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What Place for Electric Vehicles as a Research Object and a Practical Alternative to Internal Combustion Engine Vehicles in Africa?

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1 **What Place for Electric Vehicles as a Research Object and a Practical Alternative to Internal**
2 **Combustion Engine Vehicles in Africa? Toward a Research Agenda Based on a Systematic**
3 **Literature Review and a Census of Electromobility Projects**

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1 **ABSTRACT**

2 The environmental crisis due to global warming and rising oil prices has contributed to the spread of
3 electric vehicles (EVs) since the 2010s. As the global EV fleet grows, a broad scientific literature on EVs
4 is emerging. This literature, while abundant, is still concentrated on very limited geographical regions,
5 mainly Europe, North America and China, offering little analysis of, or comparison with, markets outside
6 these areas, especially Africa. In both EV deployment and scientific production, Africa could seem to be
7 lagging behind, yet there is some growing momentum for EVs in Africa. This paper examines the place of
8 EVs as a research object and practical alternative to conventional vehicles in Africa. It is based on a
9 twofold methodological approach combining a systematic review of scientific literature, and an overview
10 of electric mobility projects on the continent. The results reveal a growing interest in EVs in Africa over
11 the past decade, in both publications and projects. Nevertheless, this growth masks strong disparities in
12 the distribution of projects and papers. In addition, academic research is only weakly related to ongoing
13 electric mobility projects in Africa, with few field experiments in the methodological approaches used by
14 the authors, and, above all, several thematic aspects absent from EV research.

15

16 **Keywords:** Electric vehicle, electric mobility projects, systematic literature review, Africa

1 **INTRODUCTION**

2 Growing environmental awareness in political and collective decision-making processes has led many
3 countries to put clean mobility at the center of their priorities in recent years. This conjuncture has been
4 very fruitful for electric propulsion modes, which have become a leading object of study in research on
5 alternative-fuel vehicle technologies (1-2). This paper addresses the place of EVs (electric vehicles) in
6 Africa both as an object of study and as a substitute technology for ICEVs (internal combustion engine
7 vehicles). It is structured around two main objectives. The first is to identify the major trends in the
8 scientific production dealing with the development of EVs in Africa and the second is to examine the
9 trajectories of mobility electrification on this continent. These objectives are based on the general
10 observation that EVs are under-contextualized in Africa compared with the rest of the world.
11 As the global electric vehicle fleet grew continuously from 17,000 passenger cars in 2010 to more than
12 10 million in 2020 (3), the number of publications on EVs or electric mobility has also risen fast over the
13 past two decades. According to Ruggieri *et al.* (4), the state of the art of electric mobility had reached
14 49,500 papers as of 2021 (on Scopus only). Monographs and journal articles based on case studies have
15 recently been complemented by thematic systematic reviews integrating for some of them a specific
16 geographical dimension (5). For example, Naumanen *et al.* (6) analyzed heavy-duty EV development
17 strategies by comparing four major markets: Europe, the United States, China, and Japan. Petrauskiene *et*
18 *al.* (7) and Pollák *et al.* (8) looked at the impact of policies on the promotion of electric mobility in five
19 European regions.
20 Gradually, a broad theoretical and practical literature is being built up, fed by several cases of on-road
21 experiments and prospective studies carried out almost exclusively in the so-called developed countries
22 and the BRICS (Brazil, Russia, India, China, and South Africa). According to Ruggieri *et al.* (4), more
23 than half of this literature originates from only four countries: the USA (22% of the total), China (11%),
24 Japan (10%), and Germany (9%). A similar study by Ramirez Barreto *et al.* (9) confirms this
25 overrepresentation of developed and emerging countries in EV publications for the 10 years from 2007 to
26 2016 compared with the rest of the developing world (including parts of the Americas, Asia, and Africa
27 as a whole). In 2020, Rajper and Kumar published the only systematic review available so far on the
28 opportunities and barriers related to EV deployment in developing countries (10). Nevertheless, these
29 authors focused more on Asia and especially China, with only one reference to Africa.
30 Beyond the Chinese case that is often cited as a reference, the scientific literature on electric mobility
31 relies little on case studies produced in emerging or developing countries, particularly in Africa, while
32 EVs are attracting increasing attention there and are being deployed at a relatively rapid pace (11).
33 According to Collett and Hirmer (12), EVs could also play a key role helping the continent to achieve
34 several of the Sustainable Development Goals. Several electric mobility projects have recently emerged
35 on the continent and with them, possible clusters may be building momentum (such as Jinja in Uganda,
36 Gauteng Kwazulu-Natal and Eastern Cape in South Africa, etc.). Supporting policies ensure the creation
37 of initial niche markets (11). For example, Mozambique adopted a national electric mobility strategy in
38 2019, and Mauritius adopted incentives as early as 2009 to reduce by half the excise duty on electric and
39 hybrid electric cars (13). Cape Verde and Egypt are leading the way on bans on ICEVs (for all segments
40 from two-wheelers to buses and trucks in the former, and for passenger cars only in the latter), which are
41 expected to be enforced, respectively, from 2035 and 2040 onwards (14- 15). Yet other countries, such as
42 Uganda, hope to achieve a technological leap in their automotive industries by developing a local EV
43 industry (16). At the urban level, the transition is even faster. Some member cities of the C40 Cities
44 Climate Leadership Group (C40), such as Cape Town, have launched first experiments with electric buses
45 in their public transport networks (17), while electric two- and three-wheelers are emerging in several of
46 the continent's major capitals (18).
47 Ongoing changes combined with the specific structure of the African automotive market (dependent
48 mostly on imports) and features of mobility patterns on this continent, call for further building of local
49 knowledge about EVs and the adaptation of their design (19). Nur (20) provides evidence of this need for
50 adaptation in a study focused on an experimental project of an electric light commercial vehicle (LCV)
51 designed and built by a group of engineers from a German university to address the mobility issues of

1 rural populations in Africa. By comparing the perceptions of the vehicle’s designers and the local
2 response to this innovation during a road test phase in Ghana, the author shows how misanticipated or
3 misperceived societal expectations (e.g., for functionality, reliability, and payload, but also as status
4 symbol associated with the aesthetic design of the vehicle in some local contexts) and geographical
5 constraints (such as sensitivity of the vehicle’s components to rainfall and temperatures) can hinder the
6 project’s success. In particular, the emphasis of the project’s engineers on functionality rather than
7 appearance and the choice of a “simple and spartan aesthetic” (e.g., the vehicle has no doors) was seen as
8 contrasting excessively with the symbolic value that Ghanaian society places on the appearance of a
9 vehicle (20).

10 That paper echoes several others, for example, where Scott-Smith mobilizes the concept of “sticky
11 technology” as opposed to “fluid technology” to refer to the unsuitability of some innovations from
12 developed countries for local uses and practices (21); or yet where Wood and Mattson identify the lack of
13 contextual knowledge as the main cause of the failure of most designs in developing countries (22).
14 Ashmore *et al.* explored this further in a study of the symbolism of environment-friendly cars across
15 national cultures, which demonstrates that transportation decisions are not just practical, but also rooted in
16 cultural and societal perceptions. They show how qualitative symbolic differences can influence an
17 individual’s or a group’s purchase intentions, and beyond that, how difficult it is to replicate successful
18 policies in contexts that differ from the original one (23).

