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Stakeholder Perceptions and Institutional Challenges in Implementing Vehicle Scrappage Programs in Delhi NCR

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ABSTRACT

Vehicular pollution remains a major contributor to air quality deterioration in the Delhi-NCR region, with private and commercial vehicles including two-wheelers and cars accounting for nearly half of local $PM_{2.5}$ and the majority of NO_x emissions. Even before India's national Vehicle Scrappage Policy was introduced in 2021, Delhi had implemented early interventions such as the 2001 CNG mandate for public transport, the NGT's 2015 age-based bans, and the Odd-Even vehicle rationing scheme in 2016. The national policy seeks to reduce vehicular emissions, promote fleet modernization, and support a circular economy through a mix of incentives and regulatory disincentives for End-of-Life Vehicles (ELVs). Despite these intentions, progress in Delhi NCR has been limited. This study examines stakeholder perceptions and institutional barriers affecting the policy's implementation, highlighting gaps in infrastructure, enforcement, coordination, and public awareness that hinder effective outcomes. Findings aim to inform strategies for more equitable, efficient, and scalable adoption of scrappage programs in urban India.

1. INTRODUCTION

Road Transport is considered to be one of the most cost-effective and preferred modes of transport, both for freight and passengers. The Road Transport Sector accounts for about 87% of passenger traffic and 60% of freight traffic movement in the country. Road transport also acts as a feeder service to railway, shipping, and air traffic. Over the last couple of decades, the automobile sector in India has seen exponential growth due to a combination of factors such as rising income levels, rapid urbanization, improved road infrastructure, and the increasing aspiration of the middle class for personal mobility.

Air pollution is a challenge being faced globally. The pollution from vehicle exhaust is one of the main sources of air pollution. Vehicular emission refers to the release of pollutants and gases from the exhaust and other parts of motor vehicles during fuel combustion and operation. These emissions are a major source of air pollution, especially in urban areas. Vehicular emissions have long been known to have harmful effects on human health and the environment. Many countries and regions, especially those with mature vehicle markets, have taken actions to mitigate vehicle emissions.In India, the transport sector has emerged as the third-highest emitting sector, and road

transport contributes to 90% of the transport emissions (CSE, 2021). The percentage share of total carbon emissions is likely to increase from the current level of 13.5% to 19% by 2050 (TERI, 2021).

In order to offset environmental impact, policy makers had three options that is to introduce electric vehicles, introduce strict rules on emission by bringing (BS6) engines, and to introduce a vehicle scrappage policy paving the way for a circular economy.

Developed countries have already implemented a vehicle scrap policy that prevents the on-road usage of old vehicles beyond a certain age to curtail pollution. Recently Indian government also announced its plans and policies for vehicle scrapping.

In 2021, the Ministry of Environment, Forest and Climate Change (MoEF & CC) calculated that about 21.4 million vehicles existed in India that were older than 20 years with the highest number in Karnataka (39.4 lakh), followed by Delhi (36.1 lakh), Uttar Pradesh (26.2 lakh), Kerala (20.6 lakh), Tamil Nadu (15.9 lakh) and Punjab (15.3 lakh). These vehicles produced the highest carbon emissions, leading to a rise in air pollution.

A study stated that a 15-year-old diesel car emitted 7.6 times higher particulate matter (PM) and 3.4 times higher nitrogen oxides than a BS–IV car (Chowdhury and Chattopadhyaya, 2020). Thus, dealing with end-of-life vehicles (ELV) should be a part of the strategy to limit the emissions of on-road vehicles.

ELVs are vehicles that are no longer considered roadworthy, either due to age limits imposed by law or because they've been voluntarily declared unfit by their owners. As per Automotive Industry Standard (AIS -129), an end-of-life vehicle (ELV) in India is defined as a vehicle that is no longer validly registered, after having been declared unfit through automated testing stations, or self-declared by the owner as a waste vehicle.

The surge in the number of end-of-life vehicles (ELVs) has put great pressure on the environment. These vehicles contain hazardous materials like lead-acid batteries, airbags, and various fluids, which can cause pollution if not handled and disposed of properly. Additionally, the sheer volume of ELVs contributes to the landfill burden and requires efficient recycling processes.

The Ministry of Road Transport and Highways (MoRTH), Government of India, formulated the Vehicle Scrapping Policy in 2021. The policy aims to phase out unfit and polluting vehicles in an eco-friendly manner and promote safer, greener transport. It also intends to reduce vehicular air pollution, enhance road safety, boost fuel efficiency, generate employment opportunities, stimulate demand for new vehicles, while formalizing the informal scrapping sector.

The original guidelines required private vehicles to be scrapped after 20 years and commercial vehicles after 15 years. Many felt that the scrapping decision, solely based on a vehicle's age, did not fully address environmental concerns. In response to this feedback, and with a growing focus on pollution control, the 2024 amendments introduced a significant shift towards a pollution-based approach. Instead of relying only on the age of vehicles, the revised policy targets high-emission vehicles for scrapping, aligning with India's broader goals of environmental sustainability and reducing urban air pollution..

The Timeline for implementation of the Vehicle Scrappage policy was as under :

Policy	**Effective date of implementation**
Rules for fitness test & scrapping centre	1st October 2021
Scrapping of Govt & PSU vehicles above 15 years	1st April 2022
Mandatory fitness testing	
Heavy commercial vehicle	1st April 2023
Phased introduction of other categories	1st June 2024

The Government of India has formulated the Vehicle Scrapping Policy that includes a system of incentives/disincentives for the creation of an ecosystem to phase out older, unfit, polluting vehicles. The incentives and disincentives in the Vehicle Scrappage Policy are aimed at encouraging owners to discard their old and polluting vehicles, which have higher maintenance and fuel consumption costs. In order to enforce provisions of the policy, rules have been notified under the framework of the Motor Vehicles Act, 1988, and Central Motor Vehicle Rules, 1989. The respective State/UT Governments are responsible for the implementation and enforcement of the policy.

