within global norms, but on the higher side	**Medium**	**Medium**	▪ These surveys should be done more regularly so as to build a wealth of data where longitudinal assessments can be done
LCVs	▪ Age and Age Profile	▪ The number in the sample was relatively small as the segment not purposefully targeted	**Medium**	**Medium**	▪ Targeted sampling in future work will reduce the uncertainty and improve the modelling
	▪ Vehicle Kilometres travelled	▪ The derived numbers fit within global norms	**Medium**	**Medium**	▪ As above

Buses	▪ Age and Age Profile	▪ Estimates were reasonable	**Medium**	**Medium**	▪ Engage bus companies directly and use fleet records that would be more accurate ▪ Separate between urban and inter-city buses
	▪ Vehicle Kilometres travelled	▪ Estimates affected by lack of segregation between urban and inter-city buses whose travel characteristics are very different.			▪ As above
Matatus	▪ Age and Age Profile	▪ Phasing out of the 14-seater vehicles in urban has resulted in significantly ageing population, mixed in with relatively newer vehicles used on intercity routes	**High**	**Medium**	▪ Segregate between urban and inter-city *matatus*. For the latter, obtain records from their SACCOS
	▪ Vehicle Kilometres travelled	▪ Challenges faced with tampered odometers ▪ Vehicles had earlier use in another country, probably not as a matatu, this with different characteristics	**High**	**Medium**	▪ Segregate between urban and inter-city *matatus* whose annual mileage will be very different

HGVs	▪ Age and Age Profile	▪ Small sample size relative to population	**Medium**	**High**	▪ Can be improved through stratified sampling to increase their sample size or through getting the information directly from long-haul transport companies
	▪ Vehicle Kilometres travelled	▪ Fits within global norms ▪ Suffers same challenges of significant number of second-hand vehicles that had different travel characteristics elsewhere	**Medium**	**Medium**	▪ Increase in sample size to reflective of the population size ▪ Target transport company's directly, whose records will provide more accurate data for Kenya travel characteristics

Appendix A: Vehicle Registration Summary

Table A.1 Vehicle Registrations in Kenya, 1968-2017

Year	Saloon Cars	Station Wagons	Vans, Pick-ups, etc	Lorries/ Trucks	Buses and Coaches	Mini Buses /Matatu	Special Purposes Vehicles	Trailers	Rollers, Graders, Cranes	Wheeled Tractors	Crawler Tractors	Motor and Auto Cycles	Three Wheelers	Other Vehicles	Total
1968	5,631		3,465	1,483	274							1,013		1,185	13,051
1969	6,389		4,232	1,760	311							1,244		1,045	14,981
1970	7,680		4,959	2,472	435							1,317		1,419	18,282
1971	8,072		5,514	2,038	639							1,393		1,157	18,813
1972	6,337		4,671	1,494	408							1,437		1,419	15,766
1973	6,850		2,593	1,689	562							1,072		1,105	13,871
1974	6,469	2,112	3,528	1,402	263	322	104	670	232	957	13	1,137	16		17,225
1975	5,575	2,047	3,878	1,262	186	218	79	587	108	1,042	7	986	13		15,988
1976	4,981	1,942	4,156	1,417	215	202	120	669	89	1,129	3	1,316	7		16,246
1977	7,296	2,517	7,354	1,857	171	214	100	827	73	1,916	46	1,707	27		24,105
1978	7,565	2,626	5,257	2,745	190	140	72	1,062	93	1,894	105	1,714	13		23,476
1979	4,811	2,312	5,979	2,669	275	216	380	1,030	153	1,141	152	1,757	8		20,883
1980	6,881	2,298	7,454	2,255	208	217	163	763	207	1,023	14	1,749	14		23,246
1981	2,751	1,560	6,599	2,091	247	434	163	868	178	1,217	47	1,945	15		18,115
1982	3,018	1,527	5,447	1,355	330	295	103	524	96	822	26	1,506	12		15,061
1983	3,010	1,689	4,365	1,400	259	289	76	438	208	779	27	936	3		13,479
1984	3,571	1,877	5,187	1,424	651	391	31	498	57	852	18	1,124	3		15,684
1985	3,230	1,821	4,652	1,421	791	426	39	477	15	876	3	1,046	0		14,797
1986	3,027	2,957	4,261	1,726	617	337	19	458	70	864	2	1,131	3		15,472
1987	4,914	3,008	4,720	1,759	761	569	46	619	54	1,124	3	1,146	4		18,727
1988	5,561	2,795	4,783	1,790	1,075	509	32	643	26	1,172	4	1,131	3		19,524
1989	5,007	2,898	4,899	1,477	785	465	29	618	13	1,111	8	1,095	0		18,405
1990	4,703	2,452	4,996	1,611	914	525	35	419	42	1,127	10	1,188	1		18,023
1991	4,671	2,712	4,189	1,387	856	439	37	447	54	813	4	1,359	0		16,968
1992	4,247	2,061	3,726	1,105	718	447	37	299	68	687	1	1,364	2		14,762

