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Mechanism of Logistic Chain of Disrupted Car Scrap in India – A Review

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Abstract

The Indian economy is indeed the world's fastest expanding economy. In India, middle-class families have more purchasing power, which contributes to a rise in vehicle ownership. In India, as the number of new automobiles increases, so does the number of disrupted cars or end-of-life vehicles (ELV). A lot of study has been done on the disadvantages of end-of-life vehicles including their negative influence on the environment all over the world. ELV scrap materials serve as a source of raw material for the car industry, however if ELV management is not done in a structured manner, this poses a challenge for the automobile industry's social and economic viability. In this study, the ELV recycling handling system in India is examined. ELV legal regulations and recycling management systems in various nations are also studied in the research. Based on our findings, we recommend that stakeholder collaboration and regulatory assistance can reduce dismantling costs and improve the disassembly condition in the ELV sector by supporting scrap material prices.

Keywords- ELV recycle management, ELV policies in different countries, unregulated ELV management in India.

Introduction

Now-a-days pollution is a big concern in world wide. This air pollution impacts our society's environment. Old vehicles or end of life vehicles are major stack holders for air pollution. Due to old and damaged vehicles make traffic, and thus increases the air pollution, also as environment aspect managing the scrap material of disrupted vehicles is a major undertaking. These waste items are harmful to the environment and contribute to pollution. The physical and chemical features of these substances are hazardous to the environment (Simic, Vladimir 2016, Raja Mamat, Tengku Nur Azila, et al 2018). As WRME (2014) study, these scrap materials will increase 80 millions units per year approximately till 2020, so there is a big demand to manage these waste flows.

End-of-life vehicle (ELV) recycling is supported by a variety of aspects in today's society, the most important of which are economic and technological factors, as well as social and environmental considerations. As a result, the automobile industry is seeking to adapt to this new way of doing business and to develop more ecologically friendly waste management methods (Rovinaru, et al., 2019). Santini et al. (2011) determined the recycling rate and reuse the dismantling components of End-of-life vehicles in Italian context. Their sample size was 630 End-of-Life-Vehicles. They achieved 80% recycling rate by standard Italian End-of-life-vehicles treatment process (Santini et al. 2011, Karazog et al., 2020).

70 percent of the scrap from a wrecked automobile is steel or iron. This scrap or iron material is repurposed in the automotive industry. Different elements of the junk automobile are reused after recycling, including plastic, rubber, copper, zinc, various metal alloys, and rare metals such as platinum and palladium. Because the cost of various parts varies depending on the market, legislation is essential to control them in the End-of-Life-Vehicles market (Sakai, Shin-ichi, et al 2014). There is also big demand of collection of various dismantling materials. All related activities and material, financial, and information flows between and among ELV network entities, such as vehicle users, collection centres, authorised dismantling facilities, shredders, recycling centres, remanufacturing facilities, second-hand markets, industrial landfill sites, and so on, are managed by ELV management. It is critical for environmental protection, circular economy, and long-term growth. This is a process that isn't just about making money (Karazog et al., 2020).

The collection and transportation are important task for reuse, recycle or disposal of various parts of crashed and end-of life vehicles from customer. These efforts are motivated not just by a business motive, but also by the goal of adhering to recycling requirements (Cruz Rivera and Ertal, 2009).

