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RESEARCH PAPER

Management of premature end-of-life vehicles in developing countries: Lessons from Nairobi City County, Kenya

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Abstract. Premature end-of-life Vehicles (ELVs) are on the rise in Kenya due to an increase in road accidents, as reported by National Transport and Safety Authority. These premature ELVs are poorly managed, frequently found parked in police station yards, garages, and residential estates, posing risks to public health and environment, thus undermining progress toward sustainable development goals. There have been scattered efforts on their management through policies and legislation, such as the Environmental Management and Coordination Act of 1999; the umbrella law on environment,which remains generic and insufficient in effectively addressing premature ELVs. This article presents the findings of a study conducted to assess the existing management mechanisms of premature ELVs in Nairobi City County. The study employed semi-structured questionnaires administered to households (n = 170) and conducted key informant interviews (n = 88) within relevant agencies in the County. The results show that the most common mechanism for handling premature ELVs is their sale to garages for spare parts sourcing (31%), while the least utilized method invloves selling them for recycling (3%). Furthermore, there exists an opportunity to implement circular economy principles in the management of premature ELVs. Consequently, there is a pressing need for government to develop appropriate policies, legal frameworks, and institutional support to effectively manage premature ELVs.

Keywords: Circular economy; developing countries; management mechanism; Nairobi City County; premature end of life vehicle

1. Introduction

Premature end-of-life vehicles (ELVs) refers to vehicles that have reached their useful life span prematurely, often due to damage sustained from accidents, rendering them unfit for road use (Ahmed et al., 2014; Muiruri, 2014; Numfor et al., 2021; Rovinaru et al., 2019; Wong et al., 2018). Kenya stands as a significant importer of vehicles from Asia and the European Union (EU), with limited local assembly. Most imported vehicles are second-hand, having been previously used in their countries of origin. The pool of ELVs consist of substantial numbers of vehicles deregistered in EU countries and shipped to non-EU countries for reuse as used cars or for treatment (Mat Saman et al., 2012; Mazzanti & Zoboli, 2006; Schneider, 2010; Wong et al., 2018).

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A study focused on Promoting Safer and Cleaner Used Vehicles for Africa discovered that between 2012-2014, 96% of vehicles imported to Kenya were used cars from Japan, the EU, and Asia (FIA, 2020). This report categorized Kenya among the top ten importers of used cars. Notably, Kenya's expanding economy is experiencing a surge in vehicle numbers to sustain industrial growth. Consequently, these vehicles will definitely reach the end of their lifespan, including those involved in road accidents, requiring proper treatment and disposal.

The increasing number of vehicles in Kenya can be attributed to the expanding economy of the country, necessary to support industrial growth. Between 2010 and 2018, Kenya reported approximately 1.3 million and 3.3 million registered motor vehicles respectively, which translates to a 30% increase annually (Muguro et al., 2020). The acquisition of both old and new vehicles has been consistently increasing over the years. In 2014 for instance, the vehicle population was 2,022,955, and it is projected to reach 5,062,366 by 2030. This projection is consistent with the 2019 statistics from the Kenya National Bureau of Statistics (KNBS), which recorded a total of 3,280,934 newly registered vehicles by December 2018 (Kenya National Bureau of Statistics, 2022).

The rise in accidents on Kenyan roads has led to an increase in premature ELVs. Some of these vehicles involved in accidents declared write-offs, therefore classified as premature ELVs. As the frequency of accidents has escalated, so has the volume of premature ELVs. A study conducted in 2018 showed that motor vehicle accidents globally cause over 1.2 million deaths annually, contributing to the increasing number of road transport accidents (Kenya National Bureau of Statistics, 2022). In 2020, the survey findings by National Transport and Safety Authority (NTSA) revealed an increase in road accidents, with a total of 3,572 lives lost compared to in 2019 compared to 3,004 in 2018, marking a 13.4% rise (Ngugi & Rasto, 2021). In additionally, NTSA recorded 3,572 fatalities, 6,938 serious injuries, and 5,186 minor injuries (FIA, 2020). Furthermore, the Economic Survey of 2022 highlighted a surge in driver casualties in reported road accidents, reaching 2,105 in 2021, marking 20.1% increase from 1,753 in 2020. Passenger casualties also rose by 33.8%, increase from 5,670 in 2020 to 7,587 in 2021 (Kenya National Bureau of Statistics, 2022). Reported traffic accidents rose by 14.5%, from 8,919 in 2020 to 10,210 in 2021, resulting in a 21.5% increase in road accident casualties from 16,970 in 2020 to 20,625 in 2021 (Kenya National Bureau of Statistics, 2022).