Year	Saloon Cars	Station Wagons	Vans, Pick-ups, etc	Lorries/ Trucks	Buses and Coaches	Mini Buses /Matatu	Special Purposes Vehicles	Trailers	Rollers, Graders, Cranes	Wheeled Tractors	Crawler Tractors	Motor and Auto Cycles	Three Wheelers	Other Vehicles	Total
1993	4,542	1,828	2,510	750	519	295	20	291	55	474	2	1,133	1		12,420
1994	7,031	2,699	3,380	1,315	390	427	19	541	53	578	6	1,488	1		17,928
1995	6,519	2,699	3,380	1,315	390	427	19	541	53	578	6	1,488	1		17,416
1996	8,625	4,069	7,711	2,222	888	946	38	674	104	1,047	9	2,328	3		28,664
1997	8,995	4,259	7,544	2,732	931	927	35	680	102	1,263	6	2,415	4		29,893
1998	11,126	5,175	7,295	2,578	887	874	25	539	63	1,160	5	1,986	5		31,718
1999	8,917	4,251	6,984	2,087	866	872	29	567	70	1,112	6	2,127	4		27,892
2000	6,514	4,004	4,413	1,104	466	1,751	23	331	46	510	3	1,065	6		20,236
2001	8,258	4,733	4,747	1,283	490	3,598	87	603	69	575	20	1,559	2		26,024
2002	10,534	6,746	5,834	1,919	407	3,996		503		678		1,907	3	111	32,638
2003	9,709	8,032	6,819	2,069	667	2,854		861		663		2,084	10	149	33,917
2004	12,628	8,863	7,042	2,461	872	4,405		1,112		829		4,136	134	152	42,634
2005	14,216	10,158	6,308	3,113	885	4,076		1,351		856		3,759	735	195	45,652
2006	14,829	12,631	6,721	3,610	856	3,714		1,706		920		6,250	1,075	505	52,817
2007	17,893	24,115	9,470	6,329	2,006	4,252		2,193		1,213		16,293	1,072	488	85,324
2008	18,686	24,747	8,983	6,691	1,243	5,206		2,100		1,262		51,412	704	797	121,831
2009	16,930	27,599	7,120	6,037	1,057	4,483		2,883		1,115		91,151	863	2,575	161,813
2010	16,165	37,553	6,975	4,924	1,264	3,600		2,379		1,161		117,266	1,521	3,648	196,456
2011	11,026	31,199	7,442	5,247	1,162	451		2,556		1,386		140,215	2,140	2,724	205,548
2012	12,985	39,862	7,945	7,821	1,638	78		3,761		1,386		93,970	1,845	1,753	173,044
2013	16,343	48,662	9,819	9,570	2,062	235		3,973		1,902		125,058	3,103	1,451	222,178
2014	15,902	53,542	12,568	10,681	2,210	213		2,925		2,032		111,124	4,327	2,533	218,057
2015	14,369	54,120	23,878	13,785	2,342	581		3,905		2,259		134,645	4,775	2,522	257,181
2016	12,490	46,123	12,722	9,632	1,765	519		2,829		2,478		119,724	3,815	1,618	213,715
2017	11,376	55,322	9,866	7,460	1,072	459		1,953		2,703		186,434	5,167	860	282,672
Total	**417,479**	**510,880**	**308,474**	**152,364**	**38,404**	**55,435**	**1,960**	**51,720**	**2,451**	**47,983**	**556**	**1,067,396**	**26,293**	**28,551**	**2,992,618**

Appendix B: Data Tables

Table B.1: In-service motorcycles based on developed models

Year	Low	High	Log-Log
1985	0	0	116
1986	0	0	130
1987	0	0	138
1988	0	0	142
1989	0	0	144
1990	0	0	163
1991	0	0	196
1992	0	0	206
1993	0	0	180
1994	0	0	249
1995	0	0	263
1996	0	0	435
1997	0	0	479
1998	0	0	418
1999	1	0	477
2000	1	0	255
2001	5	2	399
2002	14	5	524
2003	35	13	617
2004	142	57	1,323
2005	242	106	1,304
2006	695	336	2,361
2007	2,894	1,565	6,728
2008	13,584	8,250	23,310
2009	33,533	22,880	45,576
2010	56,568	43,140	64,935
2011	84,030	70,901	86,321
2012	66,685	61,325	64,503
2013	100,764	99,040	95,802
2014	98,067	100,594	94,727
2015	126,298	131,554	126,357
2016	116,535	119,724	119,724
Total	**700,089**	**659,492**	**738,501**

Table B.2: In-service passenger cars based on developed models

Year	Low	High	Log-Log
1985	680	332	586
1986	888	456	749
1987	1,293	697	1,070
1988	1,498	846	1,221
1989	1,554	919	1,252
1990	1,539	950	1,230
1991	1,734	1,117	1,379
1992	1,615	1,083	1,284
1993	1,774	1,237	1,414
1994	2,942	2,129	2,361
1995	3,019	2,264	2,448
1996	4,495	3,486	3,694
1997	5,063	4,055	4,232
1998	6,703	5,534	5,715
1999	5,815	4,941	5,071
2000	4,978	4,344	4,450
2001	6,573	5,882	6,033
2002	9,325	8,541	8,799
2003	10,187	9,531	9,884
2004	13,097	12,496	13,060
2005	15,725	15,269	16,090
2006	18,705	18,449	19,589
2007	30,129	30,125	32,177
2008	32,706	33,084	35,457
2009	35,102	35,846	38,421
2010	44,193	45,461	48,549
2011	36,135	37,360	39,600
2012	46,883	48,600	50,956
2013	59,564	61,750	63,883
2014	65,462	67,676	69,022
2015	66,128	67,948	68,420
2016	57,675	58,613	58,613
Total	**593,179**	**591,019**	**616,709**