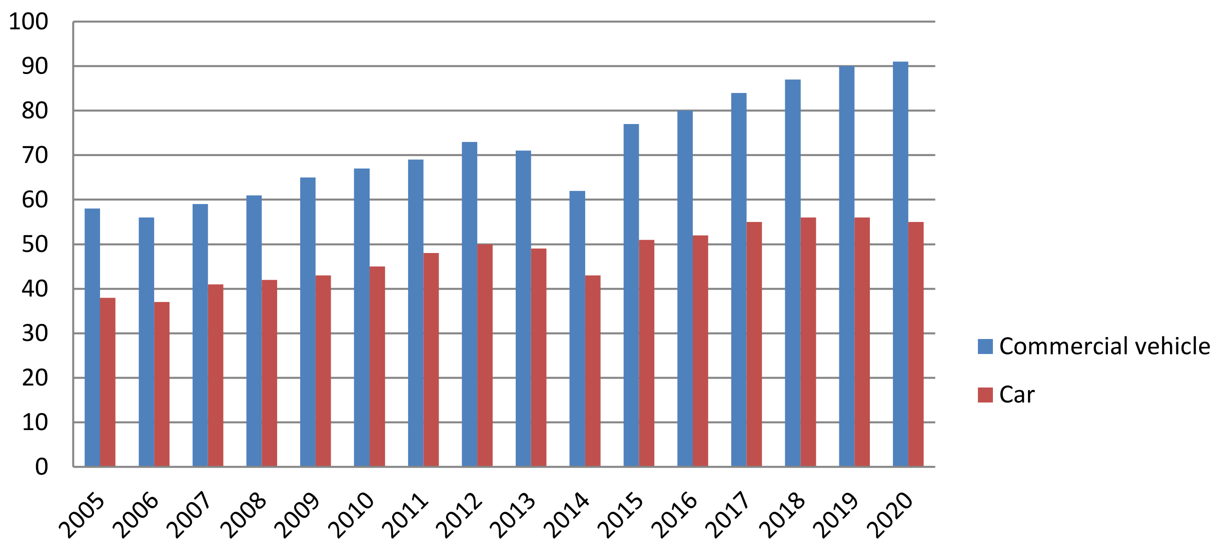

Fig: Worldwide automobile production from 2005 to 2020 (Statista portal, 2022)

Recycling Activities of ELVs

The reprocessing of materials in ELVs necessitates the collection, depollution, and dismantling of the vehicles, the sorting and shredding of the materials prior to thermochemical processing, and the disposal of the materials. The first step in ELV recycling is collection. Following collection, these ELVs are turned over to firms that collect chlorofluorocarbons (CFCs), and the airbags are removed before the cars are disassembled by approved auto-dismantling companies. The deconstructed automobiles, along with CFCs and airbags, are processed into auto automotive shredder residue (ASR), which is collected by approved manufacturers after payment.

Scrap parts are collected and purchased from various mechanic workshops, who subsequently sell the dismantled and removed scrap components to smelting firms. Iron and steel are used to make concrete reinforcing rods, flat steel sheets are utilised in the building and construction sector, and aluminium is smelted to make kitchen utensils. Old car batteries are utilised both inside and externally, with some being shipped to other nations to be rebuilt, recycled, and cell components repurposed.

The liquids (motor oil, brake oil, refrigerant) are drained (depollution stage) and the hazardous pollutants are removed individually when ELVs are collected and received at the reprocessing centre. If not adequately removed, ELVs include levels of mercury, cadmium, chromium, zinc, and other toxic materials that cause environmental harm and pollute not just soils and streams, but also other resources.

After the dismantling the vehicles the scrap materials are sorting in different category, some materials are expensive. The expensive materials (like ferrous, non ferrous and some special plastic) collected after dismantling. Different materials used in making cars in fig 2(team-bhp portal, 2022). These materials are regarded important recyclable components and are supplied in various amounts and grades for reuse in other vehicles (motor parts, batteries, gasoline, etc.) or for further recycling (tyres, precious metals, carpets, etc.). At the dismantling stage, the extent of automation is determined by labour costs and the availability of large-scale technology (Tian, J., & Chen, M. (2014)).

