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Development of Digital Library on Green Mobility (DLGM) as Knowledge Sharing Tool to Promote Electric Vehicles in India: A Case Study

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ABSTRACT

The Digital Library on Green Mobility (DLGM) aims to provide a platform for sharing ideas, knowledge, and documents among stakeholders of various organisations and institutions involved in Low Carbon Transport in India.[1] It offers full-text access to national and state-level policies, regulations, reports, articles, books, standards, case studies, etc., on green mobility. Following a case study approach, the study highlights the process of developing a knowledge-sharing platform and the success of DLGM in meeting critical objectives. The usage trend and user behaviour of DLGM were also analysed to draw inferences to improve website usability. We briefly discuss how different insights from DLGM can be obtained to benefit a diverse set of stakeholders, such as policymakers, practitioners, private companies, and researchers, for evidence-based gap identification, decision-making, and way forward in various green mobility topics. The study contributes to the original findings based on users' and website accessibility surveys undertaken by authors.

Keywords: Digital library; Knowledge-sharing platform; Electric mobility, Low carbon transport; Indo-German cooperation

1. INTRODUCTION

As the global information economy evolves, the need to ensure the best access to information becomes ever more pressing for the broadest possible community. The proliferation of networked digital information is causing a paradigm shift of libraries to the digital environment. In this changing scenario, digital libraries (DLs) provide users with organised and structured access to information in a distributed environment. DLs function as online knowledge platforms that assist users in searching, evaluating and utilising resources irrespective of their format. DLs can potentially improve access to scientific and technological data, information, and knowledge generated by the academic, research, Government, and corporate fraternity. Building DLs includes content selection, acquisition, organisation, software selection and development, content access and delivery, access management and usage.

Recent years have seen numerous digital library initiatives in India. Several DLs on topical issues have been initiated to cater to the expectations and demands of users. One such emerging topic is electric mobility (e-mobility) or green mobility. E-mobility has the potential to transform the transport sector and help countries achieve sustainable development objectives and decarbonisation goals. Integrated decision-making is a prerequisite for decarbonising the transport system in an economically viable manner. This would mean bringing multiple agencies together on a common platform to help the many players in the green mobility ecosystem learn more.

Many government agencies, private institutions and development organisations are working in the green mobility domain and publishing research outputs in research papers, reports/books, guidelines for standardisation, policy papers, etc. These knowledge resources are widely scattered and not organised in a single place. It has been observed that the stakeholders in the green mobility domain find it challenging to search and retrieve these resources on the internet from a single platform. This sets the basis for developing a digital library or knowledge platform that caters to diverse stakeholders.

2. LITERATURE REVIEW

To develop and implement a successful digital library on "Green Mobility and Low Carbon Transport domain", it is vital to assess other DLs and knowledge platforms already existing in this domain and identify the most critical technical aspects of digital library resources. DL technology can be gathered into numerous categories influencing users' satisfaction in a DL framework. Some key parameters are open access to information, ease of access, simple

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interface design, high quality of the communication process, Internet performance, performance assurance service, ease of communication via social networks, and access to users to submit records[2]. These are essential features of any digital library that need to be given due importance, as DLs are mainly designed to meet the stakeholders' needs. Users' satisfaction with DLs is significantly predicted by the quality of the information, systems, services, perceived usefulness, perceived simplicity of use, and cognitive absorption[3]. Easy access, user-friendly DL interface design, few download exceptions and limitations, quality of the interaction process, internet performance, quality assurance service, and simplicity of communication offered by a social network are just a few of the variables that can affect user satisfaction in a DL environment[4-5].

From DL's perspective, information needs must be supported by high-quality information. As a result, its qualities are frequently referred to as being consistent, designed, timely, current, trustworthy, complete, accurate, and significant[6]. As a result, DL users' satisfaction is substantially impacted by the information's quality.

Further, as a new role worldwide, digital libraries and knowledge-sharing platforms facilitate access to necessary information and knowledge resources to researchers, practitioners, social innovators and public policymakers working towards achieving the Sustainable Development Goals (SDGs) by 2030. Different institutions in India have launched several digital libraries/repositories since 2015 when Agenda 2030 (or SDGs) became operational. Das[7] studied five DLs launched between 2015 and 2020. The Digital Library on Green Mobility (DLGM) stands out as the youngest among them. Zakari[8] studied how digital libraries and intelligent technologies are being used to accelerate progress toward SDGs. In another article, the authors argued for a definitive role of university libraries and institutional knowledge repositories in bridging digital gaps through ICTs and facilitating SDG attainment, as observed in Africa[9]. Consequently, another article argued for digital and social technologies to ensure citizen participation, inclusiveness, and transparency while monitoring SDG implementation at the national and regional levels[10].

While developing DLGM portal, a great emphasis was given on easy access of high quality information contents, user participation to build content for DLGM and enabling SDGs accomplishment.

3. THE RATIONALE, OBJECTIVE AND SCOPE

As electric mobility is an emerging field, a massive digital information explosion is poised to occur in the present and near future sectors. Open sharing of research data and data validation are serious issues researchers face these days. Other stakeholders such as industry, academia, and Government require data consolidation to understand market dynamics, technology innovations, and policy updates. Hence, there is an urgent need for a digital e-mobility platform to support stakeholders through a holistic single-window knowledge dissemination platform.

