Mapping Electric Vehicle Research in Developing Economies: Insights into Sustainable Mobility and Green Transitions

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ABSTRACT
Electric vehicles (EVs) represent a pivotal innovation in reducing greenhouse gas emissions and advancing sustainable mobility, particularly in developing economies where infrastructure, policy, and market readiness remain uneven. This study conducts a comprehensive bibliometric analysis to map the intellectual and thematic evolution of EV research in these regions, identifying key trends, influential authors, countries, and emerging themes that define the field. A total of 501 articles retrieved from Scopus and Web of Science databases were analyzed using VOSviewer and Biblioshiny, employing keyword co-occurrence and performance mapping techniques. The results reveal a sharp rise in EV-related research after 2020, reflecting growing academic and policy attention toward sustainable transport transitions. The thematic structure of the field highlights the importance of policy and incentive frameworks in driving adoption, the environmental and economic implications across the EV life cycle, the integration of renewable energy sources with EV infrastructure in thermally dependent economies, and the behavioral and socioeconomic factors influencing consumer adoption. Collectively, these research directions indicate a gradual shift from technology-centric approaches toward multidimensional strategies that combine innovation, governance, and consumer engagement. The study offers actionable recommendations for enhancing EV adoption through local manufacturing, renewable-powered infrastructure, and coordinated policy mechanisms. The findings provide valuable insights for policymakers, researchers, and industry stakeholders seeking to accelerate sustainable mobility and inclusive green development in emerging economies.

Keywords: Electric Vehicles, Developing Economies, Bibliometric Analysis, Policy and Innovation, Vosviewer, Biblioshiny

1. INTRODUCTION

One of the ways towards a transition to sustainable transport systems is the innovation in mobility, in the form of electric vehicles (EVs). The second-biggest producer of carbon dioxide (CO2) is transportation, which consumes fossil fuels and accounts for 37 per cent of the emissions in the world. Moreover, it has also been revealed that by 2035, the oil consumption of the transport sector will increase to 54% (Ogunkunbi et al., 2021). The transport sector has played a key role in reducing greenhouse gas emissions (GHG), and in this regard, the 21st century has seen the introduction of EVs to replace traditional internal combustion engine vehicles (ICEVs) (Ullah et al., 2023).

EVs are considered to be one of the most appropriate solutions since they are less reliant on fossil fuels and positively affect the environment (Alanazi, 2023). Any car that consumes electrical energy through the electric grid and stores the energy in its on-board battery to propel the vehicle, either partially or entirely, is called an EV, sometimes known as an electric car. Hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and Battery Electric Vehicles (BEV) are the three main categories of EVs (Ansab and Kumar, 2022). BEVs run solely on electricity, utilizing a large battery that is charged by plugging into an electric source. HEVs incorporate both an electric motor and a traditional engine; however, they do not support external charging. On the other hand, PHEVs have an electric motor with a conventional engine and offer the choice of plugging in for short trips to use only electric power or fuel for longer trips. There are currently more than 10 million EVs registered in the world, and it is expected that by 2050, there will be approximately 300 million EVs in use, corresponding to 60% of new vehicle sales, indicating that electric mobility is gaining momentum (Barbosa et al., 2022). Despite the growing trajectory of EVs globally, these are more restricted in developed nations only. India is now the third-largest vehicle market in the world, behind only Germany and Japan, but the growth of the EV industry in India is led by electric two-wheelers (E2W), and the sales of electric four-wheelers (E4W) have been relatively stagnant (Ansab and Kumar, 2022). Moreover, as per Singh et al. (2020), major EV research is conducted in developed countries compared to developing countries (except China), and more studies are required in these countries. According to the IMF definition, there are 152 developing countries with a current population of around 6.82 billion. At 85.54 per cent, this represents a considerable proportion

of the world's population. It includes the whole of Central and South America, the whole of Africa, almost all Asian countries and numerous other island states.

In contrast, developing countries exhibit unique characteristics that necessitate distinct research attention. For instance, many developing nations, including Bangladesh, Nigeria, India, and Pakistan, face unstable electricity grids, insufficient public charging stations, and urban–rural disparities in accessibility (Shamsuddoha and Nasir, 2025). These infrastructural deficiencies reduce consumer confidence and hinder large-scale EV adoption. Unlike the structured incentives and mandates in developed countries, developing regions suffer from fragmented or underdeveloped policy frameworks. Countries such as India, Brazil, and South Africa demonstrate inconsistent subsidies, weak enforcement, and poor coordination between government agencies, which discourage both investment and consumer uptake (Carley et al., 2019; Gracia and Casals, 2024). Further, the affordability of EVs is a paramount problem among emerging economies. In countries like Bangladesh, Nigeria, and Vietnam, the market potential is limited by high importation tariffs, limited local manufacturing, and the price sensitivity of the middle and lower-income population. Furthermore, the use of imported technologies adds to the costs and constrains local innovation, which leads to the creation of a supply-side bottleneck (Khan et al., 2024). Consumer perception, trust and awareness are very important factors in EV adoption. Misconceptions about battery life, maintenance expenses, and reliability in operation, in combination with income disparity and urban-rural infrastructure disparities, turn out to be another factor that limits uptake in economic environments of developing countries (Chen et al., 2020).

In addition to the environmental and infrastructural issues, electric mobility is another sphere of sustainable entrepreneurship and innovation. In the developing world, especially in Asia, start-ups and small businesses are increasingly entering EV-related activities, which include assembly of local batteries, charging networks powered by renewable energy, and digital mobility (Prakhar et al., 2025). These entrepreneurial programs not only help in decarbonization but also contribute to the creation of employment opportunities, the development of skills and inclusion in economic activities. The strategic partnership between governments, private investors and innovation-driven SMEs is therefore very critical in creating resilient and scalable green mobility ecosystems. This nexus of technological change and viable entrepreneurship is a vital borderline for emerging nations seeking long-term growth aligned with the principles of environmental stewardship and economic equity (Prabhakar, 2025). Moreover, Fan et al. (2023) state that the environmental impact of EVs is determined by taking into account the geographic disparities in the production of power and energy supply systems. The levels of EV emissions are varied in developing countries, driven by thermal generation and different energy transmission and distribution systems. Shi et al. (2023) affirmed that clean vehicle policies would result in a peak CO2 emissions threshold that will increase until 2028, and then decrease. When compared to the CO2 emissions of the developing areas, developed areas will reach their peak before 2030. The study conducted by Wu and Zhang (2017) shows that many developed nations and developing economies, particularly Brazil, Russia, India, and China (BRIC countries), are embracing the active development of EVs. Nevertheless, the general adoption of EVs is still low because of the high purchase prices, battery life is uncertain and insufficient charging stations in the developing markets (Rajper and Albrecht 2020).

Considering such complicated issues, there is an urgent necessity for a systematic academic focus, which would chart the research territory on the state-of-the-art of EV adoption in developing nations. Although a lot of literature has been provided concerning the EV adoption and performance in developed economies, there is still a wide gap in knowledge regarding the EV research landscape in developing countries. Therefore, this study fills this gap by conducting an elaborate bibliometric analysis that assesses the sources, citations in publications, major research themes, and the growth trajectory of EV research in developing economies. This study aims to offer informed future research directions and policymaking interventions aimed at speeding up the transition toward electric vehicles in developing nations. To achieve this, the following research objectives have been formulated:

Research Objectives

1. To assess the trends in publications within the research terrain of EVs in developing economies.
2. To analyze the key contributors concerning authors, journals, papers, affiliations, and countries.
3. To point out the most used keywords and popular research topics.
4. To offer recommendations for enhancing EV adoption in developing economies

The remaining sections of the study are arranged as follows: Section 2 describes the methodology employed in the research. Section 3 presents the findings and analysis. Section 4 provides the conclusion of the research work. Section 5 contains limitations and a future research agenda.