The escalation in accidents directly correlates with the increasing volumes of premature ELVs, which contribute to environmental pollution, risks to public health, and social well-being. The current practice of premature ELVs disposal involves abandonment in police station yards, residential parking areas, and garages, often involving informal recovery of valuable parts. Implementing technically feasible, economically viable, and environmentally responsible management practices is pivotal in fostering a cleaner environment and reduced exposure to hazardous wastes associated with premature ELVs.

If managed effectively, these premature ELVS have potential for both environmental and economic advantages within Kenya. The existing informal practices of recovery, reuse, and recycling by dismantlers present an avenue for implementing circular economy principles. This approach reduces the overexploitation of natural resources for raw materials in automotive industry through dismantling and reuse of spare parts and ensures safe disposal, resulting in a net environmental benefit. Establishing a regulated spare parts market contributes to Gross Domestic Product (GDP) of the country and creates employment opportunities. Furthermore, spare parts sourced from premature ELVs are genuine, affordable and readily available.

The article is divided into four major sections as follows. Introduction, which sheds light on the issue of premature ELV management. Literature review, providing perspective from developed and developing countries on management of ELVs. Materials and methods, outlining the methodology used during the study, including specifics on the study area, population under study, research design, data collection and analysis. Results, presenting the study's findings guided

by the objectives. Conclusion, providing the appropriate approaches to deal with the gaps that informed the study.

2. Review of the literatures

Studies over the years indicate that premature ELVs are growing in volumes globally (Karagoz et al., 2020; Raja Mamat et al., 2018; Tasala Gradin et al., 2013; Yu et al., 2021). This section provides a review of the management of ELVs within the context of developed and developing countries and explores the driving factors behind the approaches deployed for management of the ELVs.

2.1. Management of ELVs in developed countries

Several countries have developed different management strategies, with countries like Netherlands, Sweden, Germany, Japan achieving an estimated success rate of 85%. Developed countries, such as EU members and Japan, have well established management approaches supported by legislative frameworks, standards, and economic incentives for handling premature ELVs (Despeisse et al., 2015; Mat Saman et al., 2012; Mazzanti & Zoboli, 2006). These countries primarily apply the principle of Extended Producer Responsibility.

In 2016, Canada implemented the End-of-Life Vehicle Recycling Law, Signifying a significant step in tackling the environmental challenges posed by the ELVs (Cocker, 2016). This legal framework, known as Ontario O.Reg. 85/15 (ELV Reg.), categorizes ELVs components as a mandatory waste stream regulated under the Resource Recovery and Circular Economy Act, 2016 (Cocker, 2016). The law mandates registration for ELV recycling facilities and specific equipment usage in ELVs recycling. Furthermore, it stipulates that operators or the employees must identify ELV waste streams and undergo comprehensive training. This training covers waste management legislation that provides regulations and guidelines relevant to the operation of an ELV waste disposal site; occupational health and safety concerns pertaining to a material that may be handled at an ELV waste disposal site; safe use and operation of equipment; emergency response; and management that provides procedures for dealing with spills (Ministry of Environment, Conservation and Parks, 2021). In these jurisdictions, the application of circular economy has greatly facilitated the effective management of premature ELVs (Arora et al., 2018; Despeisse et al., 2015). However, China, despite having the highest number of ELVs globally, is experiencing significant challenges in ELVs management. The country has both legal and illegal recyclers, both driven by profit motives. Legal recycler adhere to standards, unlike their illegal counterparts (Yu et al., 2021). This situation impairs the industry's effectiveness since illegal recyclers often offer higher compensation to ELV owners compared to legal recyclers, who prioritize meeting sector standards.

The United States of America (USA) adopts a different approach to the management of ELVs. The country lacks a specific national legislative framework dedicated for managing premature ELVs, delegating this responsibility to individual federal states to develop their respective frameworks. The USA considers premature ELV as solid waste according to its national legislation. Specific legal frameworks address certain waste streams from ELVs, including for recycling acid batteries, recovering Ozone Depleting Substances (ODS), and banning the disposal of free liquids and acid batteries in landfills (USEPA, 2017). However, each state in the USA develops its own legislation, creating in variations in objectives and implementation methods. The responsibility for recycling largely falls on automobile manufacturers. For instance, companies like Chrysler, Ford and General Motors run specialized programs dedicated to studying recyclability and reduction of the Auti Shredder Residue (ASR) rate. This initiative can be considered as a part of their Corporate Social Responsibility (CSR), aiming to improve the industry's public perception by promoting environmental awareness and pollution reduction.