The Extended Producer Responsibility (EPR) regulations for ELV, which came into effect in India w.e.f 1st April 2025, can play a significant role in the successful implementation of the vehicle scrappage policy. Automakers should be mandated to establish scrapping centres, implement the scheme, and ensure safe collection, treatment, depollution, dismantling, and recycling of ELVs.

The Vehicle Scrappage Policy is set to play a pivotal role in not just minimizing pollution, but also positioning our nation as a key player in the global steel manufacturing landscape. On average, a passenger car comprises around 69% steel by weight, along with 16% aluminium, 5% plastic, 4% rubber, and the remainder made up of materials like foam, copper, and glass (TERI, 2017). Currently, India stands as the second largest producer of steel, generating approximately 149 million tons in 2024 (Ministry of Steel). By embracing the Vehicle Scrappage Policy, the available scrap could significantly boost the government's steel production target to 300 million tons by 2030 (IBEF, 2022).

According to an estimate, the expansion of scrapping facilities across India could generate up to 50,000 direct jobs & more than 1,00,000 indirect jobs by 2030. These jobs span various roles in dismantling, recycling, and managing scrap materials, helping formalize the sector and boost economic activity.

If the vehicle scrappage policy is implemented effectively, it will become a cornerstone in India's transition to a cleaner, safer, and more efficient transport ecosystem.

As per the data tabulated in Rajya Sabha, on question No. 3761 dated 5th April 2023 in response to a question on scrapping of vehicles, it was informed that more than 6.1 crore vehicles, equivalent to or older than 15 years, were registered across the country as on 31st March 2023. Of this, 77.3% (4.72 crores) are petrol-only vehicles, 18.57% (1.13 crore) are diesel-only vehicles, and 0.14% (85,255) are CNG-only vehicles. The fuel type data of the remaining 4% of them has not been recorded in the system.

As per an estimate, more than 9 lakhs Government vehicles have crossed their End of Life Vehicle (ELV) in India as of August 31, 2024, and only around 41,432 Government vehicles have been scrapped under the scrappage policy.

The Vehicle Scrappage Policy has made very slow progress. As per MoRTH report, only 180 scrappage centre are registered in India & 117 Registered Vehicle Scrapping Facilities (RVSFs) are currently operational across 20 states and Union Territories & 136 Automated Testing Stations (ATS) are functional across 16 states. Without proper implementation of the Vehicle Scrappage policy, the fleet of ELV vehicles is expected to grow at a CAGR of 12-14% between 2025-2030.

2. LITERATURE REVIEW

Krishna Mohan and R K Amit (2020), titled "An Analysis of End-of-Life Vehicle (ELV) Recycling in Emerging Economies," investigate the ELV recycling landscape in India, emphasizing the challenges posed by informal recycling practices and the lack of regulatory oversight. It uses a system dynamics modelling approach to simulate the behaviour of informal dismantlers and assess the sustainability of current practices. The study highlights the need for formalization of the ELV recycling sector, suggests OEM participation and government intervention to improve recycling rates & demonstrates the value of system dynamics modelling in policy planning and infrastructure forecasting. From their analysis, environmentally sound recycling can be achieved by building formal dismantling operations with high capacity, vertical integration of car manufacturers, and ELV management systems matched with suitable legal frameworks.

Arora et al. (2018) conducted a comprehensive analysis of ELV management in India, emphasizing the economic potential, environmental risks, and policy gaps associated with ELV disposal and recycling. Their work is often cited for estimating the steel scrap value from ELVs at ₹115 billion annually, highlighting the untapped resource efficiency in India. He advocates for Extended Producer Responsibility (EPR), where manufacturers take accountability for vehicle disposal. His study calls for automated fitness testing stations and formal deregistration protocols to streamline ELV identification and scrapping.

Sakai S, Noma Y et al. (2007) examine Japan's approach to End-of-Life Vehicle (ELV) recycling, focusing on the automobile shredder residue (ASR) and its environmental implications. The study is framed within the context of Japan's ELV Recycling Law (2002) and compares it with European ELV directives. The author highlights the

environmental risks of ASR incineration, demonstrates the technical viability of advanced thermal processes & provides a policy model for other nations seeking to improve ELV recycling.

Zhang et al. (2020) developed an evolutionary game model by studying the rivalry between the illicit and authorized recycling sectors of ELVs. The authors tried to understand the Government's different policies on the revenue from recycling ELVs. In the evolutionary games model, a numerical simulation approach was employed to assess and validate the influence of Government policies. The findings lead to the conclusion that raising the evolutionary stable state is almost impossible when the Government imposes penalties exclusively on ELVs recycling. Sharma and Pandey (2020) have stressed the need to recover resources from end-of-life passenger vehicles recovery of resources from end-of-life passenger's cars. For this purpose, the authors developed a conceptual framework representing process flow and the reciprocity between the numerous stakeholders involved in the informal sector. The results from the conceptual framework were used to evaluate the possibility of reusing and recovering usable materials from ELVs, which are being processed by our country in the informal sector.

Adamo et al. (2020) tried to understand the correlation between the European ELV flows and two variables, i.e., Population and Gross Domestic Product, through a linear regression model. Both produced and recycled ELVs are expected to generate a total of 9.3 and 8.3 million tons in 2030, respectively, as per the author's findings.

Al Quradaghi et al. (2021) research paper titled "Optimization Model for Sustainable End-of-Life Vehicle Processing and Recycling," presents a mixed-integer linear programming (MILP) model designed to optimize the processing and recycling network for End-of-Life Vehicles (ELVs). It emphasizes industrial symbiosis, where waste materials are exchanged among industries to reduce environmental impact and enhance resource efficiency. His studies bridge gaps in existing literature by modelling post-shredding stages and cross-industry collaboration, and offer a scalable framework for policymakers and industry stakeholders to design sustainable ELV networks.

Kasim et al. (2021) realized that unless there is support from the Government and various groups of people, the policies related to End-of-Life Vehicles cannot be successful. The authors adopted methods that consisted of primary data analysis by conducting a survey among stakeholders and a related literature review. Their study concluded that ELV recyclability in Malaysia is still restricted, and certain major technological and economic constraints must be removed as soon as possible. Based on the discussions and deliberations on the above context, this study discovered that suggested policies must function in parallel with stakeholder approval and awareness among public stakeholders.