2. MATERIAL AND METHODS

The application of bibliometrics in scholarly research has witnessed a remarkable surge in recent years, facilitating its ability to objectively and methodically identify different aspects of the literature. Given the burgeoning interest in EV

research with increasing awareness of environmental sustainability, it is crucial to successfully navigate the enormous body of literature and obtain insightful information, specifically in the context of developing countries, by scrutinizing publication productivity, delineating influential works, and unveiling emergent trends and themes in the stated domain. The study also provides a basis to trace how sustainable innovation and entrepreneurship intersect within the evolving EV ecosystem in developing economies. To achieve research objectives, the study employed a systematic approach based on the 3A Framework, ensuring rigorous analysis of scholarly literature (Paul et al., 2021) as depicted in Figure 1.

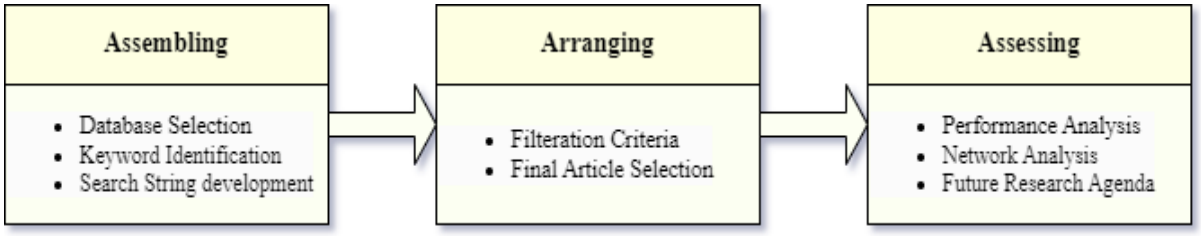

Figure 1: 3A Framework for Conducting Effective Bibliometric Analysis
Source: Paul et al. (2021)

Assembling

The first step was to find the appropriate literature to include in the research in Scopus and Web of Science (WoS), general databases that are highly popular among researchers working in various fields to conduct bibliometric reviews (Leong et al., 2022). The search was conducted on 1st January 2025 using the given search query to find documents related to the area of EVs and emerging economies.

To curate the documents for inclusion in this study, a search with the keywords "Electric Vehicle*", "EVs", "Hybrid Electric Vehicle*", "HEVs", "Plug-in Hybrid Electric Vehicle*", "PHEVs", "Plug-in Electric Vehicle*", "PEVs", "Battery Electric Vehicle*", "BEVs", "Battery Vehicle*", "Electric mobility", "Green Vehicle*", "Green mobility", "sustainable vehicle*", "sustainable transportation", "Green Transportation", "Sustainable mobility" AND "Developing economies", "Developing nations", "Developing Countries", "Developing world", "Emerging nations", "Emerging countries", "Emerging world", "Emerging economies" were conducted.

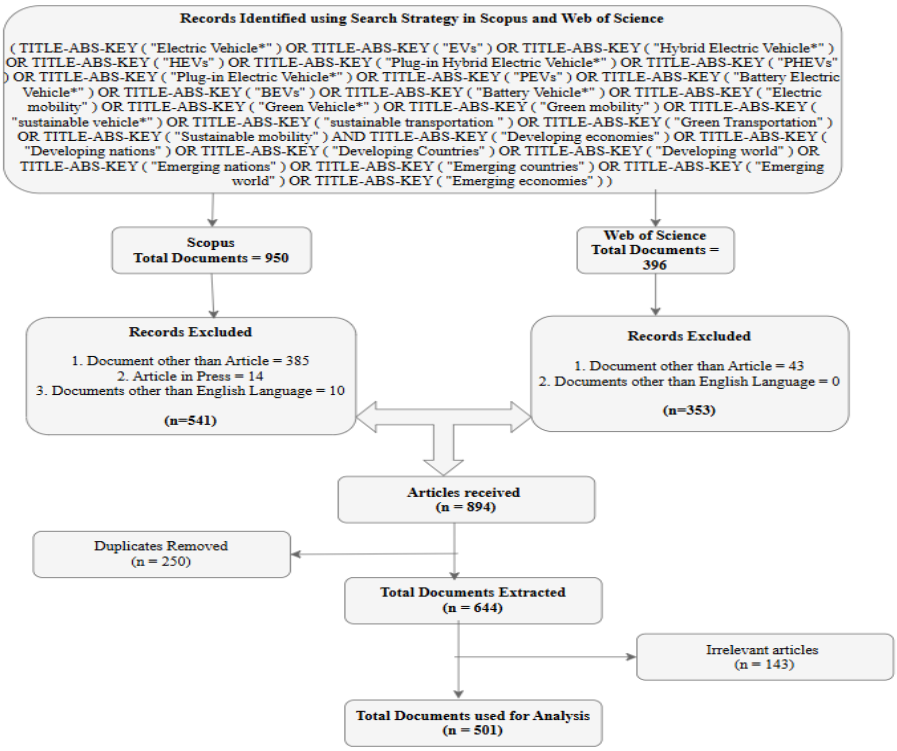

Figure 2. Data Extraction Procedure
Source: Authors' own

Arranging

To refine the corpus of literature, various inclusion and exclusion criteria were applied based on document type, publication stage and language. As presented in Figure 2, initially, 1346 articles (950 from Scopus and 396 from WoS) were retrieved in total from 1991 to 2024. These documents were further refined according to publication stage, document type, and language criteria in respective databases. Further, data from Scopus (in BibTeX) and WoS (in plain text) were converted into Excel using Biblioshiny. Carefully merged data using R-Studio. Removing duplicates (250) and irrelevant articles (143) after the screening of titles and abstracts, a final 501 articles were taken for further analysis.

Assessing

To carry out the specified bibliometric analyses, Vosviewer and the Biblioshiny package of R-studio software are the two analysis tools that have been utilized. This study employed two primary bibliometric analysis techniques, namely performance analysis and science mapping. Within the realm of performance analysis, this study provided insights into the impact, influence, and productivity by examining various facets, including publication and citation trends, top contributors in terms of authors, institutions, and countries, as well as top-cited journals and articles. In the realm of science mapping, utilizing the co-occurrence of keyword analysis, this study aims to unveil the emerging themes and topics in the domain.

3. RESULTS AND DISCUSSION

Descriptive Analysis

Figure 3 outlines the data set characteristics used for the bibliometric analysis. As is evident, the data set consists of 501 documents, published by 269 sources over the years. The average annual growth rate of the documents is 21.38%, indicating the increasing interest and research output_in the field of EVs pertaining to developing nations. A significant part of the publications was published on average just 4.06 years ago, underscoring the contemporary relevance of research. The steady growth of publications not only marks academic engagement but also signals how sustainability-driven technological innovation is gaining policy and industry relevance, especially in developing economies.

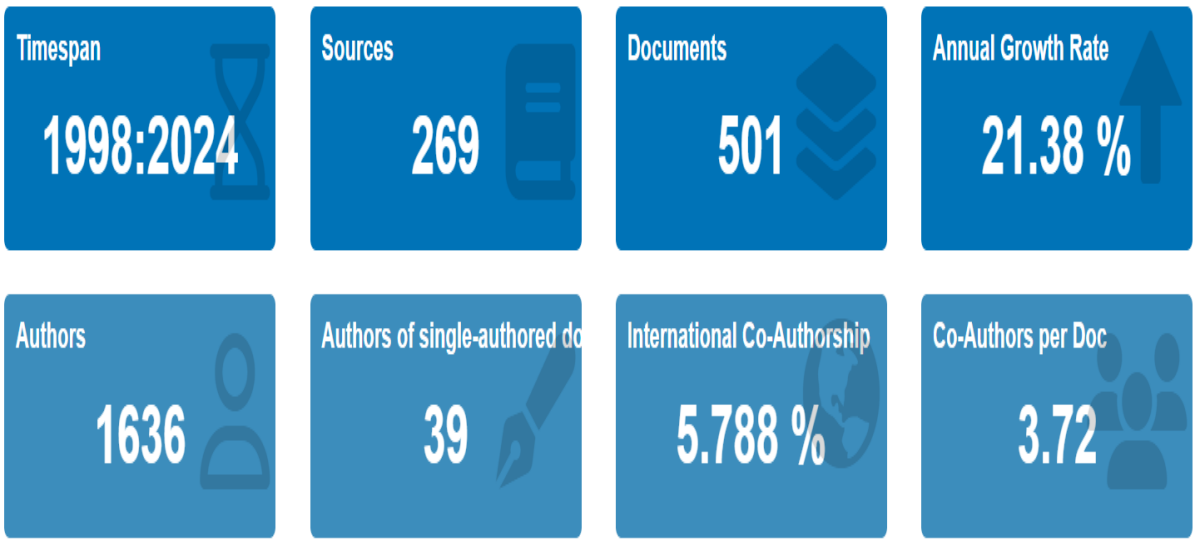

Figure 3. Data Descriptives
Source: Biblioshiny

Trend and Productivity

Figure 4 reveals that the research on EVs in developing nations underwent an extensive shift during the previous two decades. Research activities were minimal in this field from 1998 until 2010, with fewer than 20 publications. It can be attributed to inadequate government policies and costly vehicles, as well as the prevalent use of fossil-fuel-powered transportation. Developing countries prioritized economic progress first instead of sustainability, so they demonstrated little interest in EV technology development. Research and development in this sector remained restricted because of non-existent charging infrastructure and costly lithium-ion batteries (Rajper and Albrecht, 2020).