2.2. Management of ELVs in developing countries

A review of management strategies of premature ELVs in developing countries and emerging economies presents a contrary situation compared to developed countries. These countries and emerging economies are at different levels in dealing with premature ELVs, and a key determining factor is the presence of policy and institutional frameworks within the country. Indonesia, though a developing country without a specific national legislation on ELVs management, has made progress in this field. Several laws such as General Environmental Legislation (2009), Ratified Environmental Convention, Environmental Legislation for Waste Management (2008), along with Local Environmental Legislation and Provincial Environmental Legislation, have played instrumental role in management of ELVs (Kojima, 2018). Indonesian private vehicle companies have implemented take-back scheme for ELVs meeting specific criteria, which has supported ELVs recovery and recycling using the best available practices (Jamaluddin et al., 2022). The development of a specific national legislation dedicated to ELVs holds huge potential for sustainable ELV management in Indonesia.

India is also among the developing countries experiencing a growing ELV management problem. This issue has been exacerbated by rapid industrialization and a growing economy, leading to significant increase in demand of vehicles and consequently contributing to the increasing volumes of ELVs (Harun et al., 2022). ELV recycling in India has both formal and informal players. Formal players in the ELV recovery follow the requirements outlined in the Automotive Industry Standards for ELVs (AIS 129), which sets the guidelines and provisions for environmentally sound ELV recycling practices (Harun et al., 2022). The unregulated informal sector plays a significant role by achieving higher material recycling and recycling rates. However, it frequently interacts with the formal sector when dealing handling less hazardous high-value materials and scrap metals recovered from ELVs (Dhatarak & Quazi, 2019).

The formal sector typically shows little interest in recovered products and materials with low value and high hazardous nature, often leaving these items for the informal sector to trade in. This practice significantly affects the public health of those engaged in trading these ELV products and materials. In addition, the lack of a legislative framework regarding the final disposal of non-recoverable ELV products and materials is a notable concern. A study reviewing ELV management revealed that the informal sector generally neglects environmental considerations in their practices (Dhatarak & Quazi, 2019). The recovery rate remains low, with extraction and recycling rate below standard; only 7% and 76% of aluminum and iron, respectively, have been recovered and recycled (Harun et al., 2022). Lack of effective strategies for ELV recycling significantly contributes to low recovery and recycling rate of ELVs.

Driven by the need to mitigate climate change impacts, Egypt introduced the Vehicle Scrappage scheme and Recycling Program for the aging fleet of public transport (taxi, microbuses, minibuses and buses). This initiative allows registered vehicle owners to surrender their vehicles for management and is incentivized by capital provision to acquire fuel-efficient vehicle (The World Bank, 2015). The rationale behind this initiative was the recognition that many vehicles with high emissions change ownership, continue to emit greenhouse gases (GHGs) and exacerbate climate change. Despite informal recovery of ELVs occurring in scattered-sized workshops and scrap yards (Harraz & Galal, 2011; Lashlem et al., 2013), these unsystematic practices are common due to the lack of legislative framework and restrictions on exporting vehicle to developed countries due to stringent standards. Notably, the Scrappage Scheme and Recycling Program target natural ELVs and not premature ELVs, leaving a gap on how the management of premature ELVs is handled. Furthermore, the Central Bank's controlled access to the foreign exchange, as it devalued the Egyptian currency, led to downturn in other economic streams in the country (Numfor et al., 2021). These gaps present challenges in the long-term response towards effectively managing premature ELVs in Egypt.

Nigeria's approach to managing premature ELVs is quite almost similar to Kenya's. Many vehicles used in Nigeria are second-hand and have been shipped from Europe (Okafor et al., 2020). Approximately 2 million vehicles, with an average lifespan of 13.5 years, were shipped from the United Kingdom to Nigeria in 2000 (Agbo, 2011). These vehicles have reached the end of their useful lives due to age or accident. Nigeria has become a disposal zone for countries with strict legislations on ELVs management. Consequently, many of these ELVs are abandoned along the roads, in estates, and on construction sites, among other locations, due to the absence of a well-structured disposal mechanism (Numfor et al., 2021).

South Africa has implemented Extended Producer Responsibility (EPR) operating under a memorandum of understanding between manufacturers, recyclers, and the environmental authority. This system requires the collection, reuse, and recycling of high-value and less hazardous materials. A study titled "End-of-life vehicle (ELV) recycling management: improving performance using an ISM approach" found that despite South Africa being a more stable economy, it still experiences challenges in managing premature ELVs (Zhou et al., 2019). These challenges arise due to complexity in identification key drivers that influence the development of the ELV recycling industry. While EPR serves as a beneficial principle in promoting the circular economy, understanding how this model works in South Africa, especially concerning imported vehicles, would be of interest.