19 Therefore, exploring the outlooks for mobility electrification in Africa based on context-relevant literature
20 stems from a need to “tropicalize” EVs both in their technical aspects, and in the social, cultural,
21 economic, and political values that are specific to the continent. This raises the question of the
22 correspondence between the research being carried out and the actual development of electric mobility in
23 Africa.

24 This paper is organized in four sections. First, the methodological approach is presented. Trends in
25 research about EVs in Africa and trends in the development of EV projects in Africa are presented in,
26 respectively, the second and third sections. A final section discusses the results obtained and outlines
27 further research avenues in the form of a research agenda.

28 **Methods**

29 For the purpose of this study, we have considered a wide range of road vehicles with an electric drive
30 (with the exception of non-plug-in hybrids), in all segments, from two-wheelers to heavy vehicles (trucks
31 and buses for example), including three-wheelers, passenger vehicles, LCVs, quads, and scooters, as well
32 as electrically-assisted bicycles. This scope has guided the methodological approach below, which is
33 structured in two main phases.

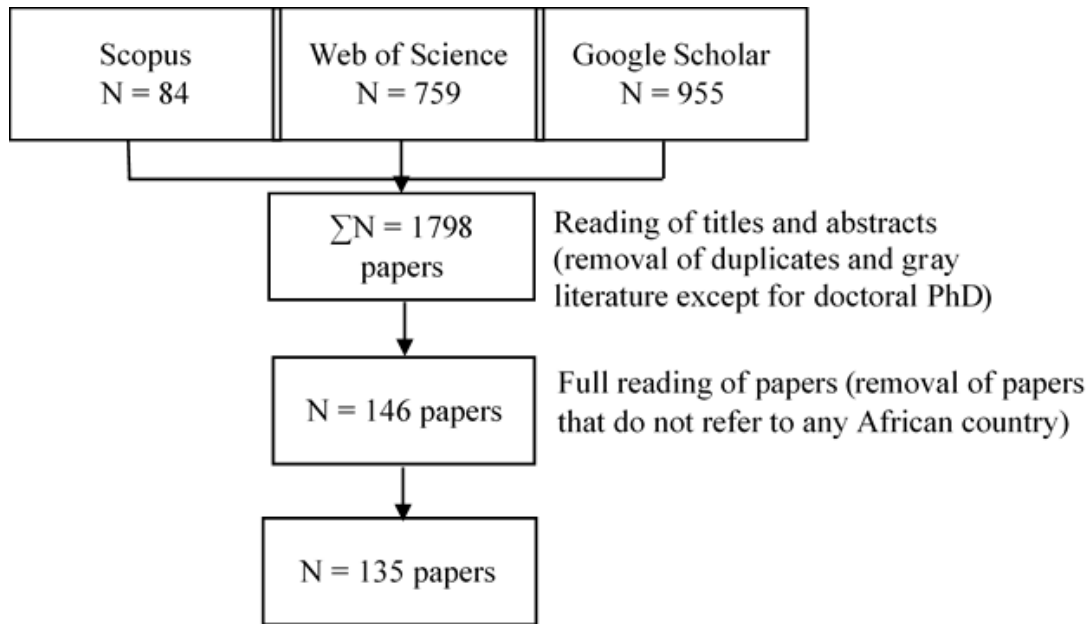
34 **Systematic Review of the Literature on EVs in Africa**

35 The first part of the methodological approach is based on a review of the scientific literature on the
36 diffusion of EVs in Africa. It was based on a Boolean search using three databases: Google Scholar,
37 Scopus and Web of Science (WoS). This was conducted in French and English only, with keywords
38 including two main search strings: [“electric mobility” or “electric vehicle”] and [“Africa”]. The same
39 query was applied to all three databases, while limiting the search to peer-reviewed articles, conference
40 papers, book chapters, and doctoral dissertations. Such wide criteria for the selection of literature aim to
41 achieve the most comprehensive collection possible of scientific literature on EVs in Africa. The same
42 logic was followed with regard to the reference period, which no restrictions imposed. A first round of
43 paper collection was carried out between December 2020 and May 2021. More recent papers published
44 between June and July 2021 were later retrieved and integrated into the initial database through alerts on
45 WoS and Scopus and an update on Google Scholar. Finally, the papers were selected in a two-step
46 process: first, the titles and abstracts were read, and second, the full papers were screened using two
47 criteria. The first criterion related to the study object (i.e., explicit reference found in the paper to at least
48 one category of EV, whatever the segment). A second criterion related to the geographical area (i.e.,
49

1 explicit reference found in the paper to the African context, be it at local, national, sub-regional, or
 2 continental scale). A total of 135 papers were eventually selected (Figure 1).

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Figure 1: Process and outcome of paper selection



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A four-step bibliometric analysis of the papers selected was conducted: (i) a diachronic analysis (to trace the evolution of the annual production of papers on EVs in Africa), (ii) a thematic analysis (to identify the main research themes addressed by this literature), (iii) a methodological analysis (to document the main methods used by the authors, the difficulties of accessing information in African contexts, and their impacts on the results obtained on reliability, for example in the case of modeling based on questionable mobility data), and finally, (iv) a geographical analysis (to examine the spatial coverage of this literature, the institutional and geographical affiliation of the authors as well as the origin of the funding allocated to research on EVs in Africa). Following the thematic analysis, each single paper could be matched with one or more themes. Similarly, the geographical analysis could link each paper with one or more countries with regard to the scope of study (e.g., in the case of comparative studies), the institutional affiliation of authors (e.g., in the case of joint publications), or the funding sources. In contrast, a specific “mixed method” class was used in the methodological analysis to account for a set of papers that combined different methodological approaches, mostly in the field of social sciences (e.g., observation, interviews, documentary research).

Overview of Electric Mobility Projects Based on a Project Analysis Approach

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The second part of the methodology is based on a project analysis approach articulated in two complementary phases. The first phase involved an exhaustive census of electric mobility projects in Africa, including for the purpose of this research, local EV manufacturing projects (excluding industrial presence of traditional, non-native manufacturers) and local projects of mobility/transport services involving EVs (excluding plain EV dealership). Each project corresponds to a specific vehicle segment regardless of the number of vehicles deployed. Specifically, the approach consisted in identifying and selecting, by keyword searches, all print media articles and online multimedia content, but also other gray literature materials (such as reports, monographs, etc.) relaying a concrete case of an electric mobility project corresponding to one of the previously defined project categories. The keywords used for this purpose included a combination of three search strings. A first string included the concepts of “electric mobility” or “electric vehicle” in the query. A second string included a wide range of motorized road

1 vehicles segments powered by an electric drive, and a third string included a geographical reference. It
2 was repeated until saturation at the level of each African country, with consideration of the linguistic
3 mosaic of both official languages and working and everyday languages (French, English, Spanish,
4 Portuguese, Arabic, *Afrikaans*, *Kinyarwanda*, *Swahili*, etc.). For countries with more than one official
5 language, queries were translated only into the first two languages, for example, English
6 and *Afrikaans* for South Africa, English and Arabic for Egypt, *Kinyarwanda* and English for
7 Rwanda, *Swahili* and English for Kenya. Also, in some countries where the working and everyday
8 languages are more widely used than the official language, the choice was made to use both categories of
9 languages, for instance in Mauritania, where French is more widely used as the everyday and working
10 language and Arabic as the official language.