During the period from 2011 to 2019, the number of published articles grew substantially from 25 in 2011 to 104 in 2019. It has been driven by government policy changes, financial incentives and the adoption of Sustainable Development Goals (SDGs) in 2015, which heightened environmental sustainability concerns. For instance, the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme by India, with wide-ranging

subsidies, brought EV adoption and manufacturing to the fore. The advancement of battery systems has shaped ongoing studies with their practicality as well as adoption.

The number of research articles showed extraordinary growth beginning in 2020, up to 154 published articles in 2024. BMW, Volkswagen and other significant automotive manufacturers announced a transition toward EVs around 2020 (Zhu and Lamsali, 2024). EV research has displayed rapid growth in the context of developing nations since more than sixty per cent of studies emerged during the last four years. The field will continue to evolve, aligning the transition toward sustainable transportation. The post-2020 surge in publications also reflects a parallel momentum in innovation-led policymaking and private-sector engagement in EV transitions, as research attention begins to align with entrepreneurial activity in sustainable mobility.

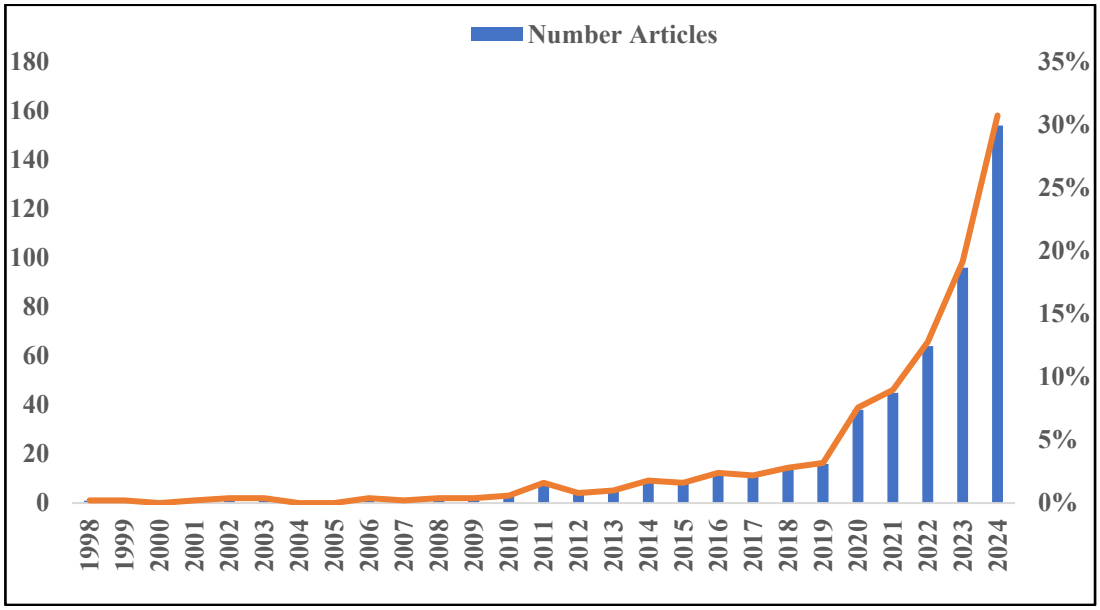

Figure 4. Publication Trend
Source: Authors' own

Author Analysis

Table 1 displays the list of ten authors who have led scholarly publications regarding EV research in developing countries. The authors Wang C and Yang J appear jointly at the top of the list through the publication of 5 documents each. Wang C stands as the leading author in terms of both citations at 187 and an h-index rank of 5. Followed by Ahmad S and Singh R as the second and third most cited, with 144 and 119 citations.

Wang C is working on sustainable transportation research, especially related to developing nations. Their work area includes multiple fields such as sustainable last-mile delivery systems in Vietnam, climate policy effects related to Chinese combustion engine bans on emissions and public health, life cycle emissions assessment methods and transportation emission decoupling from economic growth.

Table 1. Top 10 authors based on the number of citations and documents

Author	NP	TC	h_index	m_index	PY_start
WANG C	5	187	5	0.833	2020
YANG J	5	75	3	0.429	2019
LI S	4	75	3	0.3	2016
SINGH R	4	119	3	0.375	2018
KHAN M	4	13	2	0.5	2022
AHMAD S	3	144	3	0.3	2016
ALI Y	3	108	3	0.5	2020
ASIF M	3	36	3	0.6	2021
BHAT F	3	18	3	1	2023
HA T	3	23	3	0.429	2019
Number of Publications (NP) Total Citations (TC)					

Source: Biblioshiny

Lotka's Law displays an extremely lopsided distribution pattern of scholarly publications where a few authors make most of the contributions (Figure 5). Table 2 shows that authors who published one paper represent a significant majority (88.7%); in contrast, those who presented two papers represent only a small segment (9%). Few authors exceed two scholarly papers, with three and four-paper authors representing only 2% and less than 2% respectively. This represents sporadic involvement of infrequent authors instead of stable participation, which indicates a gap in maintaining long-term research endeavours.

Table 2. Authors' Contribution

N.Articles	N.Authors	Freq
1	1451	0.88691932
2	148	0.09046455
3	32	0.0195599
4	3	0.00183374
5	2	0.00122249

Source: Biblioshiny

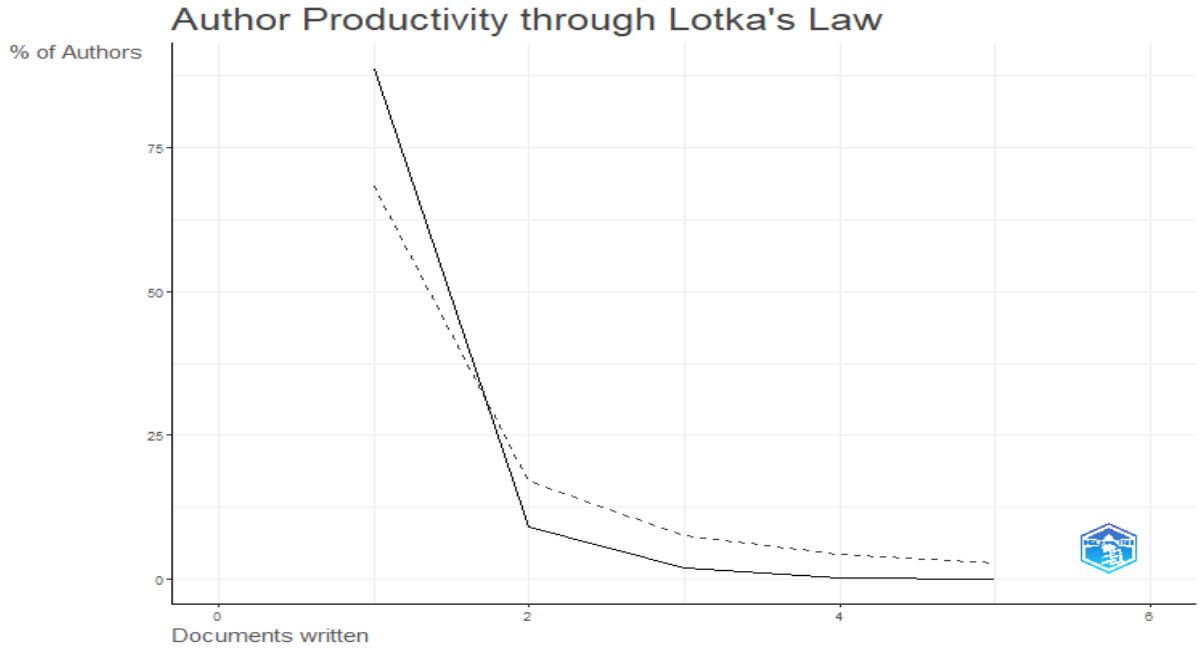

Figure 5. Authors' Productivity through Lotka's Law
Source: Biblioshiny

Figure 6 showcases the top author affiliations with a rise in publications post-2010 and significant growth after 2018. Eight articles from Tsinghua University, seven from the University of Johannesburg and six articles from the University of Oxford demonstrate institutional commitment from China, South Africa and the UK. The global distribution of research emerges through contributions from affiliations of Asia and the Middle East also.