2.3. Management of ELVs in Kenya

The KNBS reported an increase in the volumes of imported vehicles, rising over 300% from 33,000 to 110,474 units between 2003 and 2012 (Deloitte Africa, 2016). The study further highlighted passenger vehicle as Kenya's fourth largest import in 2014, with commercial vehicles ranking seventh. Projection from this study suggest that if the current trend continues, Kenya should expect five million vehicles by 2030 (Deloitte Africa, 2016). According to the Economic Survey Report, there was a notable increase in newly registered motorcycles and three-wheelers, rising by 15.4% from 252,601 units in 2020 to 291,553 units in 2021 (Kenya National Bureau of Statistics, 2022). Furthermore, Kenya heavily relies on imports, constituting about 94% of its bilateral automotive trade, with 80% of these imports being second-hand cars (Deloitte Africa, 2016). This surge in the automotive industry is reflective of Kenya's expanding economy, necessitating an increasing number of vehicles to support industrial growth. Consequently, many of these vehicles will eventually reach the end of their operational life, including those involved in road accidents, requiring proper treatment and disposal.

Kenya lacks any statistical control or tracking system for vehicles that have become premature ELVs. Institutions such as the NTSA and the National Environment Management Authority (NEMA), despite being considered to have mandates on vehicle management within their respective legislative regimes, have not taken action regarding the issue of premature ELVs.

The registration process for any imported vehicle in Kenya falls under the mandate of NTSA. Meanwhile, NEMA is responsible for regulating emission levels from mobile vehicles (Government of Kenya, 2014). Furthermore, NEMA manages various categories of wastes, including hazardous waste streams (Government of Kenya, 1999, 2006). Unfortunately, the regulations lack explicit provisions for managing premature ELVs and NEMA currently lacks a strategy for their management.

The management practices related to premature ELVs offer certain opportunities in addressing this issue. Some of these ELVs are recovered, reused, and recycled by garages and salvage companies, many of which operate informally. These entities often handle low-hazard, high-value materials and parts by selling them to garages and salvage companies. It is evident that despite the environmental hazards posed by premature ELVs due to their hazardous materials, there is a significant value associated with recoverable parts. Recognizing this value, various countries are exploring various approaches, including policy and legal frameworks, along with

technical and technological advancements, to address the ELVs management (Petronijević et al., 2020).

The increasing volumes of the premature ELVs and their consequential impact on environment and public health raise concerns about Kenya's approach to managing this waste stream. This study, conducted in Nairobi City County (NCC), focused on understanding the management mechanisms used in Kenya involving various stakeholders in the sector. The study's findings have shaped conclusions and recommendations on the management of premature ELVs. It is noteworthy that there is an unregulated management approach to premature ELVs, lacking recognition of the potential environmental and economic benefits associated with the ongoing recovery and reuse practices within this industry.

3. Material and method

In developing this research, several hypotheses were developed to guide the study; firstly, that key informants have adequate information on information on the management of premature ELVs; and secondly, that personal attachment serve as a key determinant in households' choice of management mechanism for premature ELVs. To achieve the research objective, two key sampling methods were used; purposive sampling and stratified random sampling. Purposive sampling aided in identifying subject matter experts as key informants, thereby focusing on a specific population of interest (Ames et al., 2019; Robinson, 2014) and avoiding generalization of findings. Stratified random sampling was utilized to select households based on their diverse characteristics to ensure adequate representation (Hillson et al., 2015). The households were defined according to income strata-high-income, middle-income, and low income – which proved essential in assessing their knowledge regarding management options for premature ELVs.

3.1. Study area

Nairobi City County is located at GPS coordinates 1° 17' 11.0004'' S and 36° 49' 2.0028'' E in Kenya, where the service industry stands as the most vibrant sector, contributing 59.2% to Nairobi's GDP (Nairobi City County, 2017). This sector includes the transport sector, which is the primary source of premature ELVs. Within the County, vehicles are the most prevalent mode of transportation due to a high percentage of motorable roads, affordability for the resident population, and limited alternative transportation options, such as commuter trains. Most vehicles within the County are mainly public service vehicles, with a reasonable percentage being private vehicles belonging by institutions and individuals. The County hosts a total 35 police stations, 12 of which are dedicated to handling traffic-related issues. Additionally, numerous garages operate within the County, primarily small scale, with vehicle technicians who have acquired sill through on-the-job training. A few of the garages are owned by motor vehicle assembly companies, while others are medium-scale establishments with professionally trained motor vehicle technicians, such as the Automobile Association of Kenya (AA). As the capital city of Kenya with rapid urbanization, Nairobi has the highest vehicle population compared to other towns in Kenya, leading to the increasing volumes of premature ELVs. This study aimed to comprehend the mechanisms employed by Nairobi's citizens, informal sector players, private sector entities, and government institutions in managing ELVs, identifying the determining factors influencing these practices. Furthermore, the study offers recommendations on achieving effective management premature ELVs.