11 Depending on their maturity of development, three levels of projects were included in the census, namely
12 projects at the prototyping stage, pilot projects, and projects in the deployment phase, which excluded
13 proofs of concept (24). Finally, the census was conducted between March and July 2020, followed by an
14 update on July 15, 2021. For each project identified, the information collected concerned:

- 15 • the launch date;
- 16 • the location (depending on the category, the head office of the project owner and/or the
17 deployment zone in the case of a project based on a service, for example);
- 18 • the motorization segment(s) covered;
- 19 • the project owners, defined as any natural or legal person at the origin of the design and definition
20 of a project, who ensures the gathering of various resources that lead the project to a concrete
21 implementation and to the start of the activities.

22 The second phase of the analysis was based on semi-structured interviews with the project owners. In
23 total, 10 interviews were conducted between July 2020 and June 2021. The upheavals caused by the
24 COVID-19 pandemic and the constraints related to working remotely did not allow us at that stage to
25 reach the initial objective of organizing one interview per project identified. Additional information was
26 however retrieved from the websites of the project owners whenever possible.

27 The data collected were analyzed in three main ways: (i) a diachronic analysis traced the trends in electric
28 mobility projects in Africa based on the launch dates of new projects; (ii) a geographical analysis showed
29 the spatial distribution of projects and highlighted some areas with specific potential for electric mobility
30 development; and finally, (iii) a typological analysis highlighted various categories of projects and actors
31 supporting these projects and shed light on various deployment logics.

32

33 **Trends in Research About EVs in Africa**

34 **Evolution of Publications on EVs in Africa**

35 Research on EVs in Africa is relatively recent (Figure 2). The earliest evidence of publication found in the
36 scientific literature dates back to 1978, between the two oil shocks (1973 and 1979), which were real
37 stimuli for EV research (25).

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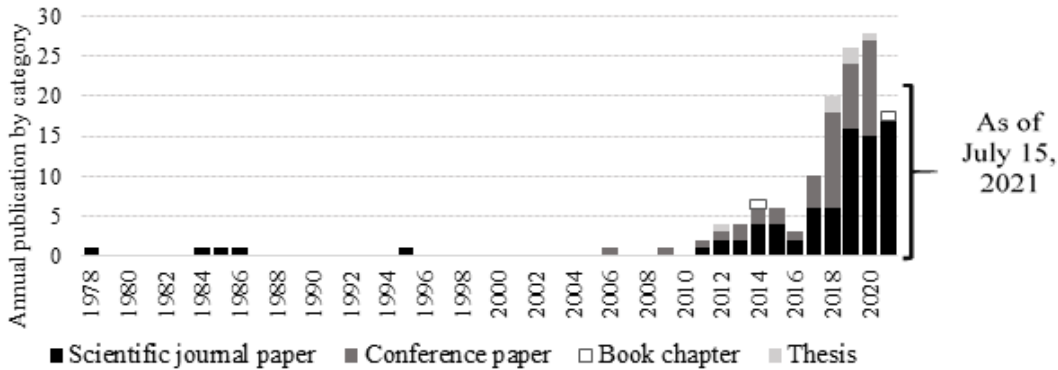
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1 **Figure 2: Publications about electric vehicles in Africa by year from 1978 to mi-july 2021**



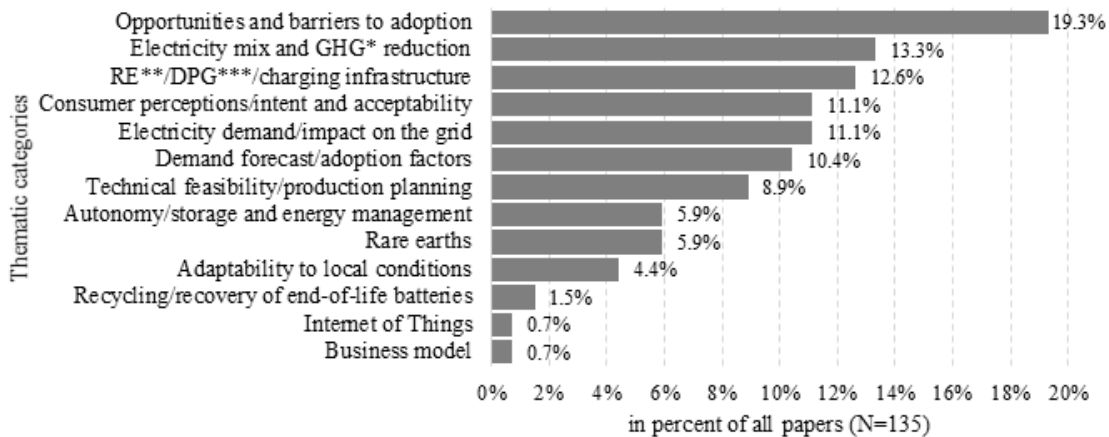
2
3 The trends in annual publications indicate two main phases in the evolution of this literature. The first
4 phase covers the period before 2011. It is characterized by a very scarce production, with a total of seven
5 papers published over more than three decades. The second phase extends from 2011 to July 15, 2021 and
6 totals 128 papers. It shows an acceleration of publications interested in EVs in Africa, first timidly during
7 the first six years and more markedly from 2017 onwards. During the first six months of 2021, 18 papers
8 were published, exceeding the production from the first phase altogether (from 1978 to 2011).
9

10 **Main Research Topics Addressed in the Literature**

11 The analysis of the papers identified 13 themes ranked by their occurrence in the literature (Figure 3).
12

13 **Figure 3: Main research topics of publications on electric vehicles in Africa**

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* Greenhouse gases, ** Renewable energy, *** Decentralized energy production

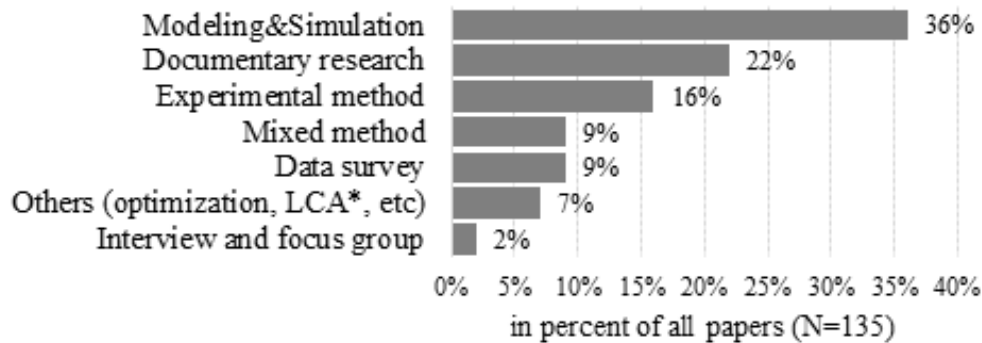
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16 Studies dealing with the opportunities for, and barriers to, EV adoption rank first, with 19% of papers.
17 They are followed by research on the environmental impact of EVs in relation to the electricity mix (13%
18 of papers). Options for optimizing EV environmental impacts are also studied in the literature through
19 focuses on renewable energies and their integration in decentralized energy production systems backed by
20 appropriate charging infrastructure (13% of papers). Other ecological dimensions of EVs such as rare
21 earth supplies (6% of papers) and end-of-life battery recycling (slightly over 1% of papers) close the top
22 four sustainability issues studied in the literature on EVs in Africa. Other high-impact themes that emerge
23 in the literature include the impact of EV adoption on the power grid (from the supply perspective);
24 consumer perceptions; purchase intentions, acceptability of EVs, demand forecasting and drivers of
25 adoption; and technical feasibility testing and production planning for EVs. In contrast, some issues such