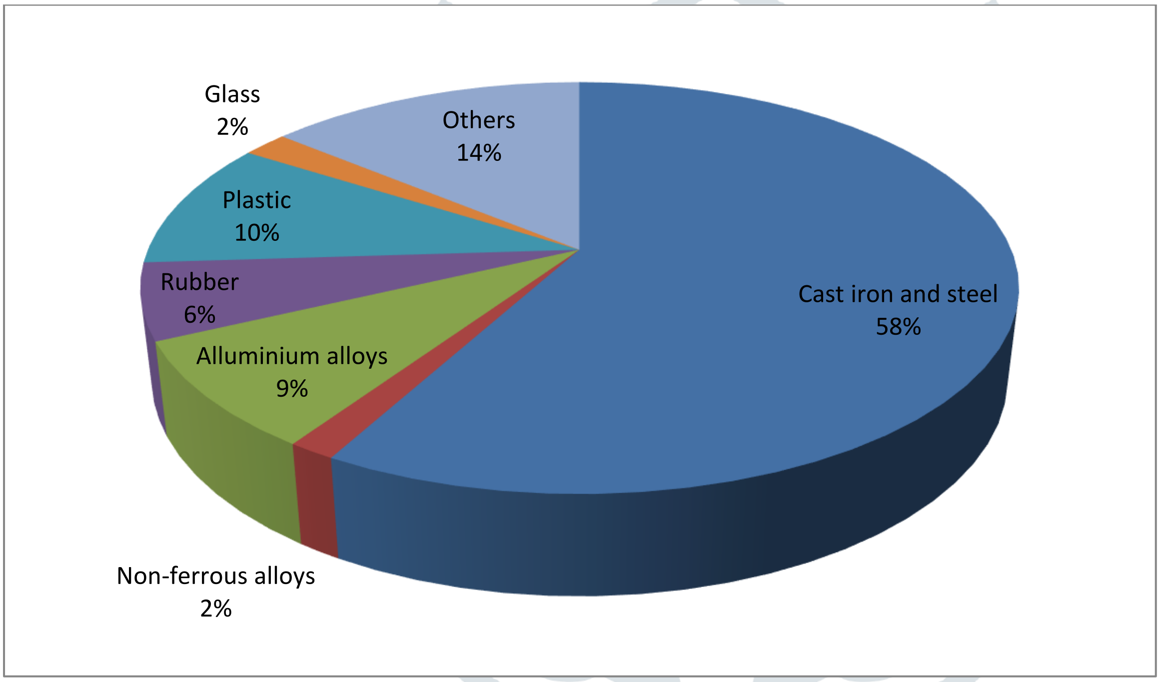

Fig 2:- The percentage of different materials used in car (team-bhp portal, 2022)

In the shredding step, the vehicle's residual hulk is crushed and chopped up into fist-sized bits by enormous shredders. By using complicated gear such as magnetic separators, air classifiers, and infrared systems, the shredded material is divided into ferrous metals for material recovery, non ferrous metals (heavy automobile shredder residue (ASR)), and other materials (light ASR) (Sakai, Shin-ichi, et al 2014). Flow cart of end-of-life vehicle shows in fig 3 (Numfor et al., 2021). Scrap is mainly processed in smelters to make secondary steel in electric arc furnaces (EAFs), which employ 100% shredded scrap, or basic oxygen furnaces (BOFs), which use up to 20% scrap as a cooling agent (calrecycle portal, 2022).

To meet the approval requirements for further refinement, composite materials and fibres usually require further treatment. Aluminum and copper are melted combined with other materials from different product streams, such as building scrap, WEEE-derived metals, and industry waste, at specialised facilities. In the last 15 years, the EU's lowering of vehicle average life to around 10 to 12 years has resulted in a significant increase in the number of ELVs. As a result, ELV recycling has become a noval subject of scientific inquiry and a reflection of a country's approach toward environmental preservation. Concerns with ELVs in terms of waste management are twofold: on the one hand, around 25% of this waste flow must be deemed dangerous, and on the other hand, about 75% of this waste flow (mostly steel and aluminium) may be readily recycled (Nicolli et al., 2012).