3.2. Data collection

The study used primary data collected from various categories of respondents, complemented by observations and secondary data. Primary data collection from households occurred between April to June 2020, using semi-structured questionnaires. These questionnaires constituted both rating scales and open-ended questions. This questionnaire format aims to mitigate biases from single data sources (Choi & Pak, 2005). It was developed to allow the respondents to provide information on any knowledge of premature ELVs, including the existing

management mechanisms used within the country. Stratified sampling divided the whole study area into strata based on income levels (high, medium and low). Fifteen estates were selected across three strata: high-income residential estates being Runda, Kileleshwa, Nyayo Embakasi, Ngong and South C; middle-income residential estates being Race Course, South B, Buruburu, Utawala, Fedha and Kariokor; and low-income residential estates encompassing Kasarani, Umoja, Lucky Summer and Kariobangi. The selection of households utilized systematic random sampling, administering the questionnaire after every 10 households in densely populated areas and after every 15 households in sparsely populated areas.

In addition to household surveys, key informant interviews were conducted with various expert groups, including policy-making institutions, regulation and enforcement agencies, salvage and garage companies, as well as insurance firms during this period. The key informants engaged during the study either were relevant agencies on issues of premature ELVs or were directly affected due to the nature of their operations. Simple random sampling through an online number generator was employed in the selection of insurance firms, police stations, garages and salvage companies for structured key informant interviews. This approach ensured that all participants had an equal and fair chance of being represented (Lavrakas, 2008). Interviews were conducted with 88 key informants from various institutions, categorized by work sector as follows; policy making institutions i.e. Ministry of Environment, Climate Change and Forestry and State Department of Transport; regulators i.e. NEMA, NTSA, Directorate of Occupational Safety and Health Services (DOSHS), Insurance Regulatory Authority (IRA), County Government of Nairobi City (Environment, Transport and Planning Departments), and Traffic Police Department, and 'Matatu' Owners Association, a privately registered organization that regulates public service vehicles in Kenya. A reconnaissance survey aimed to establish the total number of police stations in Nairobi County, of which nine out of the selected twelve were interviewed. The choice of the 12 was due to their extensive experience in handling traffic-related incidences, including those involving premature ELVs. Additionally, these police stations also provide parking yards for premature ELVs.

Secondary data was then used to supplement primary data. Its collection entailed a detailed review of both published and unpublished data related to ELV management from developed and developing countries, including Kenya, although relative few studies on ELVs have been conducted in the developing countries. The information obtained during the review provided insights into the technical, technological, and policy, legal and institutional frameworks that are pivotal in the effective management of premature ELVs.

3.3 Data analysis

Collected data were entered into an MS Excel spreadsheet for cleaning and preparation. The statistical package used (SPSS V.26) (George & Mallery, 2019) was used for data analysis, Primarily focusing on understanding the households' and key informants' comprehension of existing mechanisms used in managing premature ELVs within the study area. Socio-demographic data, particularly gender analysis, duration of stay for households, and years of experience for key informants, were obtained from the respondents. The key informants were categorized in various work sectors; policymaking, law enforcement and regulation, insurance firms, garages and salvage firms.

A G-test of independence was conducted to assess the statistical significance of the knowledge of institutions and households regarding the existing management mechanisms for premature ELVs. Additionally, an ANOVA test was performed to determine the statistical significance of factors influencing the choice of management mechanism among the respondents. Variables with a probability value (p) of less than 0.05 were considered significant, informed findings and conclusions aimed at supporting effective management of premature ELVs.

4. Results and discussion

A total of 258 households and key informants (77% male and 23% female) were interviewed across five categories: households (170), salvage and garage facilities (62); regulation and enforcement (15); insurance (9); and policy-making institutions (2). The 170 household respondents were from 15 residential estates within NCC, selected to ensure representativeness of the income quantiles in Nairobi. On average, these household respondents had resided in their respective estates for of 8.3 years. Fifteen households per residential estate were interviewed, resulting to a response rate ranging from 10 to 14 respondents per estate.

The key informants had served in various sectors for an average of 7.3 years, with those in insurance, regulation and enforcement, salvage and garage sectors having the longest tenure. This indicated that both key informants and households possess adequate experience in their respective field or area of residence, allowing them to provide reliable information on premature ELVs.

4.1. Management of premature ELVs

The responses from households and key informants' regarding existing premature ELV management mechanisms showed significant differences, as determined by a G-Test of independence (G = 37.15, DF 6, p < 0.000). Approximately 38% of the respondents stated that premature ELVs in Kenya are predominantly sold to garages for spare parts, while 19% indicated that they are sold to scrap metal dealers. About 14% said that these vehicles are left indefinitely in police yards without proper disposal guidelines, and 11% highlighted salvaged by insurance companies for resale. Among female, 3% specified selling vehicle recycling centres for dismantling, sorting, recovery, reuse, and recycling. Additionally, 6% either were unaware or did not know what happens to premature ELVs in Kenya (Figure 1).