The above literature review provides an insightful overview of vehicle scrappage, highlighting its significance as a national initiative to improve environmental standards and public health while fostering economic growth. Further research should focus on empirical assessments of the policy's actual impact and the factors influencing public engagement with scrappage processes.

From the reviewed papers, it was found that good ELV resource recovery and recycling do not ensure that the resources will be recycled again. Hence, ecologically sound recycling may be accomplished through the development of formal dismantling operations with high capacity, vertical integration of automobile manufacturers, and ELV management systems matched with appropriate regulatory frameworks in a professional way in India. The findings lead to the conclusion that raising the evolutionary stable state is nearly impossible when the Government imposes penalties solely on ELV recycling. Therefore, there should be support from the Government and various stakeholders in order to make the proposed Vehicle Scrappage Policy a success.

A review of various studies highlights the dual benefits of vehicle scrappage policies:

Environmental Impact: Scrapping older vehicles may result in a significant reduction in harmful emissions. Sharma and Pandey (2020) noted that phasing out older diesel vehicles could lead to decreases in particulate matter (PM) and nitrogen oxides (NOx) levels, contributing to improvements in urban air quality. Implementing efficient recycling processes for materials from scrapped vehicles can also mitigate the demand for raw materials and reduce the overall carbon footprint of the automotive industry (Buberger et al., 2022).

Economic Growth: Vehicle scrappage policies stimulate the automotive market by increasing demand for new vehicles, thereby boosting production and sales. Estimates suggest that the policy could lead to an increase in vehicle sales by as much as 18% (IMPRI, 2024). Moreover, the scrappage process can create numerous job opportunities in the recycling and automotive sectors, with projections of generating up to 50,000 direct jobs by 2030.

3. OBJECTIVES OF THE STUDY

The vehicle scrappage policy implemented by the Government of India is expected to have a far-reaching impact on Air Pollution, road safety, the Indian economy & automobile sector. The following set of objectives has been identified in this study :

1. To analyse the acceptance of the Vehicle Scrappage Policy 2021 among car owners in the Delhi NCR region
2. To analyse the consumer perception and awareness about the policy
3. To analyse the impact of scrapping unfit vehicles on vehicular air pollutants, improving road and vehicular safety
4. To Analyse the Institutional challenges in implementation of Vehicle Scrappage policy
5. To Estimate the impact of end-of-life vehicle (ELV) recycling on Air pollution of Delhi NCR

4. WHY DELHI NCR

Delhi NCR constitutes the National Capital Territory of Delhi along with adjoining districts from neighboring states, including Haryana, Uttar Pradesh, and Rajasthan, forming one of the largest urban agglomerations in the world. Delhi-NCR of India is the most polluting region in the Country & transport is the largest contributor to Air pollution, and steps need to be taken to control it. More than 80 lakh vehicles operating in this region are more than 15 years old. Delhi's registered vehicle population has crossed 15 millions as of March 2025, equaling the combined registrations of Mumbai, Kolkata, and Chennai. Further, lakhs of vehicles enter Delhi every day from neighboring cities in NCR, which aggravates the pollution level of Delhi.

Over the past two decades, Delhi's population has increased significantly, from 13.78 million in 2001 to 22.27 million in 2025 reflecting a consistent upward trend. This population growth has driven greater demand for urban infrastructure, employment opportunities, and mobility. However, the city's public transport system has not kept pace with this rising demand. With only 45 buses per 100,000 residents well below the recommended benchmark of 60 the existing infrastructure falls short of adequately serving commuters. As a result, public transport becomes a less viable option for many, leading to increased reliance on private vehicles and further exacerbating Delhi's pollution levels.

According to data collated by the transport department, till September 2024, there were 60,14,493 ELVs in Delhi & 27,50,152 ELVs in Haryana. Further, 50% car, 33% two two-wheelers & 33% original equipment manufacturers in India is located in Haryana. Delhi NCR, being one of the most polluted and densely populated urban agglomerations in the country, serves as a vital test bed for evaluating the policy's effectiveness

In Delhi, end-of-life vehicles (ELVs) refer specifically to diesel vehicles older than 10 years and petrol vehicles older than 15 years. These vehicles are no longer legally permitted to be registered or driven in the city, as per directives from the Supreme Court and the National Green Tribunal (NGT).

Delhi's vehicle scrappage policy, effective July 1, 2025, mandates the scrapping of petrol vehicles older than 15 years and diesel vehicles older than 10 years. This policy aims to reduce air pollution by removing older, more polluting vehicles from the road. Owners have the option to scrap their vehicles at authorized facilities or convert them to electric models. Incentives like road tax rebates and registration fee waivers are available for those who scrap their vehicles. To enforce compliance, 520 Automatic Number Plate Recognition (ANPR) cameras have been installed at 500 fuel stations across Delhi . These cameras will scan vehicle number plates and check their registration status using data from the VAHAN database. If a vehicle is flagged as an ELV, attendants will be alerted to deny it fuel. Violators may face penalties, including vehicle impounding and enforced scrapping.

So, the easiest way to curb pollution, is to restrict the usage of vehicles with older technology that are assumed to be more polluting. The vehicle scrappage policy is the next step to prevent them from further commuting on the roads.