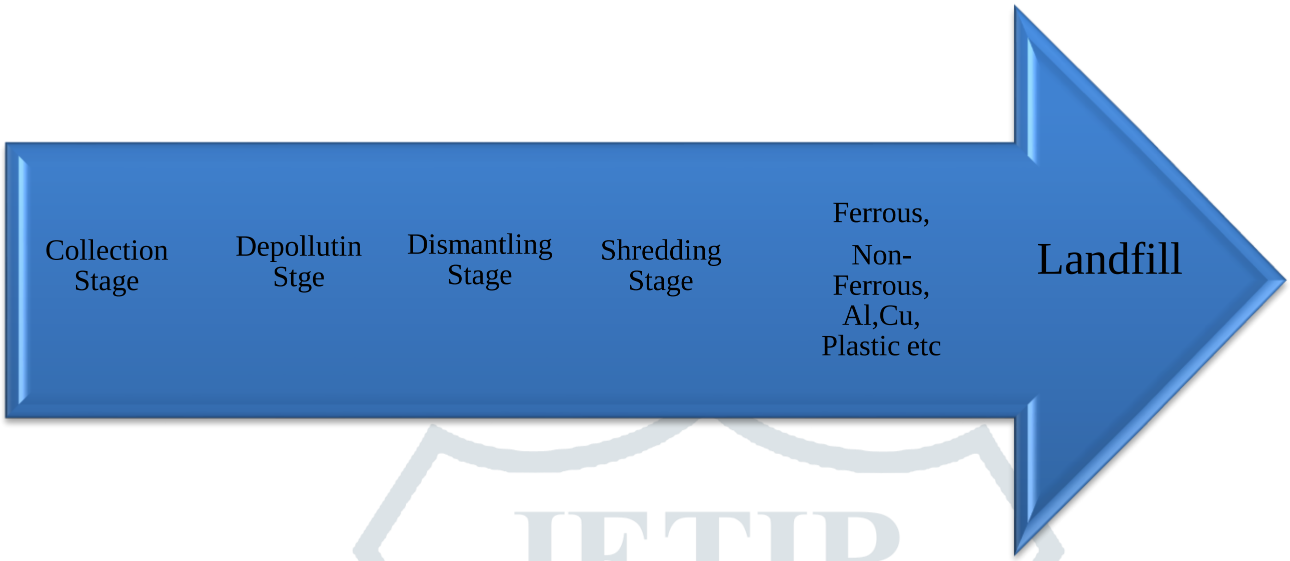

Fig 3:- Flow chart of end-of-life vehicle (Numfor et al., 2021)

In this way, contemporary ELV recycling is intended to not only assist safe guard the environment and natural resources, but also to be cost-effective. However, in order to collect, reuse, and recycle the materials, the management of the ELV recycling process is difficult and necessitates a multi-faceted strategy.

Literature Review

Bandivadekar et al. (2004) carry out a scenario analysis to determine the effect of changes in material composition on the automotive recycling sector. There are three possible scenarios: replacing ferrous materials with aluminium and plastic, aluminium simply, or plastics and polymer blends. The impact of these adjustments on the profit margins of dismantlers and shredders, as well as the quantity of ASR generated, is examined. They predict that the number of ASR will rise in the future, and they advise dismantlers to enhance the degree of dismantling to retain profitability. Kumar and Yamaoka (2007) evaluated the relationship between reuse, reduce and scrap in the Japan automobile sector, prepared and analyzed by system dynamics modelling methods, suggested the japan end-of-life vehicle legislation will improve the export rate of used car and improve economy by reverse supply chain.