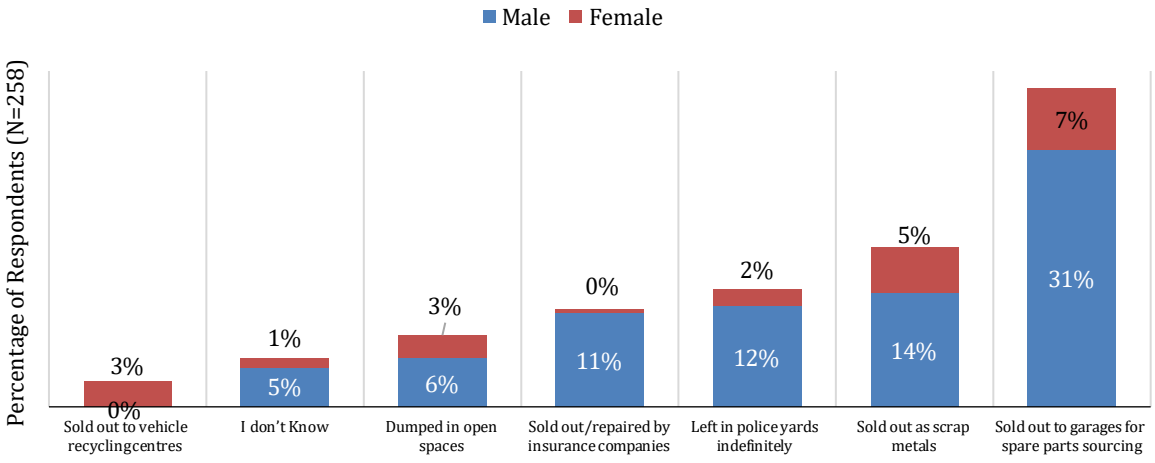

Figure 1. Management options of premature ELVs in Nairobi City County, Kenya

The management of premature ELVs involves informal and formal groups. The premature ELV management value chain includes various key factors such as insurance firms, NTSA, Kenya Police Service (Traffic Department), garages, salvage companies, and scrap metal dealers. Following a vehicle involvement in a road accident, both by NTSA and the responsible insurance firm conduct independent assessment to determine its roadworthiness. The insurance firm utilizes the assessment report to establish whether to repair the vehicle or compensate the owner, while NTSA conducts its assessment to ascertain the vehicle's safety for road use. In cases where the vehicle is declared un-roadworthy (classified as a premature ELV), disposal options outlined in Figure 1 are implemented.

Selling premature ELVs to garages for spare parts sourcing, which is the most commonly used management mechanism in Kenya, offers economic benefits as it creates a rich niche for easily accessible, affordable and genuine parts. A study titled "A review of challenges and opportunities for End-of-Life Vehicle recycling in developing countries and emerging economies: A SWOT Analysis" corroborates this finding. The study highlighted that ELVs management involves the recovery of valuable parts used by garages, parts' vendors, and small scale-scrap dealers. Meanwhile, lower-value parts are collected and sold to foundries for secondary parts through melting (Numfor et al., 2021).

This indicates that application of a circular economy model has been existing in the ELV industry, although it hasn't attained formal recognition. Similar to Kenya, in Nigeria, dismantlers recover high-value parts used in garages and sold to scrap metal dealers (Agbo, 2011). Developing countries face challenges in achieving effective and efficient recovery due to inadequate and inappropriate technology, as well as inadequate skilled personnel in recovery and recycling. China experience highlights inefficient recovery of valuable ELVs parts due to technological and technical capacity challenges (Yu et al., 2021). The recovery, reuse, and recycling of premature ELVs are inefficient, primarily conducted manually with a focus on financial gains.

An author noted that the recovered parts from the premature ELVs often serve as spares and sometimes don't require any restoration of their technical parameters, allowing for immediate reuse (Merkisz-Guranowska, 2018). A study conducted in Asia and China argued that most premature ELVs, consisting of 70% iron, are largely sold as scrap metal, depending on market conditions (Sakai et al., 2014). This finding contrasts with the study in Nairobi City County, Kenya, which established that majority (38%) of premature ELVs are sold to garages for spare parts sourcing, while only 19% sold for this purpose. ELV recyclers noted that the ELV recycling industry supplies customers either retail or wholesale.