5. VEHICLE SCRAPPAGE POLICY OF DELHI

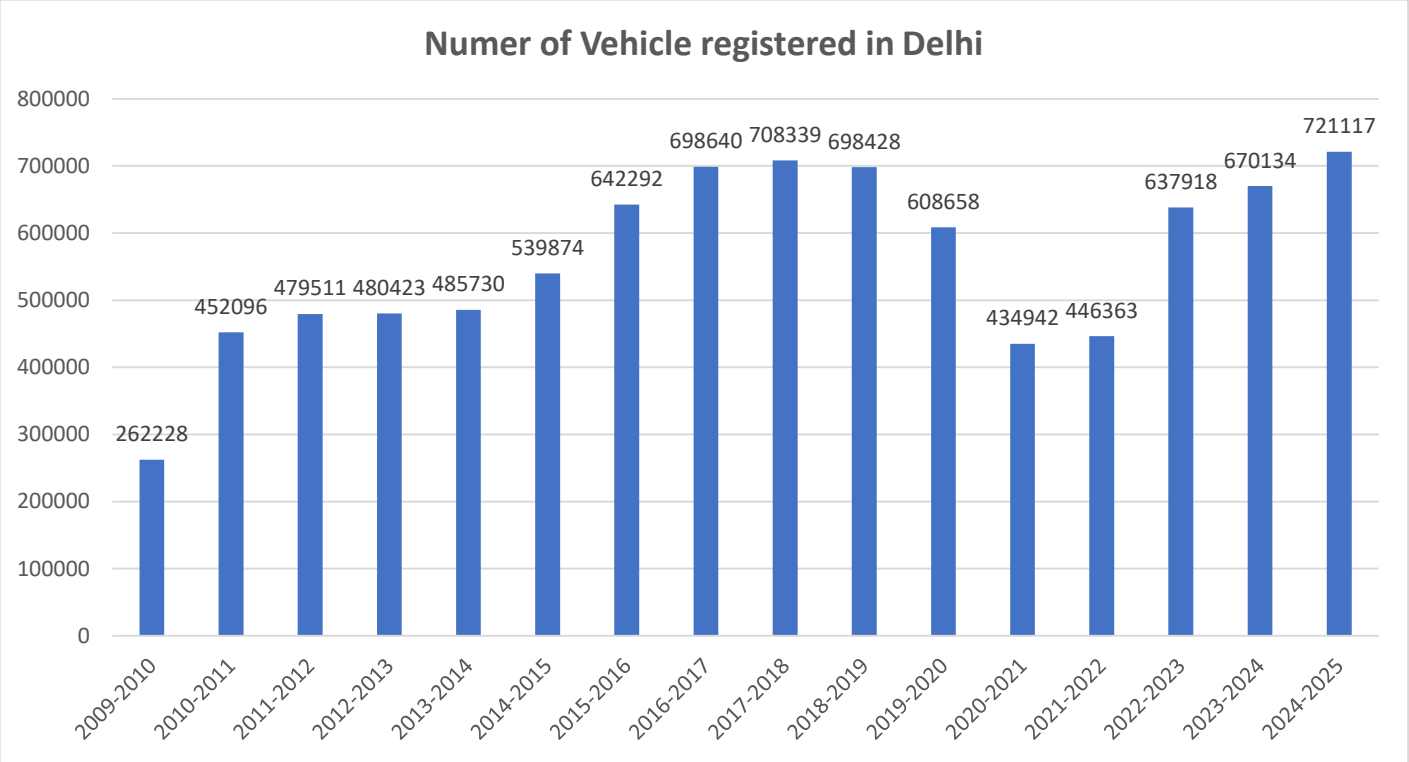
The number of registered vehicles in Delhi has been steadily increasing over the past decade, with over 1.5 crore vehicles currently on the city's roads. This includes both privately owned and commercial vehicles. Recent

data indicates a significant rise in the registration of new vehicles in Delhi, with an 30% increase in FY 2024-25 over FY 2014-15.

The 2024 guidelines mandate scrapping diesel vehicles older than 10 years and petrol vehicles older than 15 years. The policy offers a discount of up to Rs 20,000 or 1.5 per cent of the ex-showroom price (whichever is lesser) on new car purchases and scrap value at 4-6 per cent of the ex-showroom price, but these incentives pale against new vehicle costs.

Delhi has only one RVSF i.e EZ Waste Recycling Pvt Ltd at Badarpur and two Automated Testing Station centre i.e at Jhuljhuli (Southwest Delhi) & DTC Nand Nagri Depot (Northeast Delhi) for Automated Fitness Testing of commercial vehicles as of September 2025. Delhi's infrastructure continues to lag behind other States, creating bottlenecks and delays for vehicle owners seeking fitness tests or scrappage services.

5.1 Vehicle registration data of Delhi (2009-10 to 2024-25)



Delhi's vehicle registration data indicates a significant increase in the number of vehicles on the road. In 2024-25, over 7 lakh (7,21,117) new vehicles were registered in Delhi, marking a 7.8% increase from the previous year. This translates to an average of approximately 1,900 vehicles being registered daily in Delhi.

De-registration Vrs. Scrappage in NCT, Delhi*

Year	No of Vehicles De-registered	No of Vehicles scrapped
2021-22	4877646	4923
2022-23	618192	140342
2023-24	200000 (Approx)	14000
2024-25	300000 (Approx)	39273

*Souces : **Delhi Transport Department**

There was a massive spike in deregistration due to enforcement of age-limit rules for diesel (10 years) and petrol (15 years) vehicles. However, actual scrapping remained extremely low. While de-registration is being enforced on a large scale in Delhi, scrappage lags significantly, pointing to a gap in actual disposal of end-of-life vehicles. The discrepancy highlights the need for better incentives, more scrapping centers, and improved compliance from vehicle owners to prevent de-registered vehicles from remaining in circulation or occupying public spaces.

5.2 Criteria of De-registration of Vehicles in Delhi

Fuel Type	Age threshold in Delhi for ELV / deregistration eligibility
Diesel vehicle	~10 years or more
Petrol / CNG vehicle	~15 years or more

Deregistration constitutes an administrative intervention intended to restrict the operation of overaged or End-of-Life (ELV) vehicles within the transport fleet. However, this measure, in isolation, does not inherently lead to a reduction in vehicular emissions or a tangible improvement in ambient air quality. It is therefore imperative that deregistration not be conflated with the process of vehicle scrappage, which entails the environmentally responsible dismantling and material recovery of ELVs. Policymakers must exercise caution against perceiving the act of deregistration as a conclusive step towards emission mitigation or pollution abatement, as it represents only a procedural component rather than a substantive environmental outcome.