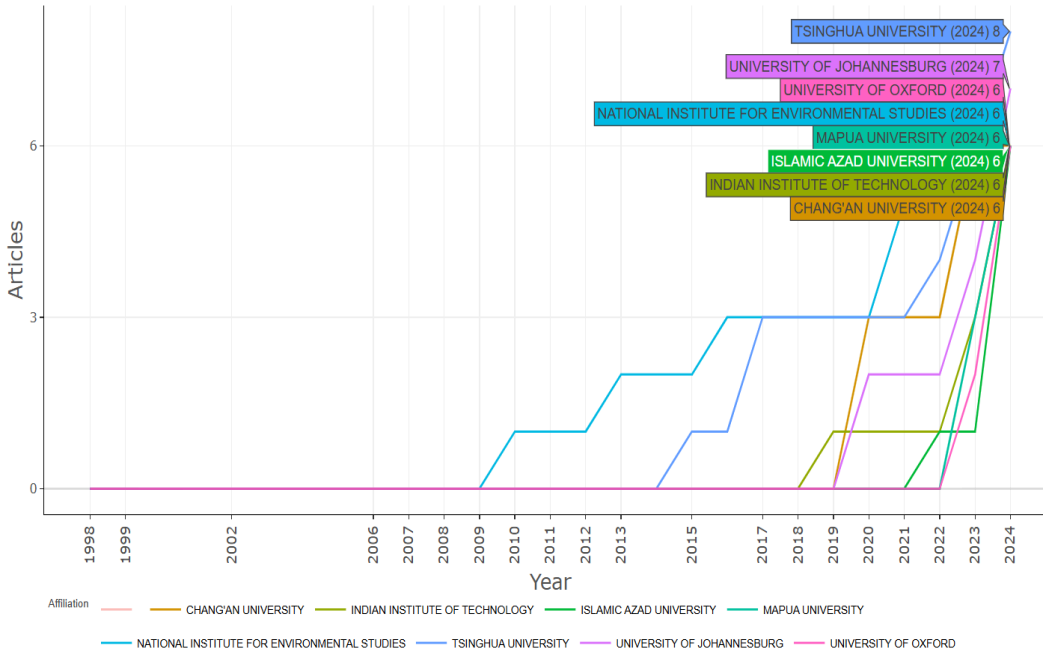

Figure 6. Authors' Affiliation over time
Source: Biblioshiny

Article Analysis

Table 3 presents the top articles with the number of citations, and notably, the study by Fishman and Cherry (2016) is the most influential one with 352 citations, followed by Banister (2011) with 341 citations. The document by Rajper and Albrecht (2020) is ranked 3rd, with 165 citations in total. The presence of over 110 citations for the top ten most relevant documents in the domain of EV research in the context of developing nations underscores the significant popularity and impact of this subject among researchers.

Fishman and Cherry (2016) summarised e-bike studies spanning ten years, highlighting their potential for carbon emission reduction. The study also reaffirmed China's leadership in e-bike sales and the necessity for more research to inform decision-making. According to Bannister (2011), technology innovation alone is insufficient to provide sustainable transportation; instead, an integrated economic, planning, and policy approach is needed. This is a demand reduction within the urban context rather than a shift to some form of greener transport. Rajper and Albrecht (2020) conducted a review of EVs in developing economies through critical challenges and opportunities. Such challenges include charging infrastructure, battery technology, affordability, range anxiety, consumer knowledge, and regulatory barriers. The study further elaborates on the contribution of EVs towards lower greenhouse gas emissions, energy security, and fiscal development. It concluded that electric four-wheelers are not economically viable in emerging economies; electric two-wheelers are much better. Brilliantova and Thurner (2019) described the development of blockchain technology in the energy sector and its potential impact on EVs' integration into peer-to-peer microgrids. However, supporting blockchain applications in energy needs adaptive regulatory structures, particularly in emerging economies.

Table 3. Most Cited Articles

Authors	Title	Year	TC	TC per Year	Source Title	DOI
FISHMAN E; CHERRY C	"Ebikes in the mainstream: reviewing a decade of research"	2016	352	35.2	Transport Reviews	10.1080/01441647.2015.1069907
BANISTER D	"Cities mobility and climate change"	2011	341	22.73	Journal of Transport Geography	10.1016/j.jtrangeo.2011.03.009
RAJPER S; ALBRECHT J	"Prospects of electric vehicles in the developing countries: a literature review"	2020	165	27.5	Sustainability (Switzerland)	10.3390/su12051906
BRILLANTOVA V; THURNER T	"Blockchain and the future of energy"	2019	163	23.29	Technology in Society	10.1016/j.techsoc.2018.11.001
MOHIUDDIN M; AL M; SYED F; MASUD M; SU Z	"Environmental knowledge, awareness and business school students' intentions to purchase	2018	150	18.75	Sustainability (Switzerland)	10.3390/su10051534

	green vehicles in emerging countries"					
WU Y; ZHANG L	"Can the development of electric vehicles reduce the emission of air pollutants and greenhouse gases in developing countries"	2017	148	16.44	Transportation Research Part D: Transport and Environment	10.1016/j.trd.2016.12.007
ACHEAMPONG R; SIIBA A; OKYERE D; TUFFOUR J	"Mobility-on-demand: an empirical study of internet-based ride-hailing adoption factors, travel characteristics and mode substitution effects"	2020	146	24.33	Transportation Research Part C: Emerging Technologies	10.1016/j.trc.2020.102638
RAUGEI M; WINFIELD P	"Prospective LCA of the production and EOL recycling of a novel type of Li-ion battery for electric vehicles"	2019	145	20.71	Journal of Cleaner Production	10.1016/j.jclepro.2018.12.237
GUERRA O; TEJADA D; REKLATIS G	"An optimization framework for the integrated planning of generation and transmission expansion in interconnected power systems"	2016	112	11.2	Applied Energy	10.1016/j.apenergy.2016.02.014
SINGH S; CHAUHAN P; SINGH N	"Feasibility of grid-connected solar–wind hybrid system with electric vehicle charging station"	2021	110	22	Journal of Modern Power Systems and Clean Energy	10.35833/MPCE.2019.000081

TC = Total Citations
Source: Authors' own

Table 4 captures the salient journals in EV research within developing countries based on Total Citations (TC) and Number of Publications (NP). Sustainability (Switzerland) comes first with 759 TC and 34 NP, followed by Transportation Research Part D with 734 TC and 21 NP. It should be noted that these journals are well-indexed, which is an indication of good research output dissemination. The findings demonstrate the increased scholarly interest in sustainable mobility, energy policy, and transportation innovation in developing regions.