1 as the adaptability of EVs to local conditions (4% of papers), the articulation between EVs and the
2 Internet of Things (less than 1% of papers), and the analysis of business models for EV diffusion (less
3 than 1% of papers) remain under-researched.

4
5 **Methods Used by the Authors**

6 Modeling and simulation and documentary research are the methods most commonly used by the authors
7 of selected papers (Figure 4).

8
9 Figure 4: Main methodological approaches used in the selected papers



10 * Life cycle assessment

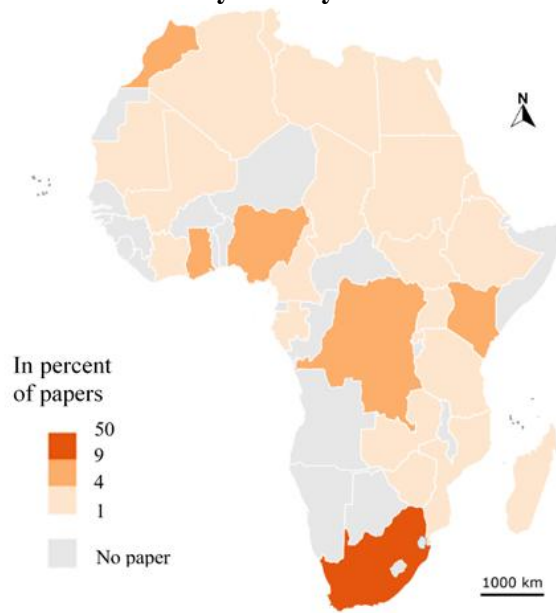
11
12 Experimental research comes third. Primary data collection from surveys, interviews, or focus groups is
13 not frequently carried out. The limited use of some resource-intensive methods (e.g., surveys,
14 experiments) may be explained by the notorious problems of research funding on the continent. More
15 theoretical approaches (e.g., modeling, simulation) are understandably less hindered by the recentness of
16 EV diffusion in Africa.

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18 **Spatial Focus of Literature**

19 The geographical focus of research on EVs in Africa is unevenly distributed across the continent (Figure
20 5). A total of 27 countries were the focus of research in the selected papers (whether at country level or
21 more locally).

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1 **Figure 5: Geographical focus of literature by country**



Source: 2021 Census, LVMT
 Realization: YTA, LV>MT, 2021. In WGS 84
 * Excluding all papers that do not specifically refer to a given country

2
 3 South Africa ranks first among countries of focus of the publications on EVs in Africa. It is followed by
 4 Morocco, Ghana, Nigeria, Democratic Republic of Congo (DRC), and Kenya. At the sub-regional level,
 5 all North African countries (except Western Sahara) were the focus of at least one study, unlike the other
 6 sub-regions. The coverage rates by subregion (number of countries covered as a ratio to the total number
 7 of countries in the subregion) are relatively low in Central Africa and Southern Africa, at 19% and 20%
 8 respectively, compared with 44% for West Africa, 56% for East Africa, and 86% for North Africa.
 9 Despite such sub-regional disparity, data show that South Africa is overrepresented with almost half of
 10 the papers (44%), which is consistent with the mapping of author affiliations (Table 1 and Figure 6) and
 11 research funding institutions (Table 2 and Figure 7).
 12

13 **TABLE 1 Author Affiliations and Contributions**

| Categories | All institutions concerned | African institutions only | Number of papers with one author or more affiliated with an African institution in this category |
|--------------------------------------------|----------------------------|---------------------------|--------------------------------------------------------------------------------------------------|
| Research organizations | 119 | 39 | 94 |
| Companies | 11 | 6 | 12 |
| Associations & International Organizations | 3 | 0 | 0 |
| States/ | 2 | 1 | 3 |
| Total | 135 | 46 | 109 |

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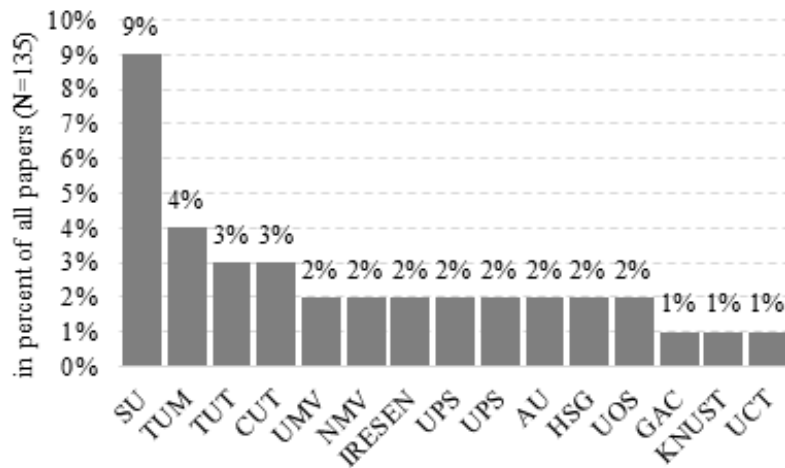
TABLE 2 Research Funding by Region and Type of Funds

| Region | Number of papers funded | Funding type | | Percent of papers funded out of a total of 135 |
|----------------------|-------------------------|--------------|-----------|------------------------------------------------|
| | | Private | Public | |
| Africa | 21 | 6 | 15 | 16 |
| Europe | 11 | 2 | 9 | 8 |
| North America | 6 | 2 | 4 | 4 |
| Asia and Middle East | 5 | 2 | 3 | 4 |
| Latin America | 1 | 0 | 1 | 0.7 |
| Total | 44* | 12 | 32 | 33 |

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*Two papers acknowledging funding did not disclose the funding sources

Figure 6: The top 15 research organizations based on their respective contributions