6. CONSTITUTIONAL AND LEGAL CHALLENGES FOR THE IMPLEMENTATION OF DE-REGISTRATION/ SCRAPPAGE OF END-OF-LIFE VEHICLES (ELV)

In the National Capital Territory of Delhi, vehicles classified as “end-of-life” namely petrol vehicles over 15 years old and diesel vehicles over 10 years old, are subject to deregistration and removal from public roads under detailed guidelines. If such a vehicle is found plying or parked in a public area, it can be impounded; the owner must submit an application within three weeks, pay a penalty (₹10,000 for four-wheelers, ₹5,000 for two-wheelers) and either move the vehicle out of Delhi/NCR or park it only in a private space. Vehicles that are impounded a second time or diesel vehicles beyond 10 years cannot be released and must be sent to a registered vehicle-scrapping facility for disposal.

The implementation of the vehicle scrappage policy in Delhi faces significant constitutional and legal challenges, particularly in light of a recent plea before the Supreme Court. Central to the legal contention is the alleged violation of Article 300A of the Constitution of India, which guarantees that no person shall be deprived of their property except by authority of law. The petitioner argues that mandatory scrappage of well-maintained, emission-compliant vehicles constitutes an arbitrary deprivation of property, as these vehicles are still operational and have not reached the end of their functional life. Moreover, vehicle owners are not being compensated for the unutilized portion of their registration period, despite having paid registration fees with the legitimate expectation that their vehicles would remain road-legal for a full 15-year term. The retrospective application of the policy disproportionately affects individuals who purchased vehicles prior to 2015, when no clear age-based restrictions had been codified. Such retroactive enforcement raises serious concerns around legal certainty, fairness, and the protection of vested rights under constitutional and administrative law. These issues underscore the need for a more balanced policy framework that aligns environmental objectives with legal safeguards for individual property rights.

7. INSTITUTIONAL BARRIERS IN THE EFFECTIVE IMPLEMENTATION OF VEHICLE SCRAPPAGE POLICY IN DELHI

Despite the formal adoption of the Vehicle Scrappage Policy, its effective implementation in Delhi has been hindered by several institutional shortcomings. A key issue lies in the misinterpretation of administrative actions such as vehicle deregistration as equivalent to physical scrappage. While over 6.1 million vehicles have been de-registered in Delhi under various regulatory mandates including NGT orders, however actual scrappage and environmentally sound disposal of End-of-Life Vehicles (ELVs) remains minimal. This disconnect between policy intent and on-ground execution has significantly undermined the environmental, safety, and economic objectives of the policy. Moreover, there is insufficient coordination among central and state-level institutions, with fragmented responsibilities between MoRTH, the Delhi Transport Department, and municipal bodies, resulting in ineffective enforcement and weak integration of databases for ELV tracking. The slow pace of establishing Registered Vehicle Scrapping Facilities (RVSFs), limited clarity on OEM responsibilities under Extended Producer Responsibility (EPR), and absence of vehicle take-back infrastructure have further stalled momentum. Importantly, the administration has also failed to adequately promote the policy through digital platforms, leading to low public awareness among vehicle owners about scrappage benefits, processes, and incentives. The continuing dominance of

the informal sector, coupled with these institutional gaps, poses a serious challenge to the policy's long-term effectiveness in Delhi-NCR.

8. METHODOLOGY

8.1 Pilot Study to assess public acceptance of the Vehicle Scrappage Policy 2021 within the Delhi NCR

This study aims to assess public acceptance of the Vehicle Scrappage Policy 2021 within the Delhi NCR area. Before evaluating respondents' perceptions, policy awareness was introduced through focused group discussions and a pilot study to ensure informed responses. Participants were classified into categorical groups based on key demographic and behavioural variables. The collected data were then analyzed using the Chi-Square test to explore associations and interdependencies among the variables

To explore public understanding and acceptance of the Vehicle Scrappage Policy 2021, a pilot-scale experiment was conducted focusing on personal car owners in the Delhi NCR region. This structured survey, divided into four key sections, aimed to uncover attitudes, awareness levels, and behavioural tendencies linked to vehicle scrapping.

1. In the first section, basic personal details of respondents were collected, which include their name, age, occupation, and whether the respondents own 4-wheeler vehicles. Only if the respondent owns a vehicle, the survey shall continue

2. In the second section, specific attributes related to the respondents' vehicles help establish a connection with the Vehicle Scrappage Policy. Key areas of inquiry include:

   - Number of four-wheeled vehicles owned.
   - Age of each vehicle.
   - Fuel type (Petrol or Diesel).
   - Operational status—whether the vehicle is currently in use or has expired.
   - Intentions to sell the vehicle.
   - Awareness of the Vehicle Scrappage Policy 2021.

   Collecting these details allows for a nuanced understanding of how individual vehicle profiles align with scrappage criteria and public readiness for policy adoption.

3. The third section serves to inform respondents about the key aspects of the Vehicle Scrappage Policy 2021. It outlines :

   Benefits of scrapping outdated vehicles, such as environmental gains and economic incentives.

   Disincentives for retaining End-of-Life Vehicles (ELVs) emphasize the drawbacks of keeping expired automobiles.

   Scrapping Procedure, providing a step-by-step guide for owners interested in voluntarily discarding their vehicles under the policy framework.

   The goal of this section is to ensure that all respondents have a baseline understanding of the policy before their perceptions are evaluated, enabling more informed and meaningful responses in the following section.

4. This section offers a deeper understanding of the apprehensions, motivations, and acceptance levels among personal vehicle owners, shedding light on the broader societal readiness to adopt scrappage practices.

   Building on the awareness established in the previous section, respondents were asked to share their views and preferences on key aspects of the policy, including:

   - Willingness to scrap old vehicles versus opting for resale.
   - Perceived environmental impact of scrapping aged vehicles.
   - Evaluation of the policy's overall benefit, rated on a 5-point scale.

- Expectations and suggestions directed toward government implementation and incentives.

8.1.1 **Chi-Square Test**

The collected data were analyzed using the Chi-Square test, a statistical method well-suited for examining discrete outcomes. This technique relies on the chi-squared probability distribution to assess associations between two or more response categories with distinct outcomes. The primary goal of the test is to identify significant relationships between nominal or categorical variables. Using JMP software, the analysis involved comparing the frequency distributions of two categorical variables. Through this process, the relationship between the independent variable (occupation) and the dependent variable (awareness) was established. Based on this variable selection, features that exhibited strong dependence on the response variable were considered.