Table 4. Most relevant Sources

Sources	H index	TC	NP	PY start	Publisher	Indexing
Sustainability (Switzerland)	12	759	34	2016	MDPI	Scopus
Transportation Research Part D: Transport and Environment	13	734	21	2017	Elsevier	Scopus, ABDC (A)
Journal of Cleaner Production	12	559	16	2013	Elsevier	Scopus, ABDC (A*)
Journal of Transport Geography	4	404	5	2011	MDPI	Scopus
Transport Reviews	1	352	1	2016	Taylor and Francis	Scopus, ABDC (A)
Applied Energy	5	291	6	2014	SAGE	Scopus, ESCI
Energy Policy	8	216	9	2003	MDPI	Scopus
International Journal of Sustainable Transportation	7	207	11	2009	Elsevier	Scopus, ABDC (A*)
Transport Policy	7	202	8	2013	Elsevier	Scopus, ABDC (A)
Technological Forecasting and Social Change	5	180	6	2018	Elsevier	Scopus

Source: Authors' own

Country Analysis

Table 5 presents an analysis of state-of-the-art publications on EVs by country, along with citation counts. From the table, it is evident that Asia dominates EV research in developing countries. Out of the top ten contributors, seven countries, India, China, Japan, Malaysia, Iran, Pakistan, and Indonesia are from Asia, highlighting the continent's strong focus on EV-related studies.

It is worth noting that India was the most active in the discipline, with 87 publications, 1,107 TC, and 12.7 citations per article. This is in line with the national objective of reducing its carbon-intensive GDP by 33-35% by 2030. China is also noteworthy for its 55 publications and 1,315 TC, yielding an average of 23.9 citations per article, indicating a higher impact. The UK has a credibility of research in the field with 21 articles, 870 TC and the highest (41.4) citations/article score. Some Asian countries, namely Iran, Pakistan and Indonesia, have minimal research impact that may reflect chances of improved research in this territorial region. This pattern corresponds to how nations such as India and China are developing local innovation ecosystems from manufacturing to infrastructure that enable entrepreneurship and SME participation

within the green mobility value chain. Overall, Asia emerges as the epicentre of EV research among developing nations, driven by policy focus, market potential, and rapid industrial growth.

Table 5. Top Countries

Country	Continent	Articles	SCP	MCP	Freq	MCP_Ratio	TC	Average Citations
India	Asia	87	86	1	0.174	0.011	1107	12.7
China	Asia	55	47	8	0.11	0.145	1315	23.9
USA	North America	26	23	3	0.052	0.115	378	14.5
United Kingdom	Europe	21	20	1	0.042	0.048	870	41.4
Japan	Asia	18	17	1	0.036	0.056	305	16.9
Brazil	South America	16	16	0	0.032	0	392	24.5
Malaysia	Asia	15	14	1	0.03	0.067	313	20.9
Iran	Asia	14	12	2	0.028	0.143	113	8.1
Pakistan	Asia	13	13	0	0.026	0	188	14.5
Indonesia	Asia	11	11	0	0.022	0	60	5.5

Source: Authors' own

Figure 7 shows the contributions of countries to the research field in terms of Single-Country Publications (SCP) and Multiple-Country Publications (MCP). The research in India shows 87 published articles that consist mostly of SCP (86), which reflects domestic research predominance. These publications were then followed by China, with an MCP ratio of 0.145, indicating international research collaboration. The data exhibits global research cooperation through modest MCP ratios between the USA, UK and Japan, along with their substantial publication counts. Exclusive Single-Country Publications (SCP) represent the publications from Brazil, Pakistan and Indonesia, which indicates minimal international research partnerships. The research demonstrates India's and China's substantial role in EV development but highlights an existing deficit in international cooperation for research in developing countries.

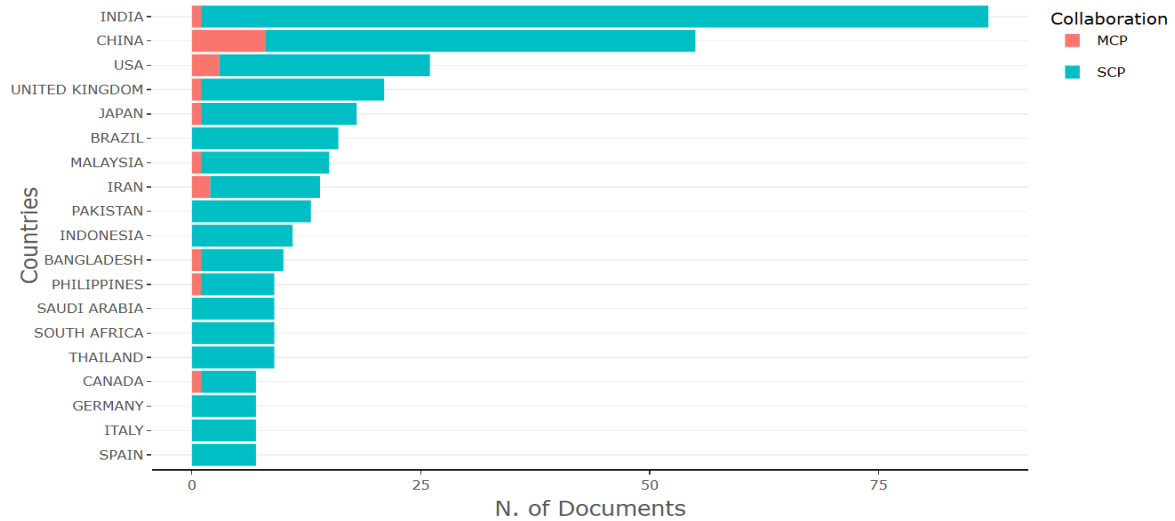

Figure 7. Collaboration among Countries
Source: Biblioshiny

Word Cloud

Figures 8 and 9 illustrate the word cloud of the keywords most frequently used based on author keywords (AK) and keyword plus (KP) analysis. Font sizes represent the most frequent terms. The term "electric vehicles" appears most frequently, thus underlining precisely the main focus of this study. The terms "developing countries" (AK-33, KP-144) and "developing world" (KP-75) suggest a strong regional emphasis in EV studies. Other terms that follow are those connected to sustainability, such as "sustainable transportation" (AK-28, KP-27), "sustainability" (AK-22, KP-39), and "sustainable development" (AK-14, KP-62). The environmental advantages of EVs when they merge with clean energy sources are highlighted by "renewable energy," which occurs 16 times in AK. EVs' role in reducing pollution and carbon footprint is evident

from words such as "carbon dioxide emissions"(KP34), "carbon emission"(KP26), "climate change"(AK-9, KP-26) and "air quality" (KP-26). Transport system (30 in KP) and urban transport (23 in PK) denote the application of EVs in the broader context of public transit. The terms charging batteries (KP-34) and charging station denote that infrastructure research has identified as the key barrier to adoption within emerging economies.

Beyond frequency, the clustering of keywords related to sustainability, renewable energy, and infrastructure suggests a shift in research emphasis, from purely technical evaluations toward system-level transformation and innovation. This convergence implies growing academic attention to how technological progress in electric mobility interacts with institutional frameworks, clean energy transitions, and collaborative models for sustainable growth.