Kumar and Sutherland (2008), reviewed studies on vehicle recovery infrastructure and found the following flaws in the available mathematical models: economic transactions within the infrastructure and insufficient description of the complex material flows, lack of consideration for government policies and minimal consideration of market factors. Ilgin, M. A., & Gupta, S. M. (2010) reviewed the literature on environmentally friendly manufacturing and product recovery and found that more research is needed to better control the consequences of uncertainty. A survey of ELVs, recycling, disassembly technologies, and related disciplines was presented by Go et al. (2011). Mayyas et al. (2012) reviewed many studies in the automobile industry's sustainability research, including life cycle, disposal, and end-of-life (EoL) evaluations, as well as the various sustainability metrics and models used to estimate the environmental impact. Wang et al. (2014) focused at how China's subsidy policies affect the remanufacturing and recycling industries. Initial subsidy, recycling subsidy, R&D subsidy, and production subsidy on automobile engine remanufacturing are all considered. They look at the impact of implementing the subsidies alone and in different combinations. They claim that combining subsidies improves remanufacturing performance more than implementing subsidies one at a time. Combining subsidies, on the other hand, is more expensive than adopting individual subsidies.

Inghels et al. (2016) create a model to analyse the Belgian ELV recycling system for passenger cars. They validate their model with past data and draw conclusions for the future based on their forecasts. They look at different circumstances and figure out how much ELV can be reused and recovered. The effects of several factors on ELV reuse and recovery rates are examined, including GDP, investment in glass, plastic, and tyre recovery, change in average vehicle life span, and change in automobile export rate. They argue that Belgium can meet EU ELV regulation targets and offer ways for doing so. Hedayati (2016) outlines the most technically feasible ASR energy recovery practises in Australia. The author also determines the optimum business model for energy recovery and conducts a sustainability assessment of the same using a system dynamic model. In addition, the study has policy implications for improving ELV recycling in Australia.

Azmi, M., & Tokai, A. (2017) developed system dynamics modelling method to estimate the number of passenger vehicles of electric vehicles, hybrid electric vehicles and end of life vehicle in Malaysia till 2040, used simulation done on Analytica software. M Kosacka-Olejnik (2019) proposed the selection process and waste management method of end-of-life vehicle, considering the business management during vehicle recycling. Rovinaru, F. I., Rovinaru, M. D., & Rus, A. V. (2019) proposed analysis of dismantling or recycling activities, recycling regulation, process flow, market analysis in Romania to other countries and determined the impact of dismantling end-of-life vehicles on the economy and environment. Wang et al. (2019) determined the impact of government regulations, researchers built an energetic Stackelberg model approach dominated by manufacturers, which revealed that the government's reward-penalty policy has a direct moderating impact on the legal recycling rate of ELVs, and legal recyclers can receive various recycling rates under various governmental policies. The legitimate recycler will have a lesser recycling rate if the government adopts an incentive strategy.

Khabou, A. (2019) developed reverse logistic to minimize the transportation costs of collection of purchased ELVs, in warehouse to resale, recycle of ELV parts from group of dealers, proposed a mixed integer linear programming model and huristic algorithm to get the optimum solution. Numfor et al. (2021) evaluated the challenges and opportunities of ELV recycling process in developing countries by SWOT (strength, weakness, opportunity and threats) analysis, identified the opportunity of large market size for recycler, reuse end-of-life parts and low labour cost for recycle of end-of-life parts, identified the common strength for vehicle manufacturing, end-of-life vehicle legislation, vehicle registration process, end-of –life vehicle recycling.

Kurogi et al. (2021) developed compositional data of obsolete end-of-life vehicle (motorcycle), estimated the number of obsolete ELV and amount of material in ELV in respect of Vietnam, estimated the data for the period of 2010-2030 in Vietnam, estimated the number of obsolete ELVs in 2030 will be more than 2.6 times of 2010 year, estimated the average lifespan of ELV 18.5 years, determined the feasibility of intermediate treatment through techno economic assessment. Lenort et al. (2021) analysed the ELV recycling process, improve end-of- life vehicle disassemble process and organization of ELV recycling network.

Al-quradaghi et al. (2022) prepared mathematical programming model for recycling ELV and sustainable ELV process, realised the environmental advantages and resource efficiency by including a processing and recycling network based on industrial ecology, in which waste products are turned into positive reduction of emissions that reduce pollution and the demand for raw resources, the model discovered the ideal processing pathways while maximising the supply of the parts of significance, maximising profit, reducing cost, or minimising waste.