The results from JMP software are expressed in a contingency **Table 2**, and the degree of freedom is calculated by the formula (r-1) *(c-1) where r and c, are the number of rows and columns.

8.1.2 DATA COLLECTION

The study sample was drawn from the Delhi NCR region, with responses gathered through personal interviews conducted in cities including Delhi, Gurgaon, Noida, Faridabad, and Ghaziabad. Respondents were selected without any gender/profession bias. **Table 1** presents the consolidated data reflecting public understanding.

Table 1. Consolidated Information on Public Comprehension

Questions	Responses	Frequency	Percentage
Do you own a 4-wheeler	YES NO	287 213	57.4 42.6
How many Vehicles do you OWN?	ONE MORE THAN ONE	212 75	73.87 26.13
Occupational Categories	Salaried Self Employed	167 120	58.19 41.82
What is the Fuel Type of your Vehicles	Petrol Diesel Other	160 105 22	55.75 36.58 7.67
Age of your Vehicles	Less than 10 years 10-15 years More than 15 years	150 105 32	52.26 36.58 11.15
What is the status of the Vehicle Registration Certificate	Running Expired	205 82	71.42 28.57
Are you aware of the Vehicle scrappage policy, incentives & disincentives	YES NO	90 197	31.35 68.64
Do you think that if an old vehicle is scrapped, it will help in the reduction of environmental/ Air pollution	YES NO	175 112	60.97 39.02
Are you familiar with the procedure for applying to scrap your car?	YES NO	25 262	8.71 91.29

Are you aware of the NGT/Supreme Court guidelines regarding the banning of old vehicles in Delhi	YES NO	225 62	78.39 21.60
Do you know the Registered Vehicle Scrappage facilities (RVSF) centre available near you?	YES NO	12 275	4.18 95.81
Are you planning to sell your car	YES NO	110 177	38.32 61.68
What should you do if you want to get rid of your old car	Scrapping Vehicle Resale	156 131	54.35 45.64
Are you aware of the Extended Producer Responsibility (EPR) regulations for ELV	YES NO	28 259	9.76 90.24
On a scale of 5, how beneficial is the Vehicle Scrappage Policy to you? (5 being the highest and 1 being the lowest)	1 2 3 4 5	55 45 27 75 85	19.16 15.67 9.41 26.13 29.62

8.1.3 Summary of Data Analysis on Vehicle Scrappage Policy Awareness:

Out of 500 total responses collected, 287 respondents owned a four-wheeler vehicle. These 287 responses were selected for further analysis to assess awareness regarding the vehicle scrappage policy.

To simplify the study of occupational trends, respondents were categorized into two groups: **Salaried** and **Self-Employed**.

- The **Salaried** category includes Professors, Engineers, Managers, Teachers, and other salaried employees.
- The **Self-Employed** category comprises Businessmen, Photographers, Entrepreneurs, Farmers, Homemakers, Pharmacists, Hoteliers, etc.

Additionally, the age of the vehicles was grouped into three categories for clearer segmentation:

- **0–10 years**
- **10–15 years**
- **More than 15 years**

8.2 ESTIMATION OF IMPACT ON AIR POLLUTION , IF VEHICLE SCRAPPAGE POLICY IS IMPLEMENTED ON A FULL SCALE IN DELHI NCR AREAS

8.2.1 The following data and assumptions have been considered to estimate the impact on air pollution in the Delhi NCR region

Data point	Value / estimate
Total $PM_{2.5}$ emissions in Delhi (2021 emission inventory report by TERI)	~ **20.32 kilotonnes/year**
Portion of these emissions from vehicles (tailpipe)	**~47%** of $PM_{2.5}$ emissions in Delhi are vehicular emissions

Data point	Value / estimate
Total NO_x emissions in Delhi (2021)	~ **153.53 kt/year**
Portion of NO_x emissions from vehicles	~ **78%** of NO_x in Delhi from vehicular sources. (TERI Report)
Number of "old / end-of-life vehicles" in Delhi	~ **6.1 million** as of early 2025.

Sources : The Emission inventory report by TERI 2021, The Indian Express, Economic Times & Mint

Other assumptions for the estimate:

- "Full scale" means most of these EOL vehicles that are still emitting heavily are identified and removed or replaced with cleaner (BS-VI or equivalent, or electric) vehicles.
- Emission factor of very old vehicles is significantly worse than newer ones. From media / CAQM statements: e.g. pre-BS VI or old diesel/petrol vehicles may emit ~4.5× more PM, or ~6× more NO_x compared to "clean" ones.
- After removal, assume replacement with "average modern vehicle" that meets current norms (BS-VI) or cleaner, so the residual tailpipe emissions from replaced fleet are much lower.

8.2.2 Estimate of Emission Reductions

Using the above, here is how much pollution ($PM_{2.5}$, NO_x) could be reduced under full implementation.

1) **Estimated Impact on $PM_{2.5}$ Emissions reduction**

Vehicular $PM_{2.5}$ = 9.55 kt/year (47% of 20.32 kt)

Assume ~35% of this is from high-polluting EOL vehicles = ~3.34 kt/year

Scrapping and replacing them with BS VI/electric vehicles (with ~75–80% $PM_{2.5}$ reduction)

Estimated $PM_{2.5}$ reduction:

75% of 3.34 kt = ~2.5 kt/year

2) **Estimated Impact on NO_x Emissions**

- Vehicular NO_x = **119.75 kt/year (78% of 153.53 kt)**
- Assume ~35% from EOL vehicles = **~41.9 kt/year**
- Replacing them with modern vehicles (with ~85% NO_x reduction)

Estimated NO_x reduction:

85% of 41.9 kt = **~35.6 kt/year**

Summary of Estimated Reductions of Pollution in Delhi NCR (Full-Scale Scrappage)

Pollutant	Estimated Annual Reduction	% of Total City-Wide Emissions
$PM_{2.5}$	~2.5 kilotonnes/year	~ 26.2% of vehicular $PM_{2.5}$ emissions (12.3% of the total $PM_{2.5}$ emission of 20.32 kt/year)

Pollutant	Estimated Annual Reduction	% of Total City-Wide Emissions
NO_x	~35.6 kilotonnes/year	~29.7% of vehicular NO_x emissions (~23.2% of total NO_x 153.5 kt/year)

Interpretation

- Air quality improvement from full-scale implementation would be significant, especially in urban hotspots where old vehicles are densely used.
- The most noticeable gains would be in reducing NO_x and $PM_{2.5}$, two of the most harmful pollutants for human health.
- However, actual reductions will depend on real-world factors: enforcement quality, public compliance, infrastructure readiness, and the emission profile of replacement vehicles.