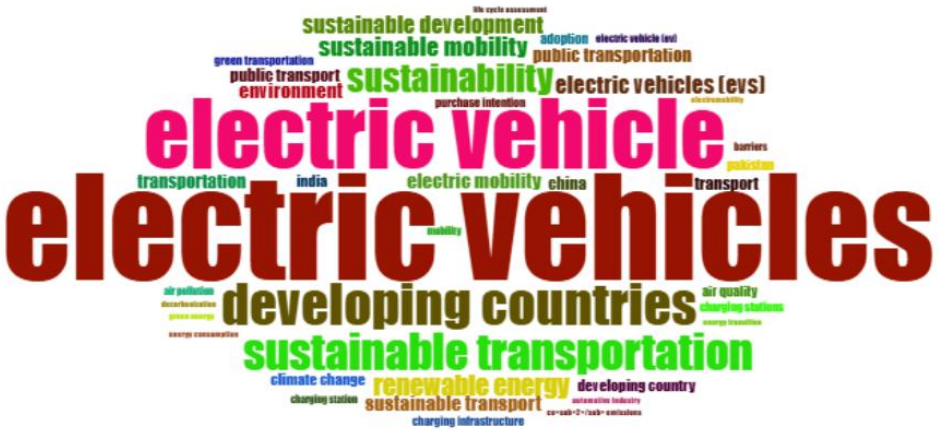

Figure 8. Word cloud- based on AK
Source: Biblioshiny

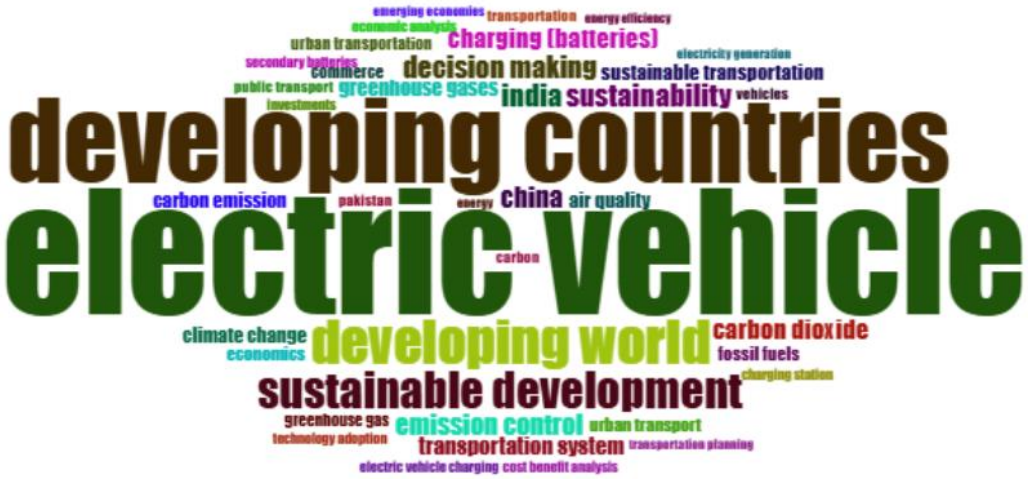

Figure 9. Word cloud- based on KP
Source: Biblioshiny

Trending Topics

Figure 10 depicts that EV research displays a progression from foundational energy analysis to advanced socio-economic and sustainability studies. At inception, it dealt with energy planning and fuel economy in order to establish alternative transportation options. With time, EV deployment triggered a shift toward research about specific vehicle categories encompassing BEVs and hybrid vehicles, as well as the study of infrastructure needs like charging station development. During this time period, health concerns related to environmental issues emerged, probably because of the increased pollution from traditional vehicles. The research landscape currently spans sustainable development to sustainability in developing countries, suggesting significant interest in EV adoption worldwide. Terms like decision-making and economics reflect a

growing awareness of the financial and policy implications of EV deployment.

The current direction of research (2022-2024) is centered on electric vehicle charging, charging stations and technology adoption. The term "India" in recent years stands as an indication of growing EV adoption focus in the country.

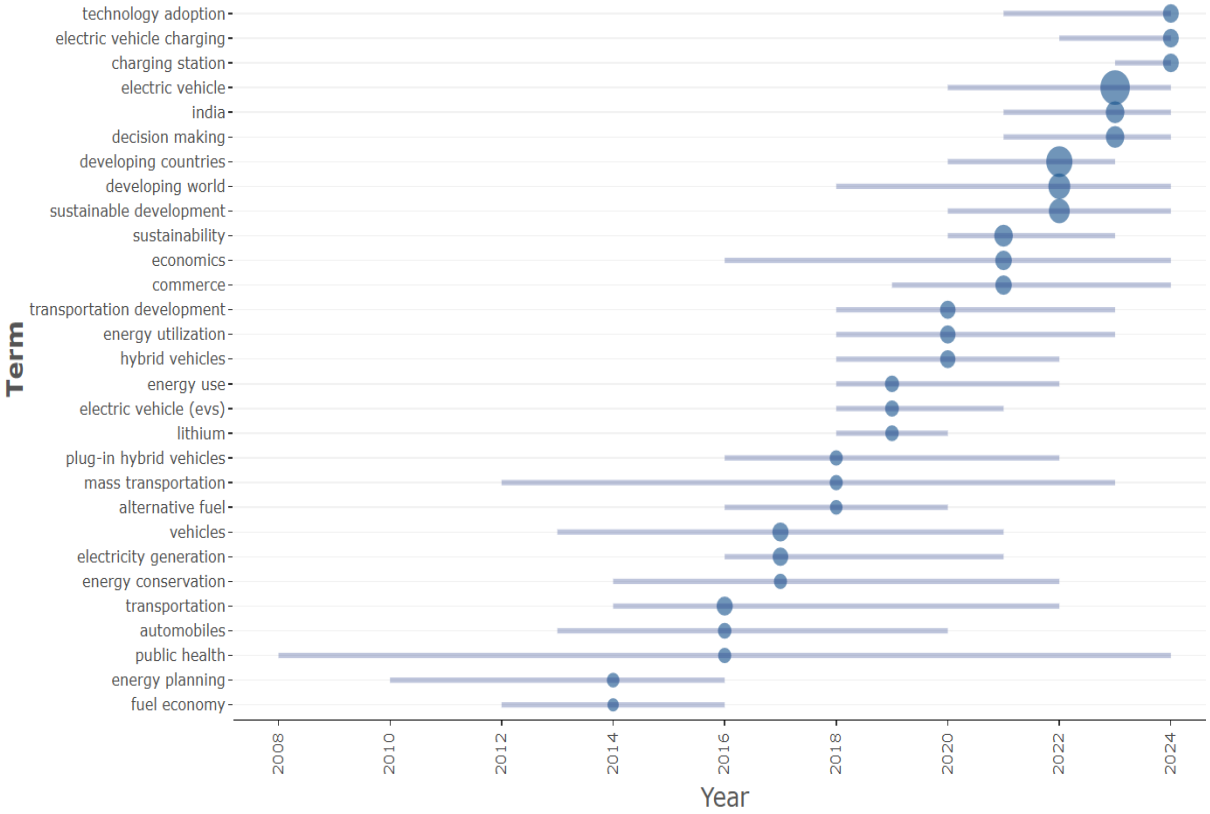

Figure 10. Emerging Topics
Source: Biblioshiny

Co-word Analysis

The co-word network map seeks to examine semantic relationships between keywords used in academic literature to discern the major research themes (Muritala et al., 2020). Out of the total number of keywords, which was 1687, when a threshold of two occurrences was set, 293 keywords met. After removing the irrelevant keywords, the final 287 keywords were used for analysis. The green cluster centers on *electric vehicles*, *developing countries*, and *climate change*, emphasizing environmental impacts and emission reduction. The red cluster, with terms such as *hybrid electric vehicles*, *adoption intentions* and *automotive industry*, highlights behavioral and emerging market dynamics. The blue cluster, containing *solar energy*, *microgrid*, and *charging station*, connects technological progress, renewable energy integration with EV infrastructure and grid development. The yellow cluster, defined by *public transportation*, *policy*, and *decision-making*, represents urban planning, government policies, optimization models, and evaluation frameworks for sustainable mobility.

Together, these clusters illustrate a shift from isolated technological and environmental analyses toward system-level perspectives that integrate innovation, energy transition, and planning strategies. The interlinkages among terms such as “innovation,” “energy transition,” and “sustainable transport” indicate growing scholarly interest in coordinated frameworks and adaptive strategies supporting sustainable mobility in developing economies. Figure 11 represents the visual network of analysis of the co-occurrence of keywords in the domain of EV research in developing countries. Table 6 and Figure 11 delineate four thematic clusters that are being formulated to serve the study objective.