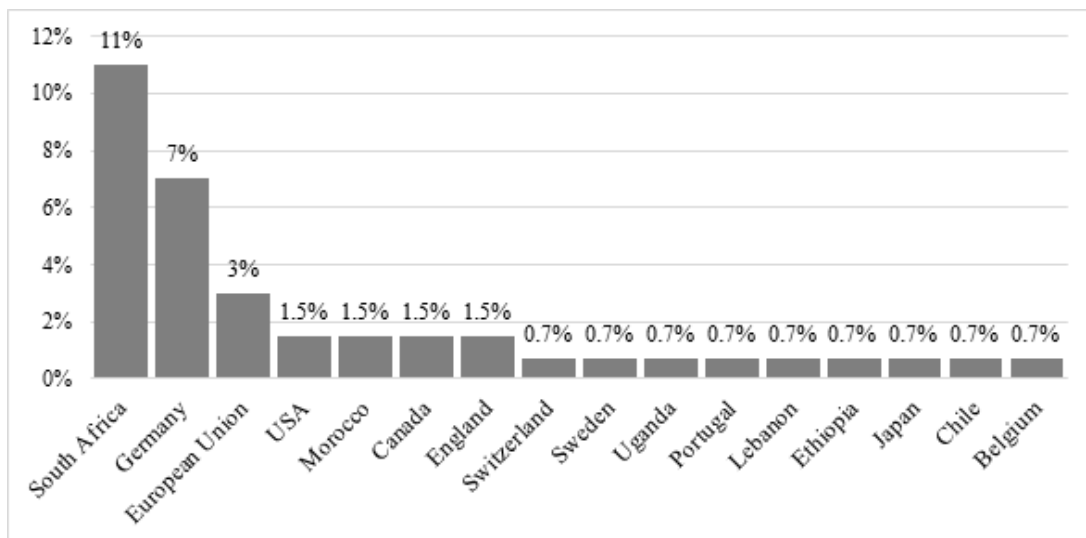


- SU: Stellenbosch University (South Africa)
- TUM: Technical University of Munich (German)
- TUT: Tshwane University of Technology (South Africa)
- CUT: Central University of Technology (South Africa)
- UMV: Mohammed V University (Morocco)
- NMU: Nelson Mandela University (South Africa)
- IRESEN: Institut de Recherche en Énergie Solaire et Énergies Nouvelles (Morocco)
- UPS: Université Paris-Saclay (France)
- UP: University of Pretoria (South Africa)
- AU: Aarhus University (Denmark)
- HSG: University of St. Gallen (Switzerland)
- UOS: University of Sussex (England)
- GAC: German Aerospace Center (German)
- KNUST: Kwame Nkrumah University of Science and Technology (Ghana)
- UCT: University of Cape Town (South Africa)

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1 Research organizations in Africa (including universities and research institutes) are the main contributors,
 2 with contributions in 94 papers. African companies also stand out, although with contributions in 12
 3 papers only. Among the institutions driving EV research on the continent, South African universities rank
 4 first among research organizations, followed at a distance by German and Moroccan research
 5 organizations (Figure 6).
 6 As to research funding, just 46 papers (one third of all selected papers) explicitly acknowledged receiving
 7 financial support in the production of the research. In half of these papers, this was endogenous funding,
 8 mainly from public sector actors (Table 2).
 9 At the country level, the origin of funding confirms the leading role of South African institutions (Figure
 10 7).

11 **Figure 7: Research funding by country of origin of the institution**
 12



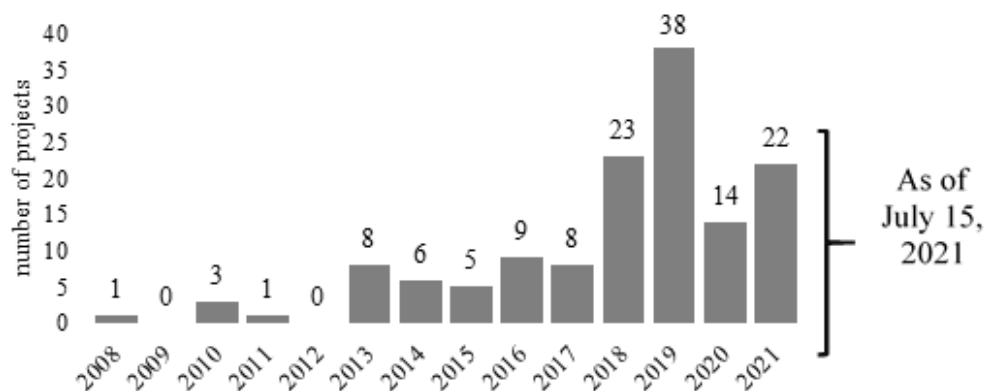
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 14
 15 The South African utility Eskom Holdings SOC Ltd is the single largest financial supporter of EV-related
 16 research in Africa, with six papers funded.
 17

18 **Deployment of Electric Mobility Projects in Africa**

19 **Growth of Electric Mobility Projects in Africa**

20 Electric mobility projects in Africa are even newer than research on EVs in Africa. The census revealed
 21 138 electric mobility projects launched in Africa up to July 15, 2021. The continent’s first EV (the Joule
 22 by South African automaker Optimal Energy) was first unveiled at the Paris Motor Show in 2008 (26),
 23 three decades after the first research on EV (including battery technologies) was initiated by the Council
 24 for Scientific and Industrial Research (CSIR) in South Africa (25). Overall, the census suggests a four-
 25 phase evolution (Figure 8).
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1 **Figure 8: Launch dates of electric mobility projects in Africa**
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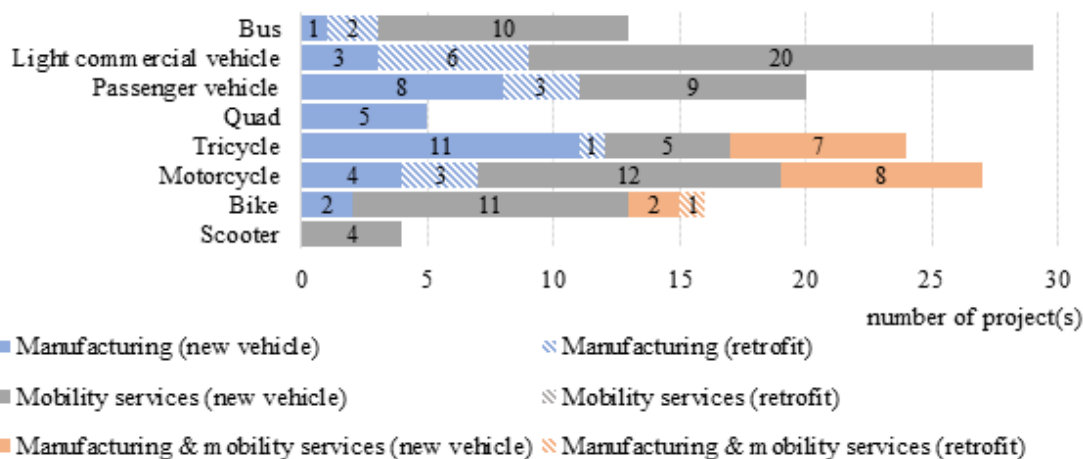


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 4 The first phase (2008–2012) is characterized by very scarce project launches on the continent. The second
 5 phase (2013–2017) is an initial lift-off, with an average of 74 projects per year. The third period runs over
 6 2018 and 2019, and is marked by a rapid increase in the number of projects (on average 30 projects per
 7 year). 2020 may mark the beginning of a new phase, the dynamics of which are yet to be determined.
 8 Only 14 project launches occurred in 2020, possibly because of the effects of the COVID-19, which has
 9 slowed down considerably all economic activities and most acutely in the transport sector with the
 10 generalization of containment measures. Most recent data point to a possible recovery in 2021, with 22
 11 projects launched during the first 6.5 months of the year, although high uncertainty remains as to future
 12 developments in the pandemic and its effects on economic activities in the years to come.