World-wide practices of vehicle recycling

Sakkas and Manios (2003) assessed ELV management investment methods in Greece's recycling organisation, recommending that ELV deregistration be redefined, industry partnerships be formed, and considerable dismantle space be provided. Kim et al. (2004) surveyed in Korea by questionnaires including recovery rate to recyclers (dismantlers) and proposed the policies to meet future recovery rate for the end-of-life vehicle management. Nakajima and vanerburg (2005) analyzed the take back system of end-of-life vehicle in Germany in terms of its impact on the environment, compared German vehicle system to American vehicle system and concluded that although it is successful scheme, it is not maximize the value recovered from end-of-life vehicles in German.

Forton et al. (2006) discussed the barriers of shredders residue of ELV, recycling and their drivers in the UK and focused their real effects on ELV recycling practice. Edwards et al. (2006) emphasized the recovery technology and procedures in the UK's car recycling industry, concluding that the EU ELV Directive's (2000/53/EC) eco-efficiency targets are contingent on the availability of post-shredder separation technology. Zameri and Blount (2006) reviewed the ELVs recycling and recovery legislation practices in Japan, Europe, Australia and USA, the influence of ELV stakeholders and markets in industry. Dalmijin and De Jong (2007) studied end-of-life vehicle processes in Europe and compare with USA, in USA end-of-life vehicle recycling volume was high and in Europe high grades and recovery was directed for optimization of processing plants, and concluded that consumption of metal high in China, which influence product development in USA. Joung et al. (2007) investigated ELV recycling rate and management during the dismantling stage, reviewed the ELV management policies in Korea by replied from dismantler by questionnaires, concluded that installing modern sorting equipment in a car shredding plant might improve separation efficiency and boost the recycling rate. Chen and Zhang (2009) focused insight thinking about end-of-life recycling and recovery activities within China, and studied on EU's ELVs directive and its impact on China's automotive industries. Chen et al. (2010) reviewed the legislation of the end-of-life recycling system in Taiwan, provided recommended reduction in auto shredded residue and concluded that to make recycled materials more competitive, it's vital to improve and optimise the tactical and operational planning process.

Altay et al. (2011) studied the ELV recycling system in Turkey, 16% green house gases emitted due to ELV, analyzed recover 68% iron steel, 8% other metal and 22% aluminum by banning the ELV from traffic. Cheng et al. (2012) considered production capacity, power efficiency, and recycling rate as metrics, researchers looked at the operational features of Taiwan's recycling and treatment sector for ELVs and their link to recycling performance. Vehicle shredding plants are advised to optimise their operation schedules in order to increase the recycling rate of ELVs. Wang and Chen (2012) investigated used automobile electronic control component recycling sector was for development plans in China, looked at its advantages, disadvantages, prospects, and obstacles. They noted that the ELV recycling business has responded successfully to all of the causes and advocated new growth initiatives.

Farel et al. (2013) proposed model to investigate potential cost and future of ELV recycling for all value chain stakeholders and for the network in France, analyzed that by reducing glass cullet price, landfill cost, network coverage and transportation cost, increase the income. Mamat et al. (2016) examined the end-of-life vehicle management in

Malaysia, conducted survey from vehicle manufacturers, distributors, ELV collectors, responses analysed by IBM SPSS statistics, prepared structural equation modelling.

Yu et al. (2019) examined the ELV recycling policies in China, found positive effect of subsidy policy in China, prepared a statistical model to identify the future trend of number of end-of-life vehicles in China. Diao (2019) examined the various policies for sustainable transportation in Singapore, including land constraints, city constraints, economic growth, and population growth, and concluded that sustainable transportation can be reduced by optimizing car reliance, promoting public transportation, integrated land use and transportation planning, and transportation policies that are smarter, greener, and more inclusive. Kusakc et al. (2019) suggested framework discussed the reverse logistic design flaw for ELVs generated in the Istanbul metropolitan area, using a fuzzy mixed integer location-allocation model that conformed to existing directives in Turkey, assumed the ELV supply network is uncertain, the proposed model tried to address the reverse logistic design problem for ELVs produced in the Istanbul metropolitan area.