Table B.3: In-service LCVs based on developed models

Year	Low	High	Log-Log
1985	5	1	397
1986	7	1	392
1987	13	3	468
1988	21	5	513
1989	33	10	570
1990	51	17	632
1991	63	25	577
1992	82	36	560
1993	78	39	412
1994	146	81	609
1995	199	123	669
1996	609	409	1,681
1997	782	570	1,816
1998	976	764	1,942
1999	1,183	988	2,061
2000	931	822	1,446
2001	1,225	1,136	1,728
2002	1,812	1,751	2,362
2003	2,509	2,509	3,070
2004	3,021	3,106	3,521
2005	3,108	3,265	3,496
2006	3,748	4,000	4,113
2007	5,894	6,356	6,368
2008	6,157	6,674	6,591
2009	5,306	5,755	5,651
2010	5,582	6,035	5,927
2011	6,324	6,790	6,692
2012	7,090	7,539	7,466
2013	9,109	9,571	9,521
2014	12,010	12,452	12,427
2015	23,306	23,839	23,830
2016	12,590	12,722	12,722
Total	**113,971**	**117,394**	**130,230**

Table B.4: In-service buses based on developed models

Year	Low	High	Log-Log
1985	9	7	27
1986	9	7	22
1987	12	10	29
1988	20	16	44
1989	17	14	35
1990	23	19	43
1991	25	21	44
1992	24	20	40
1993	21	17	31
1994	18	15	25
1995	21	18	28
1996	54	48	69
1997	66	58	79
1998	73	65	83
1999	82	74	90
2000	51	47	54
2001	62	57	64
2002	59	56	60
2003	111	106	111
2004	167	162	165
2005	195	191	193
2006	216	214	215
2007	580	583	589
2008	411	419	428
2009	399	412	430
2010	545	569	611
2011	570	604	667
2012	912	979	1,110
2013	1,301	1,414	1,627
2014	1,575	1,733	1,975
2015	1,879	2,087	2,274
2016	1,584	1,765	1,765
Total	**11,091**	**11,807**	**13,027**

Table B.5: In-service *matatus* based on developed models

Year	Low	High	Log-Log
1985	1	10	16
1986	1	9	13
1987	2	17	24
1988	3	17	23
1989	3	18	23
1990	4	23	27
1991	5	22	25
1992	6	25	27
1993	5	18	19
1994	9	30	30
1995	11	34	33
1996	30	85	81
1997	36	94	87
1998	42	100	90
1999	51	112	99
2000	125	255	222
2001	313	590	511
2002	421	740	638
2003	364	596	515
2004	675	1,038	905
2005	749	1,083	959
2006	815	1,113	1,007
2007	1,108	1,438	1,338
2008	1,603	1,986	1,914
2009	1,623	1,929	1,935
2010	1,524	1,747	1,830
2011	222	247	270
2012	44	48	55
2013	153	164	189
2014	157	167	192
2015	480	515	566
2016	474	519	519
Total	**11,057**	**14,790**	**14,181**

Table B.6: In-service HGVs based on developed models

Year	Low	High	Log-Log
1985	80	19	146
1986	105	28	186
1987	116	34	199
1988	129	41	213
1989	116	41	185
1990	137	53	212
1991	128	54	193
1992	111	51	163
1993	82	41	117
1994	157	84	218
1995	171	99	231
1996	315	195	417
1997	422	281	547
1998	434	310	553
1999	383	292	481
2000	221	179	274
2001	281	241	344
2002	458	416	557
2003	540	516	652
2004	702	704	845
2005	971	1,018	1,168
2006	1,233	1,345	1,486
2007	2,367	2,676	2,867
2008	2,742	3,197	3,346
2009	2,714	3,245	3,340
2010	2,430	2,962	3,019
2011	2,846	3,514	3,566
2012	4,668	5,794	5,881
2013	6,296	7,786	7,921
2014	7,762	9,456	9,633
2015	11,095	13,120	13,307
2016	8,626	9,632	9,632
Total	**58,839**	**67,424**	**71,895**

Registration information

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices

Bonn and Eschborn
Germany

Friedrich-Ebert-Allee 36 + 40
53113 Bonn
Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn
Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de

Registered at

Local court (Amtsgericht) Bonn, Germany: HRB 18384
Local court (Amtsgericht) Frankfurt am Main, Germany: HRB 12394

VAT no.

DE 113891176

Management Board

Tanja Gönner (Chair of the Management Board)
Dr Christoph Beier (Vice-Chair of the Management Board)