13
 14 **Different Categories of Projects**

15 The analysis by segment shows that almost all road vehicle segments are represented, with the exception
 16 of trucks (Figure 9).

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 18 **Figure 9: Project category by vehicle segment and condition (new or retrofit)**
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 22 Projects related to LCVs (including safari cars) are in the lead (29 projects), just ahead of
 23 motorcycles (27 projects) and tricycles (24 projects). Altogether they account for a little more than half of
 24 all projects. By contrast, higher-capacity vehicles included in the bus segment (minibuses, midi-buses,
 25 buses, etc.) only account for 13 projects (about 10%).

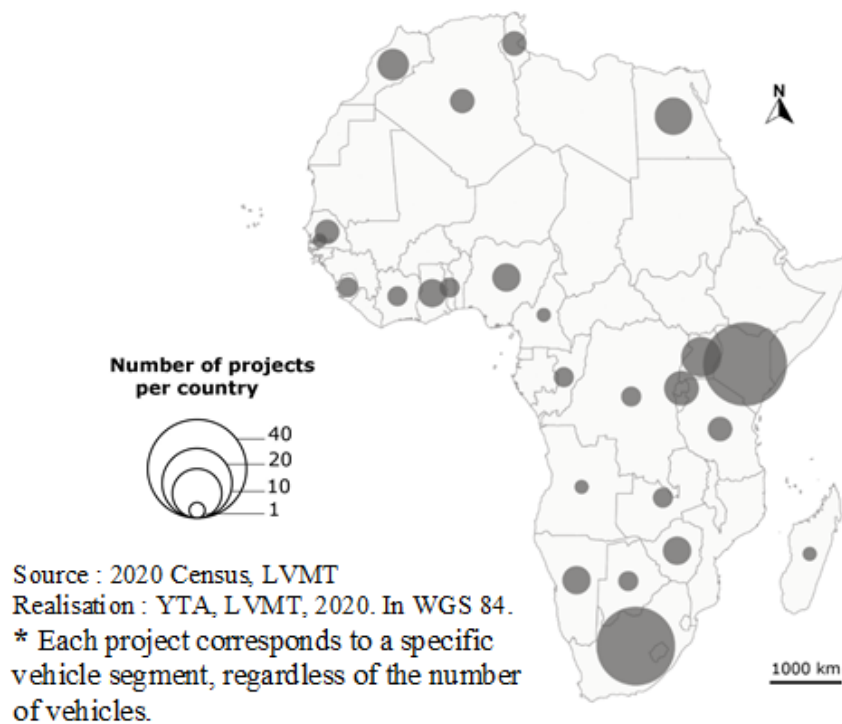
1 More than one third of all projects (49 projects) relate to local manufacturing (with tricycles, passenger
 2 vehicles, and motorcycles as the main segments). They concern local manufacturing and/or assembly
 3 projects using vehicle parts that are imported. This category includes projects that differ according to the
 4 quantity of imported parts used in the vehicle manufacturing process and the condition of the vehicles
 5 (new or retrofit). Three variants can be identified: (i) local assembly using imported parts only; (ii) local
 6 assembly with both imported and locally manufactured parts; and (iii) conversion of old conventional
 7 vehicles to electric with some imported parts. Projects based on a mobility service represent more than
 8 half of the projects (71 in total). This category includes projects that involve on-demand passenger
 9 transportation and/or delivery services via an application, projects that organize the electrification of
 10 public or private fleets, and battery-swap services. LCVs, electric motorcycles, electric bikes, and electric
 11 buses are the top four segments of this project category. Finally, a third category of projects that combine
 12 a mobility service with local manufacturing (e.g., as part of an end-to-end managed service model), may
 13 be singled out. This category accounts for less than a quarter of all projects (18 projects) and only
 14 involves motorcycles, tricycles, and bikes.

15 Whether in a manufacturing project or in a mobility service project, the vehicles deployed also differ by
 16 their condition (new or retrofit). A total of 16 projects are based on the conversion of old ICEVs, with all
 17 retrofitting activities being carried out in Africa (there are no mobility services projects involving
 18 imported retrofitted vehicles). LCVs are the segment most associated with retrofitting. Only one project
 19 combines a mobility service with retrofitting.

20
 21 **A Contrasting Geography of Deployment**

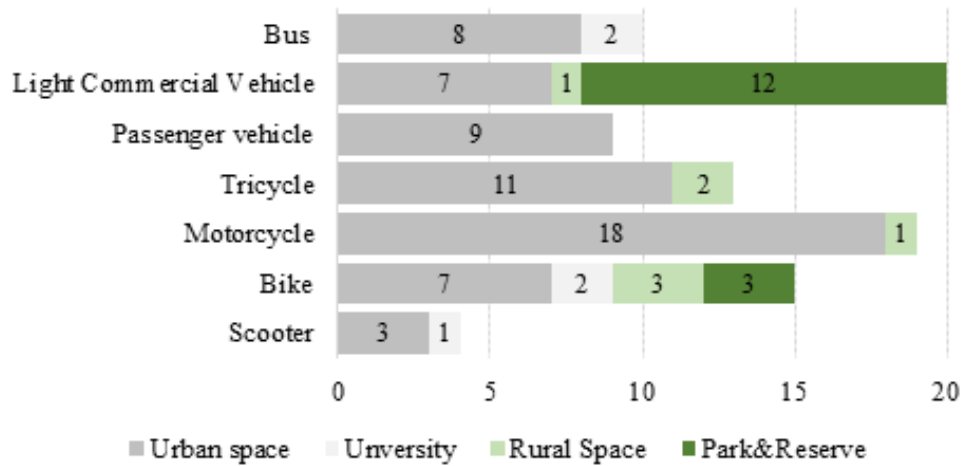
22 The 138 projects launched from 2008 to mid-July 2021 are located in just 25 countries (Figure 10). Kenya
 23 and South Africa alone account for almost half of all projects on the continent (35 and 31 projects
 24 respectively). The same disparities are observed at the sub-regional level, with East Africa having the
 25 largest number of projects (59), compared with 36 in Southern Africa, 18 in West Africa and Northern
 26 Africa, and just six in Central Africa.

27
 28 **Figure 10: Distribution of projects by country* (all segments included)**



1
2 Finally, depending on the countries in which they are deployed, service projects are not located in
3 the same types of areas. The choice of markets thus varies greatly from one country to another, but
4 especially from one segment to another (Figure 11).