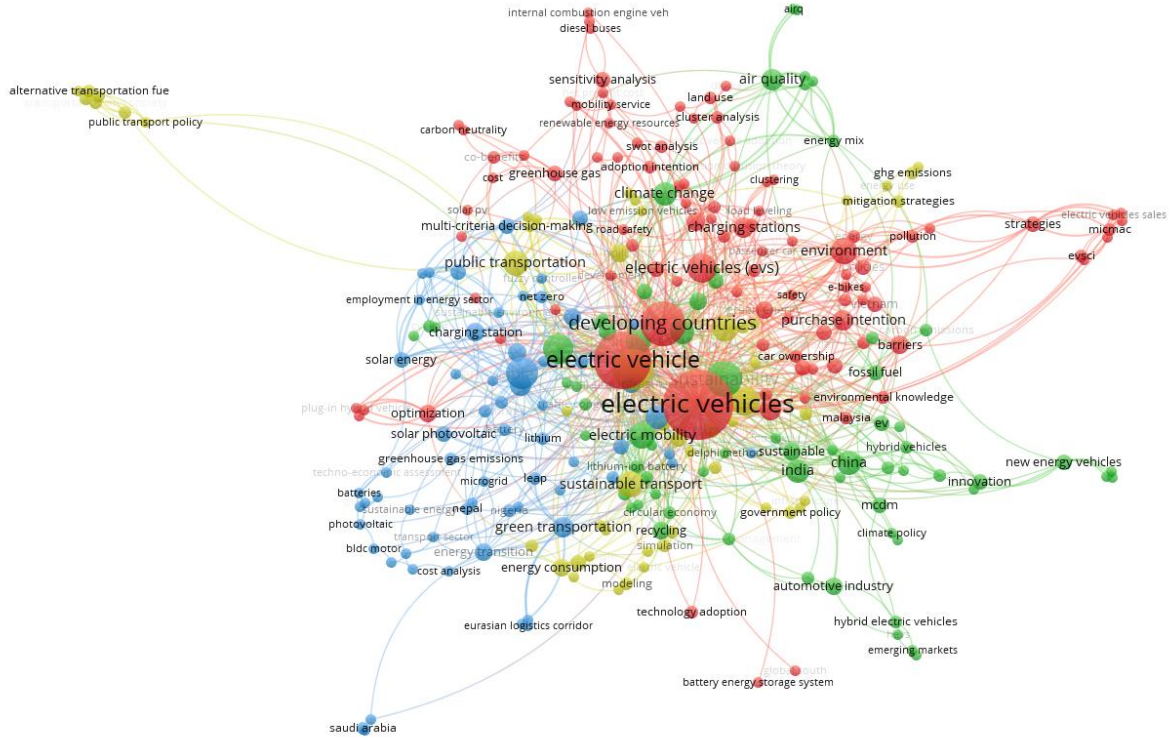

Figure 11: Co-Occurrence of Keywords
Source: Vosviewer

Consumer Adoption and Behavioral Aspects

This cluster stresses the psychological, social, and economic factors influencing customer interest in embracing EVs in emerging nations. Boubker et al. (2024) applied TAM and TPB in the Moroccan context and accentuated perceived ease of use, perceived usefulness, environmental concern, and social influence as key determinants. According to Tripopsakul (2024), environmental awareness and product knowledge have a moderating effect on the impact of marketing mix elements on EV buying intention in Thailand. The problem of high purchase price, and the absence of the charging infrastructure are only a few factors that converge to hinder EV adoption in developing economies (Virmani et al., 2023). Similarly, Preedakorn et al. (2023) also found that limited technological preparedness, absence of charging stations, dependence on fossil fuel and economic impacts of automobile industry transformation were key EV challenges in Thailand. Overall, this cluster reflects a growing behavioral transition in developing regions, where environmental consciousness and perceived economic value are shaping early consumer engagement. The findings imply that consumer perception and affordability remain critical levers for accelerating EV adoption and fostering demand-driven sustainability.

Technological Innovations and Sustainability

This cluster comprises articles that specifically dwell on integrating renewable energy sources, particularly solar and wind, into EV charging infrastructures. This aims to provide a reliable, sustainable power supply, especially in developing countries with unreliable grids and high emissions. Alanazi et al. (2024) determined the feasibility of solar and wind energy over grid-connected systems to supply EV charging stations in Riyadh. A new metaheuristic optimization algorithm, Giza Pyramids Construction Algorithm (GPCA), was applied, the results of which reduced CO2 emissions considerably and enhanced the uptake of renewable energy. The article by Sommro et al. (2024) provided a roadmap to make Pakistan lean towards clean transport by creating EV charging stations that can be fueled by renewable sources, solar and wind, with V2G (vehicle-to-grid) options. The study suggests that the effectiveness of the use of renewable sources must be combined with a boost converter and PI controller for a stable power output. Brilliantova and Thurner (2019) described the development of blockchain technology in the energy sector and its potential impact on the integration of EVs into peer-to-peer microgrids. Nonetheless, to facilitate the use of blockchain applications in the energy sector, it requires flexible regulatory frameworks, especially in developing economies. Taken together, these works underscore the technological foundation for sustainable mobility and demonstrate the role of innovation, the incorporation of clean energy, and digitalization in creating resilient EV ecosystems in developing countries.

Table 6. Thematic Clusters

Themes	Clusters	Keywords with their occurrences
Consumer Adoption and Behavioral Aspects	Cluster 1- Red Cluster (100 items)	Adoption behaviour (2), behavioral intention (2), consumer behaviour (4), theory of planned behaviour (3), purchase intention (7), barriers (6), efa (2), confirmatory factor analysis (2), cluster analysis (3), environmental knowledge (3), electric vehicles (81), technology acceptance model (3), technology adoption (3), willingness to pay (2), vietnam (4), indonesia (2)
Technological Innovations and Sustainability	Cluster 2- Blue Cluster (53 items)	Artificial intelligence (4), blockchain (2), alternative fuels (2), batteries (2), decarbonization (5), machine learning (3), microgrid (2), lithium-ion-battery (3), recycling (5), solar photovoltic (4), tapio decoupling (2), wind turbine (3), solar energy (4), biomass (2), bldc motor (2), circular economy (3), pakistan (8), saudi arabia (3), nigeria (3), jordan (2), nepal (3)
Policy and Urban Planning	Cluster 3- Yellow Cluster (64 items)	Government policy (3), mitigation strategies (3), public transportation (11), public transport policy (2), policy instruments (2), infrastructure (2), urban transportation planning (3), spatial planning (2), public perceptions (2), sub-saharn africa (2), korea (2), iran (2)
Environmental and Economic Implications	Cluster 4- Green Cluster (70 items)	Energy mix (3), business model (2), climate policy (2), climate change (9), health effect (2), sustainability (22), well-to-wheels (2), supply chain management (3), life cycle emissions (2), global value chain (3), air quality (8), india (9), china (10)

Source: Authors' own

Policy and Urban Planning

This cluster focuses on the role of government policies in facilitating the adoption of EVs in developing countries by eliminating regulatory hurdles, providing financial aid, and developing strategic plans. Fartash et al. (2023) noted that sound policies can accelerate the transition between fossil-dependent and sustainable mobility in emerging economies. Such policy measures include regulatory frameworks, subsidies, charging infrastructure investment, and local EV production support. On the same note, Moeletsi (2021) investigated the entry barrier to EVs in South Africa and found that the absence of a favourable policy environment and cost are the main obstacles to EV adoption, and thus, interventions, such as subsidies and tax rebates, are needed. Developing countries, which are rich in oil, like Iran, need to go beyond the political rhetoric and concentrate on reducing fossil fuel subsidies as well as enhancing the incorporation of renewable energy. To achieve economic and environmental benefits, an integrated approach across smart systems and EV point-charging, along with sustainable public transportation policies, must be prioritized. Costa et al. (2018) applied the multi-criteria decision-making model to a GIS model to determine the best locations to deploy the electric vehicle supply equipment (EVSE) across Brazil. The authors have highlighted the importance of accessibility, demand and the infrastructural viability in successful EVSE adoption. Collectively, these studies prove that policy coherence, infrastructure planning, and incentive alignment play a significant role in spurring EV transitions in developing economies. The results also indicate that policy-based strategic frameworks linking policy, innovation, and local enterprise participation can strengthen implementation capacity and accelerate sustainable mobility outcomes.

Environmental and Economic Implications

This cluster examines the environmental impact of EVs throughout their entire product life cycle, including the extraction of raw materials and end-of-life, particularly in developing economies with diverse electricity generation make-ups. Tang et al. (2022) compared the life cycle emissions of BEVs and ICEVs, taking into account regional differences in energy mixes. The findings revealed that BEVs can release greater pollutants in areas that rely largely on thermal power. Likewise, Onn et al. (2017) provided a well-to-wheel evaluation of ICEVs, HEVs and EVs for developing economies. The research revealed that if electricity generation isn't made cleaner, EVs could be more environmentally destructive than HEVs and even overcome ICEVs. Mansour and Haddad (2017) stated that fully EVs are more useful in the long run with proper infrastructure and a clean energy mix; however, HEVs are appropriate in the short and medium-term, particularly in emerging economies such as Lebanon. The economic effects related to EV technology for developing nations reflect infrastructure issues, manufacturing barriers, and short-term supply chain disruptions, with key hotspots being Asian and African developing nations. This cluster, therefore, highlights the dual environmental-economic dimension of EV adoption, illustrating that sustainable transition depends not only on clean energy generation but also on the development of resilient supply chains and cost-efficient local production. Strengthening these systems can enhance green innovation, employment, and regional economic stability, which are central goals of sustainable development in emerging economies.