Mangmeechai (2020) studied on ELV recycling management in Thailand, life cycle of green house gas emissions and value chain in ELV management, concluded that ELV recycling system improved by allocate a proper collection point of ELVs, by proper transportation, by make better standards of car inspection annually, set up the standards for the dismantlers, ELV recycling plants.

End-of-life Vehicle practice in India

Garg et al. (2013) investigated the advantages and drawbacks of several end-of-life vehicle processing technologies in India. Venkatesan and Annamalai (2017) proposed a remanufacturing framework for both ELV recycling and Automotive Components, which includes an authorised dismantling plant, a recycling information centre, and an ELV recycling fund management board. This framework illustrates the integration of multiple stakeholders such as the government, industries, industry associations, universities, and research institutes, as well as their responsibilities in building a sustainable ELV recycling infrastructure.

Naik (2018) investigated the current status of end-of-life vehicles in India; the present situation is expressed by making comparisons ELV managing potentials of various firms and future ELVs; the relative importance of stakeholder involvement and shared responsibility is represented by a radar chart; and a comparison analysis of ELV legislative practices of different countries is presented by a radar chart.

Arora et al. (2019) analyzed the requirement of materials in vehicle production industries in India, increased by double during 10 years (1997 to 2007), estimated that the scraped materials generate Rs 114.5 billion from steels after ELV recycled and reused, proposed framework for exploring and build a business concept with a stakeholder involvement structure for increasing end-of-life vehicle management durability in India.

Sharma and Pandey (2020) examined the process of dismantle of hatchback cars in Mayapuri scrap market in Delhi, India, developed a framework between different stakeholders, estimated the recovery of useful materials from ELV after recycling and recovery in future.

Mohan and Amit (2020) developed a system dynamic model to analyse ELV recycling in an unregulated market, trading scrap material from decommissioned vehicles as a commodity, and concluded that dismantlers' dilemma constrains dismantling capacity and fluctuates scrap supply in ungoverned recycling markets, simulation results show that the unregulated market leads to lower dismantling capacity, suggested that limiting scrapping costs through synchronisation among the dismantlers and reducing dismantling costs through alignment among.

Conclusion

Automobiles nearing their end-of-life pose a significant problem for the entire world. As vehicle ownership becomes more accessible to the average person, vehicle ownership and end-of-vehicle numbers are increasing day by day in developing countries like India. This growth in vehicle ownership and end-of-vehicle numbers necessitates the governance of end-of-life vehicles. The stakeholders highlighted the absence of any standard method in the end-of-life vehicle recycling management in this study. The precious, reusable, and other pricey material pieces from the scrap of dismantled automobiles are not employed in the automotive system due to the uncontrolled end-of-life vehicle recycling system. It affects sectors such as scrap steel processing facilities since the scrap supply fluctuates. As discarded parts and components are used as second raw resources in the automobile industry, this tends to harm the sector's economic growth.

With the help of different countries policies, supportive literature comparing the outline to the end-of-life recycle management policy framework in India. It is also suggested from this study that unregulated ELV recycling system can be improved by cooperation of stakeholders and regulatory support. It will increase the amount of ELVs, huge availability of labour and low labour cost, and increasing environmental impact due to the emerging economy. The major need of the society the reduction of carbon emission can be achieved by using resources effectively. There is a requirement to empower to the automotive industries to deals with the problems of recycling of ELVs. Based on our findings, we recommend that stakeholder collaboration and regulatory assistance can reduce dismantling costs and improve the disassembly condition in the ELV sector by supporting scrap material prices.

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