5
6 **Figure 11: Deployment area of service projects (N= 90) by segment**
7

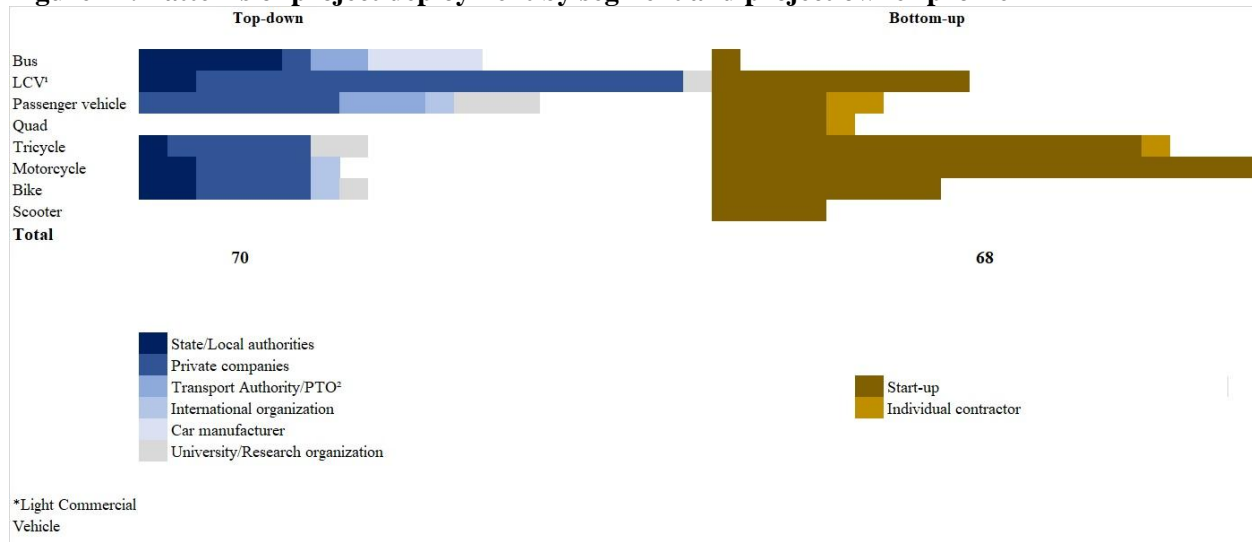


8
9
10 Except for LCVs, most service projects have been deployed in urban areas, where most of the economic
11 activity is, as well as the most dynamic increases in mobility needs (from population growth and urban
12 sprawl), and more solvent populations. Among urban projects, some private spaces such as universities
13 are used as test beds before scaling up, for example, the “Blue buses” on the campus of Houphouët-
14 Boigny University in Abidjan (Ivory Coast), the *Bikkie* electric scooters on the campus of the American
15 University in Cairo (in Egypt) or the e-bikes of Nelson Mandela University (South Africa). Animal parks
16 and reserves also play an important role in the deployment of EVs within delimited spaces, with 12
17 projects out 20 in the LCV segment, mainly dominated by safari vehicles.

18
19 **Two Patterns of Projects Deployment: Top-Down versus Bottom-Up**

20 Two main project deployment patterns can be identified, depending mostly on the profile of the project
21 owners: top-down deployment and bottom-up deployment (Figure 12).
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1 **Figure 12: Patterns of project deployment by segment and project owner profile**



2
3 **Source: The authors**

4
5 These two patterns highlight differences in the governance of projects, and in particular the role local or
6 citizen initiatives may play in the diffusion of EVs in Africa. Top-down projects are mostly led either by
7 the public sector (state or local authorities), or by transport authorities and/or public transport operators,
8 or by international organizations, private companies, car manufacturers, and research institutions
9 (universities and research institutes). Bottom-up projects may be led by startups and individual
10 entrepreneurs.

11 It should be noted, however, that top-down and bottom-up patterns cannot be used to build strictly distinct
12 categories. The whole stakeholder ecosystem around each project often combines actors of very different
13 nature, size, and scope. The Ndiaye Transport (a local transport company) project in Thiès (Senegal), for
14 instance, involves the Government of Senegal (through the Ministry of Handicrafts and Informal Sector
15 Transformation), the State of Indonesia, and the Indonesian electric motorcycle manufacturer Gesits. The
16 Solectra tricycle cab project (Egypt) is co-governed by Solectra LLC. (an electric mobility startup in
17 Egypt), the municipality of El Gouna and the International Commercial Bank of Egypt (CIB). Although
18 these two projects involve major public actors, we have classified them in the category of bottom-up
19 projects because of the profile of the project owner.

20
21 **Discussion**

22 Over the past decade, EVs have received growing attention in Africa both as an object of study and as an
23 alternative technology to ICEVs. This is illustrated in the increase in the numbers of electric mobility
24 projects and scientific publications focusing on them. An in-depth analysis of the scientific literature has
25 nevertheless revealed disparities in both spatial coverage and research focus. While the issues of
26 environmental sustainability, perception, and acceptability, as well as opportunities for, and barriers to,
27 EV diffusion are rather well documented, other issues relating to stakeholder ecosystems remain under-
28 researched. These would include: stakeholder interactions in the definition of mobility trajectories (e.g.,
29 type of vehicle, choice of markets, deployment strategies, and business models), or yet patterns of use and
30 degrees of appropriation of these innovations by end-users. Moreover, the methodological approaches
31 used in the scientific literature reveal that research is rarely based on field experiments or other empirical
32 methods (observation, interviews, questionnaire surveys), which are nevertheless necessary for a better
33 adaptation of EVs to local mobility patterns and geographical conditions.

34 The link between the scientific literature and the electric mobility projects identified throughout the
35 continent remains to be built. Despite the increase in their number, few scientific papers have been

1 published on the basis of these concrete cases of electric mobility. Out of 138 projects identified, only
2 five have been studied by researchers so far. These include: (i) the passenger vehicle called the “Joule”
3 made by the South African manufacturer Optimal Energy (26- 27), (ii) the solar-powered car “Sun
4 Chaser” designed by Tshwane University of Technology to participate in the Sasol Solar Challenge (28-
5 29), (iii) the Kayoola electric bus built by Ugandan car manufacturer Kiira Motor (16), (iv) the solar-
6 powered tricycle called Solar-E-Cycle from the Kenyan startup Solar-E-Cycle (30), and, (v) the solar-
7 powered taxi service (in the LCV segment) in Gambia (31).

8 The weak integration of these or similar projects in research activities can be interpreted in various ways.
9 It could stem from the lack of awareness of these projects since, to our knowledge, there is no known
10 census work on electric mobility projects at country and continental levels. The overview provided in this
11 paper aims to fill this gap and to provide the research community with evidence on an emerging topic that
12 is likely to have a strong influence on the future of motorized travel in Africa (with the growth in mobility
13 needs linked to population growth and the continent’s current low level of motorization), and probably on
14 its economy (through the creation of added value on the side of the local automotive industry) (32).