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9 RESULTS & DISCUSSION

9.1 Summary of Findings from the Pilot Study:

Awareness of Vehicle Scrappage Policy: Among 287 respondents who own a four-wheeler, 68.64% were unaware of the Vehicle Scrappage Policy before the market survey. In contrast, 78.39% of car owners were familiar with the NGT/Supreme Court guidelines regarding the ban on old vehicles in Delhi. Only 9.76% respondents are aware of Extended Producer Responsibility (EPR) regulations for ELV, while more than 90% have not heard of it. This may be because this regulation came into effect in India w.e.f 1st April 2025. There's high awareness of the environmental impact and guidelines, but low procedural understanding.

Perception on Pollution Reduction: A total of 175 respondents (out of 287) agreed that scrapping old vehicles would help reduce air pollution.

Lack of Information: An overwhelming 225 respondents (78.39%) did not know the location of their nearest authorized vehicle scrappage centre. Information accessibility and clarity are critical, especially on how to apply and benefit from the scrappage program.

Mixed Reactions to Policy Benefits: Car owners expressed mixed views on how beneficial the Vehicle Scrappage Policy is for them. This uncertainty may stem from inadequate clarity on the policy, concerns about forfeiting prepaid road tax on vehicles older than 10 years (particularly diesel cars), or the potential for better resale value through used car dealers.

Preference for Resale Over Scrappage: Since the policy is relatively new, most respondents preferred selling their vehicles instead of scrapping them. This may be due to limited availability of government-authorized scrapping units, insufficient financial incentives, and a lack of awareness about the scrapping application process.

Scrappage Policy Benefit Perception (Scale of 1–5)

Rating	Respondents	Percentage (%)
1 (Lowest)	55	19.16%
2	45	15.67%
3	27	9.41%
4	75	26.13%
5 (Highest)	85	29.62%

Nearly **56%** respondents rate the scrappage policy as moderately to highly beneficial, indicating reasonable support with room to grow through better implementation and awareness.

9.1.1 Numerical Results

The considered data set is to determine whether the respondents with classified occupations are aware of the Vehicle Scrapping Policy. Now the Chi-square test is performed for 2 variables. Occupation of respondents with the classified group values in terms of Salaried and Self-employed as the independent category was considered. The awareness from the respondents is based on the response values Yes/No. Here, an attempt to verify the relationship between Occupation and Awareness is conducted.

H0: There is no relationship between occupation and awareness of policy

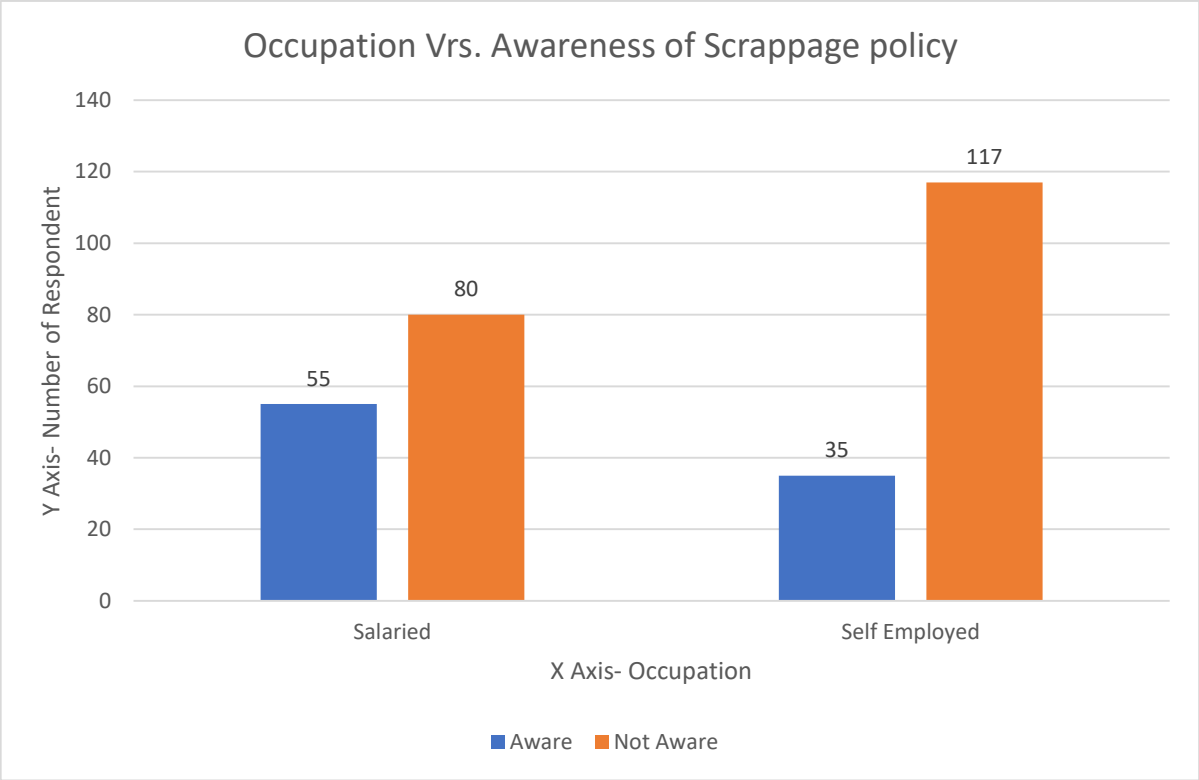
H1: There is a relationship between occupation and awareness of policy

Table 2 shows the Contingency distribution that gives the relation between two variables, occupation and awareness, one variable in the row and the other one in the column.