In another study, another author stated that marketing facts and figures have proven that auto recycling industry is a key market-driven sector, with 25 million tons of materials being recycled from ELVs, making vehicles the most recycled goods in the world today (Rovinaru et al., 2019). The development of Directive on End-of-Life Vehicles 2000/53/EC, among other reasons, was guided by the need to lower environmental impact and reduce market prices for recycling parts and materials (Petronijević et al., 2020). However, a different study presented a contrasting finding on the cost of spare parts from ELVs, stating that reuse, remanufacture, or repair of ELVs may benefit the environment but may not always be the most cost-effective options. They argued that the spare parts from ELVs might compromise their quality due to their prior use over a significant period. However, this also raises debate about the category of ELV in question. For instance, premature ELV or natural ELV may contain recoverable spare parts with high economic value, depending on their duration, tear, and wear before being declared as premature ELV.

While there's recovery for spare parts sourcing, this is not a regulated business in Kenya as it is in other jurisdictions. In Europe, recovered materials from ELVs are regulated (Despeisse et al., 2015). The current management approach for premature ELVs is fragmented and doesn't account for economic value, such as regulating the spare parts market, which would otherwise control and make revenue generated from this business accountable. Reusing various components of vehicles reduces land wastage (like junkyards), as the smaller percentage of non-recyclable parts is finally disposed of appropriately (Sakai et al., 2014). The premature ELV management hierarchy, which ideally entails depollution before any form of recovery, is never practiced in Kenya due to lack of policy and legal frameworks, standards, and technical guidance in premature ELV management.

Mechanics involved in the recovery process often remain oblivious to the health and safety risks they face, raising significant public health concerns during spare parts recovery. Several legal frameworks from across the globe require depollution before the recovery of parts from premature ELVs. Countries with policy and legal frameworks addressing premature ELVs have

integrated safety and health aspects to inform and guide their management. For instance, the United Kingdom has provided guidelines and requirements on Health, Safety and Environment for those involved in ELV dismantling (Government of United Kingdom, 2003). The US Environment Protection Agency has developed a guide on environmental protection and safety during ELV processing (USEPA, 2017).

The low uptake of selling premature ELVs to recycling centers for appropriate management is impaired by the absence of such facilities in Kenya. There is a lack of proper dismantling, sorting, recovery, reuse, and recycling facility in the management of premature ELVs. During data collection, observations and engagement with salvage companies revealed a growing market need for recycling parts and materials from premature ELVs. While these companies, although few, recover various parts of the premature ELVs and sell them to consumers, the recovery process doesn't adhere to the appropriate management hierarchy of premature ELVs, which ideally begins with depollution.

The unsustainable approach to managing premature ELV management in Kenya is largely impacted by the absence of an explicit policy or legal framework to guide their management. The country lacks guidance, whether from a legal or technical perspective, on the best approach for managing premature ELVs. Globally, appropriate policy and legal frameworks guide countries in undertaking environmentally sound and economically viable ELV management. For instance, EU member countries have established requirements for ELV management with defined targets, as outlined in the European Parliament and the Council of the European Union Directive 2000/53/EC of 18 September 2000 on End-of Life Vehicles. Developed countries like Japan have legal frameworks supporting ELV management (Karagoz et al., 2020). Several emerging economies and developing countries such as Malaysia and India, are making significant efforts in ELV management but face challenges due to the lack of or inadequate policy and legal frameworks on ELV management.

4.2. Choice of management of premature ELVs

Respondents were given with different options defining their preferred management mechanism for the premature ELVs, including aesthetic preservation, public health concerns, personal attachment, legal requirement, market availability, and financial incentives. Using a closed-ended scale for specific comparisons, respondents identified which factors influenced their choice of managing premature ELVs. The respondents ranked these determining factors from 1 (most preferred) to 6 (least preferred), forming the basis for the analysis depicted in

Figure **2.** Scores of factors determining the choice of management mechanisms for premature ELVs among households

An ANOVA test showed significant variation in factors determining the treatment and disposal choice for premature ELVs among different respondents ($F = 97.467$, $df = 5$, $p < .000$). The analysis highlighted financial incentives/motivation and market availability as the key factors determining ELV treatment and disposal choices. On the other hand, legal requirements, personal attachment/responsibility, public health, and aesthetic preservation were considered the least influential factors in determining the treatment and disposal methods for premature ELVs, ranked in descending order.

From the analysis results, it is evident that most households possess premature ELVs are motivated by financial gains, scoring an average of 4.3 after disposal of these vehicles. Market availability is directly related to financial incentives, ensuring a guaranteed financial return. As established earlier, the majority of premature ELVs are sold to garages for spare parts recovery (as shown in Figure 1), generating financial returns for those households. This aligns with similar findings from vehicle scrappage schemes in Egypt and China. In Egypt, financial incentives for scrappage scheme motivated owners of public vehicles to retire low fuel-efficient ones (Harraz & Galal, 2011). Likewise, in China, ELVs owners are motivated by the economic benefits derived from their vehicles (Yu et al., 2021).