15 Another reason could be the low expenditure that African states make on research and development
16 activities. According to the latest UNESCO report, African countries spent less than 1% of their GDP on
17 research in 2018, half that of the rest of the world (except Latin America), that is, 2.73% in North
18 America, 2.13% in East and Southeast Asia, or 2.02% in the European Union. In Sub-Saharan Africa
19 specifically, this ratio was around 0.51% on average, compared with 0.83% in South Africa (33). The
20 overrepresentation of South Africa in authors’ affiliations and sources of funding—which is consistent
21 with the large share of papers focusing on this country—, is a reflection of the particular interest in EV-
22 related projects and research in the country. It nevertheless raises the question of the transferability and
23 adaptability of the results to other African contexts—especially where the local automotive industry is not
24 as advanced. As the rapid adoption of EVs is strongly linked to the characteristics of the local contexts
25 where they are deployed (34), a detailed knowledge of said contexts seems essential.

26 The heterogeneous distribution of projects also seems to underline the existence of some socio-technical
27 and political-economic barriers that are context-specific. In particular, they reveal some form of regional
28 leadership assumed by countries such as South Africa in Southern Africa; Egypt and Morocco in North
29 Africa; Kenya, Uganda, and Rwanda in East Africa. In most cases, these are countries that have
30 announced and/or implemented policies to support electric mobility and where entrepreneurship and do-
31 it-yourself practices have been promoted by the authorities over the past few years and have seen the
32 emergence of several startups, particularly in the field of electric mobility (35). In a recent study by the
33 World Resources Institute on technology-based mobility startups in Africa (from 2010 to 2019), for
34 example, that Nairobi emerges as the city with the highest concentration in Africa of mobility startups
35 involved in shared mobility services, commuter experience, or data-driven decision-making and
36 technological innovations for vehicle performance (11). The spread of EVs in Africa is leading to a
37 qualitative and quantitative change in the mobility system, which is strongly dominated by projects led by
38 private actors and initiatives described in this paper as “bottom-up”—which does not exclude some form
39 of support from government or international organizations. Startups play a key role in boosting this
40 ecosystem, especially in the two- and three-wheeler segments, which require low investments and are
41 particularly adapted to the current mobility practices on the continent.

42 In West and Central Africa, however, electromobility initiatives remain very modest, and no sub-regional
43 leadership has emerged. Although Nigeria appears to be the largest African economy and a favorable
44 environment for mobility startups in Africa, the country’s dependence on the oil economy seems currently
45 to exclude any governmental support to the EV market, and consequently, the emergence of projects led
46 by public and/or private stakeholders (36). The overrepresentation of the DRC in EV studies across the
47 continent contrasts with the number of concrete electric mobility projects referenced in that country. This
48 representation in scientific literature reflects the geopolitical role of the DRC in the evolution of the
49 global EV market, particularly in the supply of rare earths including cobalt (37). In contrast, the limited
50 number of concrete electromobility projects deployed in this country points to various barriers to
51 adoption, including the lack of a local automotive industry. With the exception of Rwanda, the electric

1 mobility projects identified across the continent are particularly concentrated in countries where the
2 automotive industry is somewhat mature. In these particular contexts, the transition to electric mobility
3 offers an opportunity to make industrial leapfrogs, particularly through the deployment of projects based
4 on local EV manufacturing. The current supply trends allow us to outline, without being exhaustive, a
5 prospective diagnosis of the potential for EV deployment in different regions on the continent. These
6 emerging patterns of EV deployment based on indigenous electrification initiatives (through local and/or
7 locally co-constructed projects) challenge the assumption of “trickle-down electrification,” powered
8 mainly by second-hand EVs that would be exported to Africa from early-adopter countries in the North.
9 Finally, the recent emergence of electromobility in Africa and the trends toward the indigenization of EVs
10 that it generates require, based on the available scientific literature, further research about: (i) the
11 motivation of stakeholders involved in the supply side, their competitive and/or synergistic relationships,
12 and their deployment strategies; and (ii) the degree of appropriation and use patterns of the vehicles by
13 end-users. The analysis of the economic models underlying the projects, for example, will provide a
14 relevant key to understanding their successes and failures, and consequently, the adequacy of mobility
15 policies and practices to the ambitions and trajectories of mobility electrification at the scale of each
16 territory in Africa (national and/or local scale). The same is true for a better understanding of stakeholder
17 ecosystems, which is needed to articulate targeted policies to support electric mobility according to
18 service and/or industrial priorities. The role of public authorities in supporting electromobility, for
19 example, through direct and/or indirect incentives for users as well as for local EV manufacturers, also
20 needs further exploration. The literature on EV diffusion, particularly in emerging markets such as China
21 and India, provides some relevant analyses that highlight the link between public policies and the
22 indigenization of EVs (38 – 40). A cross-analysis of these policies and their availability to African
23 governments at different levels would provide the basis for regulatory and incentive schemes adapted to
24 each country’s mobility electrification potential and objectives.

25 In addition to these research needs, a strong emphasis on empirical approaches in future research on EVs
26 in Africa seems instrumental in building sound knowledge about the possibilities for EV diffusion and
27 adoption on this continent. This means reconsidering the role of field experiments and studies based on
28 the analysis of actual EV adoption behavior by end-users, and not just their intentions (41). The
29 enhancement of these methodological approaches remains necessary, for example, to understand how
30 attitudes influence EV adoption and how such attitudes change over time (41), but also to address the
31 need for EV tropicalization that results from socio-technical and geographical conditions that are specific
32 to Africa.

33

34 **Conclusion**

35 Africa is not only largely untouched by the automotive industry (32), it is also the last major region in the
36 world to develop an interest in electric mobility. Despite obvious obstacles (e.g., high cost of technology,
37 limited access to electricity, strong competition from the ICEV second-hand market, weak regulations on
38 the automotive sector, absence of user incentives), the transition to EVs is moving forward relatively
39 quickly, as evidenced by the increase in electric mobility projects, particularly since 2018. As was the
40 case with mobile phones, Africa may be on the verge of another technological leap from ICEVs to battery
41 electric vehicles, which may also be combined in this case with an industrial leap from an embryonic
42 automotive industry (and associated dependence on the used-car market) to the emergence of a local EV
43 industry.

44 This optimistic perspective on the place and future of EVs in Africa is questionable, however, in view of
45 the various issues (cost barrier, autonomy, access to electricity, etc.) related to the process of
46 electrification of mobility in Africa. Moreover, the diversity of situations (socio-technical and economic,
47 energy, political, even ecological, etc.) on the continent requires extreme caution with regard to the
48 outcome of this transition. It requires more in-depth analyses on a case-by-case basis to determine the
49 possible success factors of electric mobility projects, and the conditions for their replicability and their
50 scaling up. Research and development are instrumental in meeting the information needs of the emerging
51 stakeholder ecosystem in Africa. Continued publication efforts on this new research object in Africa are

1 in order, which calls for additional support to academia from local governments and international
2 institutions.
3 Building favorable conditions for the electric mobility ecosystem in Africa will also depend on the ability
4 of the potential stakeholders (project developers in particular) to adapt their offers to local needs. Context-
5 sensitive mobility data is a key resource in this regard, which road experiments (e.g., pilot projects) can
6 help harvest. Additional supporting measures may include incentive-based regulatory schemes and
7 national (or community) preference clauses (42). The latter option echoes the trend toward an
8 “Africanization of the economy” (43), following in the footsteps of emerging economies of Asia such as
9 China, which since 2005 has adopted an official policy to support “indigenous innovations” (44).

10

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14

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