The degree of freedom (df) here =(rows−1)×(columns−1)= (2−1)(2−1)=1

Table 2 : Contingency distribution table

Occupational Categories	Aware	Not Aware	Total
Salaried	55	80	135
Self Employed	35	117	152
Total	90	197	287



Expected Frequencies = (Row total) x (Column Total) / Grand Total

Occupational Categories	Aware	Not Aware
Salaried	42.35	92.65
Self Employed	47.65	104.35

Chi-Square Statistics calculation

$\chi^2 = \sum (O - E)^2 / E$

where:

O = observed frequency

E = expected frequency

Using the formula for each cell:

- $(55 - 42.35)^2 / 42.35 = 3.80$
- $(80 - 92.65)^2 / 92.65 = 1.73$
- $(35 - 47.65)^2 / 47.65 = 3.36$
- $(117 - 104.35)^2 / 104.35 = 1.53$

Total Chi-Square (χ^2) = 3.80 + 1.73 + 3.36 + 1.53 = **10.42**

P-value : Using JMP or a Chi-Square distribution table:

- $\chi^2 = 10.42$
- df = 1
- **P-value ≈ 0.0012** (highly significant)

There is a statistically significant association between Occupation and Awareness of the Vehicle Scrappage Policy.

Here, the calculated Chi-Square value is 10.42, which is much higher than the standard critical Chi-Square value of 5.991. Thus, there is a significant association between occupation and awareness of policy. It concludes that awareness of the Vehicle Scrappage Policy depends on the occupation of the respondents.

9.2 Summary of Findings of emission reduction due to implementation of scrappage policy in Delhi NCR

The full-scale implementation of vehicle scrappage policies is expected to yield substantial improvements in air quality, particularly in urban hotspots where older, high-emission vehicles are heavily concentrated. The most significant benefits would be observed in the reduction of nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$), both of which are among the most harmful pollutants affecting human health. However, the extent of these improvements will ultimately depend on several real-world factors, including the effectiveness of policy enforcement, the level of public compliance, the availability of supporting infrastructure, and the emission standards of the vehicles replacing those scrapped.

10 CONCLUSION AND RECOMMENDATIONS

The survey results reveal that only 57.40% of the 500 respondents own a vehicle, and a significant majority (68.64%) lacked awareness about the Vehicle Scrappage Policy. However, the market survey helped raise awareness, leading 60.98% of respondents to agree that scrapping old vehicles can reduce environmental pollution. Still, only 54.35% viewed scrappage as an effective way to replace aging vehicles, while 45.64% preferred resale.

Although the policy is appreciated, respondents remain uncertain due to its novelty and the perceived lack of sufficient benefits. Many are waiting to see how well the policy is received before opting to scrap their vehicles, choosing instead to resell them for now. This highlights a need for the government to intensify public awareness campaigns, promote the scrappage program, and emphasize its environmental and road safety advantages.

A noteworthy insight from the study is that 78.39% of 287 respondents were unaware of any Registered Vehicle Scrappage Facilities (RVSFs) in Delhi, likely because only one RVSF i.e EZ Waste Recycling Pvt Ltd at Badarpur recently begun operations in Delhi in the month of May 2025.

As public awareness grows, expectations from the Delhi Government are increasing. Rather than limiting tax rebates to 20%, the government should consider higher incentives, as vehicle owners incur substantial tax burdens through GST, road tax, cess, and tolls. Enforcing stricter emission regulations may also encourage scrappage over resale.

If the Vehicle Scrappage Policy is implemented comprehensively across Delhi NCR, it could significantly reduce vehicular emissions, which are a major contributor to the region's severe air pollution levels. As per estimation provided in this research, with full scale scrappage, $PM_{2.5}$ emission reduction is expected by 12.3% and NO_x emissions reduction is expected by 23.2% of the total emission to Delhi NCR Air pollution.

The Vehicle Scrappage Policy in Delhi faces significant institutional challenges that hinder its effective implementation. These include a lack of proactive efforts to motivate de-registered vehicle owners, poor inter-agency coordination, slow development of scrapping infrastructure, unclear roles for OEMs under EPR, and low public awareness. The dominance of the informal sector and insufficient digital outreach further impede progress. To address these gaps, Delhi must expand Registered Vehicle Scrapping Facilities (RVSFs), promote advanced recycling technologies, and introduce stronger incentives, clear operational guidelines and launch stakeholders outreach program to drive adoption and improve air quality.

11 LIMITATIONS

Limitations are inherent in almost all studies and this study is no exception. Among others, some of the key limitations of the study , quite a few of which also extend a scope for future research, are outlined below.

1) The vehicle scrappage policy is a completely new concept in India, introduced in August 2021. No research work has been carried out on the subject as of this date. Hence, an adequate literature reviews are not available.
2) The vehicle scrappage policy is in a very nascent stage and not yet fully implemented on the ground. The success & failure of the policy can be judged only upon it is implemented all over the country.
3) The public is not fully aware of the scheme. Hence, the respondents hesitate to participate in the survey.
4) Different types of vehicles are driven on Indian roads, e.g, government vehicles, commercial vehicles, private vehicles, vintage vehicles, etc. Due to this diversification, the same rules cannot apply to all vehicles.
5) Road & transport is a subject of state matter. The success & failure of the policy depend upon the adoption of the policy by the respective state government.
6) The survey was conducted in the Delhi NCR area which has highest population of vehicles. The findings of the survey may not hold good for other parts of the country and cannot be generalized.
7) Time & money constraints that limited the outreach.
8) The sampling method is non-probabilistic, and the sampling size is comparatively small; the outcome cannot be generalized without sampling error
9) The sample size can be expanded, and the study can be expanded to other parts of the country.
10) The study can be carried out for rural & urban regions separately.
11) Extended Producer Responsibility (EPR) regulation for end of life vehicles has been implemented in 2025 only. Hence, its impact on vehicle scrappage rate yet to be quantified.

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