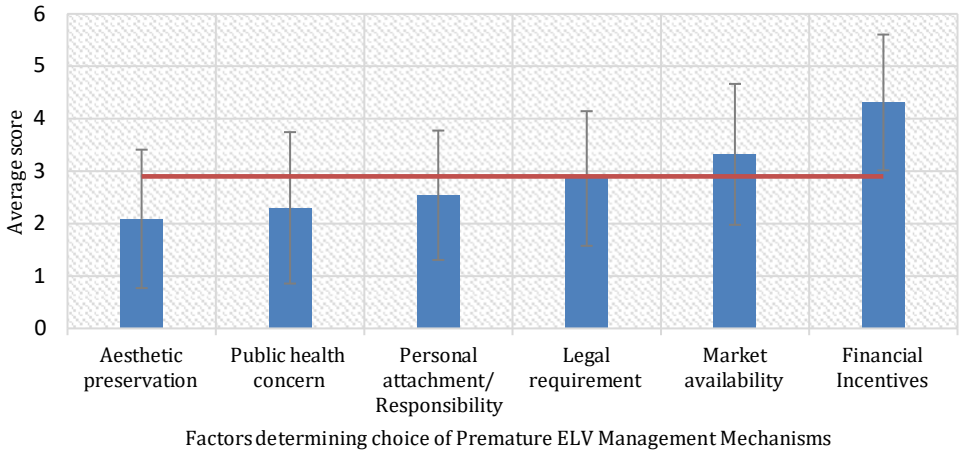

Figure 2. Scores of factors determining the choice of management mechanisms for premature ELVs among households

The environmental and social impacts associated with premature ELVs appear to be the least determining factors in choice the management mechanism for these vehicles. This implies that respondents might either lack awareness of these impacts or show apathy understanding the potential harm of premature ELVs on public health and the environment. Many waste management studies highlight that inadequate awareness of waste-related environmental risks undermines responsible waste management practices. This validates the research findings suggesting that low awareness of environmental issues has a converse relationship with inadequate waste management practices by households (Haron et al., 2018; Mwathi, 2014; Troschinetz, 2005).

The influence of legal requirement on the choice of management mechanism for premature ELVs appears to be minimal. The likely reason for this is that Kenya lacks a comprehensive legal framework that requires households possessing premature ELVs to dispose of them in an environmentally sound and technically feasible manner. While the Environmental Management and Coordination (Waste Management Regulations) of 2006 operates on 'polluter pays' principle, premature ELVs have not received adequate attention from relevant government agencies. Therefore, the regulations remain silent on the provisions for managing them. In a study addressing factors in electronic and electrical waste management, the author noted the influence of legal requirements on shaping waste management (Heeks et al., 2015). Non-compliance with regulations often incurs fines that no polluter wishes to bear, providing a competitive advantage to those complying. This parallels the experience in China, where legal recyclers adhere to established standards, while illegal recyclers prioritize profit over compliance (Yu et al., 2021).

The lack of an adequate legal framework places the relevant agency in a challenging situation. Firstly, the agency might be unaware of its role in managing premature ELVs. Secondly, even if the agency is aware, there is no legal basis for taking action against those who fail to ensuring proper disposal of their premature ELVs. Several studies highlight the crucial role of a legal framework in the effective management of premature ELVs. Countries such as EU members and Japan, which have laws regulating premature ELVs, have achieved success rates estimated at 85%, while in countries where disposal is voluntary, the impact has been remarkable (Azmi et al., 2013; Wong et al., 2018).

5. Conclusion

The reviews conducted on developing countries globally, specifically in Africa, indicate that these countries lack explicit policies or legal frameworks for the management of ELVs, resulting in inappropriate industry practices. There is limited data availability on ELV management in

Africa. This suggests that despite the increasing volumes of second-hand imported cars in Africa, most African countries have not recognized ELVs as an environmental issue requiring an appropriate response.

The study findings have revealed that majority of premature ELVs are sold to garages, where reusable spare parts are recovered. However, this process remains unregulated, making it challenging to recognize environmental and economic gains associated with this practice. Recovery of reusable spare parts offers affordable and easily accessible parts options for vehicles in need of repair. Moreover, selling premature ELVs to garages generates financial returns to individual owners, creating an incentive to sell rather than retain these vehicles.

The government plays a crucial role in managing premature ELV by creating enabling environment through establishment of relevant policies and legal frameworks to support their effective management. Regulation of the spare parts' market presents a significant opportunity in managing premature ELVs, offering dual benefits of reducing environmental pollution and increasing revenue regeneration. Increased awareness among households and institutions about the financial gains associated with premature ELV will likely reduce their abandonment. Instead, these vehicles may be more willingly surrendered to credible recovery facilities. The ongoing informal recoveries and reuse provide a rich potential for embedding circularity.

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