Recommendations to enhance EV adoption in developing countries

This study synthesises the literature on the implementation of electric mobility in developing nations and presents multi-dimensional implications, especially with regard to consumer education and adoption. The absence of technological readiness and the lack of education in these countries contribute to customer distrust, leading to a need for effective awareness of the promising opportunities of EVs. In order to create mass acceptance, special campaigns are needed to overcome the existing anxieties, like range anxiety, battery uncertainty and recharging misconceptions. The focus should be on emphasizing long-term cost-saving and direct health benefits, particularly in major urban regions with high levels of pollution. Table 7 gives an insight into the major findings and potential recommendations to improve the EV uptake in the developing economies. These initiatives can facilitate a smoother transition to electric mobility by addressing specific regional challenges. According to Serohi (2022), the adoption of EVs faces challenges like a lack of charging stations, range anxiety, and a lack of research and development capability in developing nations like India.

The adoption of electric vehicles in developing countries presents a complex interplay of opposing and supporting forces. Although EVs have undeniable advantages, including decreased emissions, decreased costs of operations, and energy efficiency, especially when it comes to affordable two-wheelers. However, there are still issues of high costs of infrastructure, insufficient awareness, and often the use of imported models. As shown in the table below, these barriers can be overcome with specific policies, such as marketing of low-cost EVs, a scalable and renewable energy-charging network, customized incentives in policy, and a gradual stepwise adoption. Urban-oriented projects, government contracts and localized production can further increase potential adoption. In general, sustainable EV development in developing nations requires a step-by-step and context-specific strategy that considers all the environmental, economic, and technological factors. A key recommendation to speed up EV adoption in developing countries is to integrate entrepreneurship, innovation-driven financing, and coordinated policies. This approach promotes local manufacturing, battery recycling, and charging startups, creating jobs and reducing imports. Coordinated policies with clear targets and incentives can align efforts across government, industry, and research, ensuring EVs contribute to decarbonization and economic growth.

Table 7. Key Findings and Recommendations

Focus Area	Implications	Resisting Forces	Recommendations
Reduction in GHG Emissions	Lower CO2 emissions improve environmental sustainability; cleaner grids amplify benefits	Grid overload, inconsistent and non-renewable energy supply	Promote renewable energy integration for charging; focus on urban areas with high pollution
Energy Efficiency & Operational Savings	EVs consume less energy; lower operating cost improves affordability and adoption	Limited awareness of cost-benefit; high electricity demand	Incentivize E2Ws and HEVs; educate consumers on long-term cost savings
Affordable Vehicle Options (E2Ws)	Greater accessibility to low- and middle-income groups	High purchase price of E4Ws and HEVs	Promote low-cost EV models like scooters and three-wheelers
Infrastructure Requirements	Availability of charging stations is critical for adoption	High cost of E4W charging stations; blackouts	Develop scalable and solar-powered charging networks, leverage existing infrastructure (poles, parking lots); public–private partnerships, apps for station locations, and bidirectional charging
Market Awareness & Consumer Behavior	Knowledge gaps slow adoption; perception of resale value affects purchase	Lack of awareness; range anxiety; road safety concerns	Invest in campaigns showing cost savings, reduced pollution, and real-world EV performance, highlighting total cost of ownership
Policy and Incentives	Tailored policies accelerate adoption	Fragmented or absent government policies limit EV adoption among low- and middle-income consumers.	Subsidies, tax reductions, concessional or micro financing; support rural EV access; incentives for shared EV fleets; Standardize charging protocols, simplify permits, offer carbon credits
Partial vs. Full Adoption Strategy	Gradual adoption minimizes risk; monitors infrastructure readiness	Overloading grids; limited local production capacity	Begin with small EVs and HEVs, and gradually scale to full adoption
Technological Considerations	Battery limitations affect range, charging time, speed, and carrying capacity	Lead-acid battery pollution, limited payload; Battery disposal and sourcing can harm the environment	Encourage R&D for efficient batteries; smart charging; integrate hybrid solutions; Enforce recycling programs, encourage responsible sourcing

Source: Authors' own

4. CONCLUSION

The present study highlighted the significant contributors in the context of EV research within developing nations using VOSviewer and bibliophily software, including publication trends, prominent authorship, country of origin, most relevant affiliations, publishing source, and such. The findings reveal a positive and growing trend in publications, especially after 2020. Wang C has emerged as the leading author in this field in terms of publications, citations and overall productivity. India, China, and the United States are the most influential nations in terms of the number of publications. Tsinghua University from China stands out as the most fruitful affiliation that has made a sizable contribution to the growth of research in this field. Sustainability (Switzerland), published by MDPI, has diffused the most documents in the research landscape. The co-occurrence analysis of keywords revealed four themes revolving around EV research and developing nations. The results indicated that EVs are emerging rapidly in the developing economies, but they have immense barriers such as infrastructural gaps, policy uncertainties, cost limitations, and a lack of awareness. The research supports the need to have a combined effort that includes monetary and non-monetary incentives, integration of renewable energy, local production and citizen awareness, to guarantee reasonable EV adoption. This research has great implications for vehicle manufacturers, policymakers, and technology innovators. EV sector companies can use the insights to identify emerging market opportunities and devise strategies that cater to the unique requirements of developing countries, considering regional differences. Policymakers can adopt data-driven incentives and regulations that will incentivise the adoption of EVs, the establishment of infrastructure and promote sustainable transport solutions. By aligning industrial capability with sustainability objectives, developing nations can not only reduce carbon dependency but also stimulate green entrepreneurship and inclusive economic growth.

5. LIMITATIONS AND FUTURE RESEARCH AGENDA

The results emphasize the crucial role of coordinated government incentives, institutional frameworks, and policy coherence in driving EV adoption, infrastructure development, and environmentally sustainable mobility in developing countries. Emerging concerns like adoption intention and battery degradation point to potential avenues for future study and innovation. There is an evident requirement for sustained partnership among academia, industry, and policymakers to address fundamental challenges, expedite technological innovation, and promote the universal uptake of EVs in developing countries. Further research should investigate the socioeconomic elements that influence EV adoption, assess the efficacy of government regulations, and propose smart ways to overcome hurdles to EV deployment.

The study acknowledges certain limitations, such as the potential exclusion of book chapters, editorials, book notes, conference papers and such, and analysed only published articles in this domain. The study's reliance on the Scopus and Web of Science databases might have led to the oversight of important papers present in other databases. Moreover, it is worth noting that the study focused exclusively on English-language academic articles. To address these limitations, future investigations should incorporate a broader range of databases, multilingual analyses, and mixed-method approaches to capture a more holistic understanding of electric mobility research across developing nations.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

Author Contributions

Kanika Gupta: Conceptualised the study, extracted data, conducted data analysis, interpreted results, and wrote the manuscript. Prof. Sanjeev Kumar Sharma: Provided critical feedback on the methodology and thematic interpretation, contributed to manuscript revision and proofreading. Prof. Upasna Joshi Sethi: Provided critical feedback on the article and reviewed the final draft.

Ethics Approval

Not applicable, as this study is based on secondary data from bibliometric sources and does not involve human or animal participants.

Data Availability

The data used in this study were retrieved from indexed scientific databases (e.g., Scopus and Web of Science). The data used for the study can be provided upon reasonable request.

Abbreviations

BEV - Battery Electric Vehicle
HEVs - Hybrid Electric Vehicles
EVs- Electric Vehicles
ICEVs - Internal Combustion Engine Vehicles
PHEVs - Plug-in Hybrid Electric Vehicles
V2G - Vehicle to Grid
CO_2 - Carbon Dioxide
E2W- Electric two-wheelers
E4W – Electric four-wheelers
AK – Author Keywords
KP – Keyword Plus
GPCA - Giza Pyramids Construction Algorithm
WoS - Web of Science

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