Subject experts regularly highlight the need and importance of digital e-mobility platforms for promoting sustainable transportation in various forums. Experts in the e-mobility domain from the Government and other organisations have stressed the importance of user-centric mobility services, which are new, upcoming, and different from traditional Transport, and recommended integrating online e-mobility tools into a digital e-mobility platform[11].

Many government agencies, private institutions and development organisations are working in the green mobility domain and publishing research outputs in research papers, reports/books, guidelines for standardisation, policy papers, etc. These knowledge resources are widely scattered and not organised in a single place. It has been observed that the stakeholders in the green mobility domain find it challenging to search and retrieve these resources on the Internet from a single platform. This lays the groundwork for creating a digital library platform that serves a range of stakeholders.

The development of the Digital Library on Green Mobility (DLGM) was initiated in July 2020 under the project – Nationally Determined Contribution - Transport Initiative for Asia (NDC-TIA), which is a joint programme of seven organisations and is funded by the International Climate Initiative (IKI) of the German Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The DLGM was developed jointly by Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ) GmbH, India and The Energy and Resources Institute (TERI), India. The website of DLGM was launched in November 2020, followed by continuous uploading of contents by TERI, GIZ, DLGM users, like-minded organisations, and government agencies.

3.1 Objectives

The Digital Library on Green Mobility (DLGM) is a knowledge-sharing platform that facilitates knowledge collaboration, augmentation and cooperation in green mobility with the following objectives:

- The portal will act as a national-level online knowledge and information compendium on e-mobility and low-emission transport for rapid expansion of stakeholders' network
- Keeping stakeholders up-to-date about the latest developments and providing them relevant sources of information they need to accelerate progress regarding Indian context
- Raising awareness by improving knowledge flow for information-seekers, educators, scholars, and general audiences enabling them to be gainfully employed

The DKL will evolve as a single window access point for e-mobility information in India. It will cater to diverse set of stakeholders such as government ministries, departments and agencies, Civil Society Organisations (CSOs), academia, citizens, research community, industry, businesses houses, consultants, etc using information posted in the DKL website, opening communication channels by organizing a few subject specific webinars, and publishing electronic newsletter.

4. METHODOLOGY

The major steps involved in the design and development of the DLGM portals are shown with the help of below (Fig. 1)

4.1 Stakeholder Identification

Experts in the EV domains were identified and consulted to understand the needs of the stakeholders and users of the web portal. Based on their inputs, a list of features was compiled to be included in the wireframe of the DLGM portal.

4.2 Survey of Existing Portal/Websites

Several knowledge platforms/websites exist in the e-mobility and clean transport domain that were surveyed and reviewed to decide the functionality of the DLGM website. One is the National Transportation Library (*https://ntl.bts.gov/)*[12], which collaborates with other public and private transportation libraries and information providers to increase information sharing throughout the transportation community and facilitates access to information required for decision-making in Government related to Transport. It has robust databases of resources with advanced search and display features. The IET Digital Library (*https://digital-library.theiet.org/*)[13] comprises a large number of technical papers, e-book chapters, magazines, conference publications and seminar digests with a robust search interface. Changing Transport (*https://changing-transport.org*)[14] is another platform that supports decision-makers in emerging and developing countries to facilitate climate action in Transport through training and consulting services and connecting stakeholders. Plug in India (*https://www.pluginindia.com*)[15], one of the country's oldest electric vehicle advocacy groups, manages and helps the growing EV owner community all over India by creating EV awareness content through its portal. EV owners usually publish content on this portal. These and a few more knowledge platforms were reviewed and evaluated based on the following aspects:

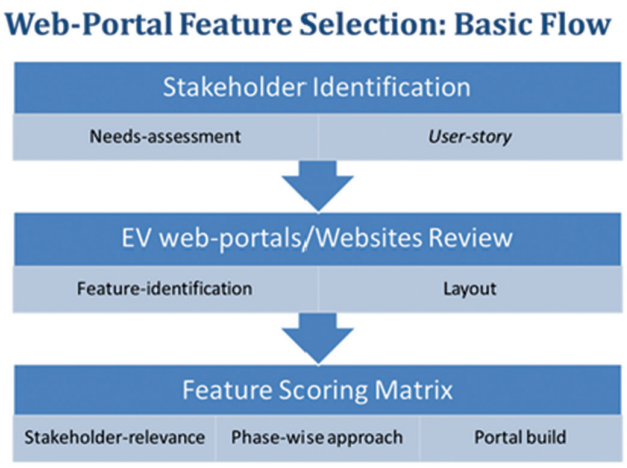

Figure 1. DLGM web portal basic flow of activities.

- Knowledge platforms deal extensively with the promotion and awareness of EV and e-mobility among stakeholders.
- Dedicated websites have information and knowledge resources on EVs for consumers/ users.
- Unique features such as robust databases of resources with advanced search and display features, Transport related thesaurus, and classification of documents with proper metadata.

A preliminary review of knowledge platforms/ websites was conducted to assess the knowledge services that are available online for users. A few scanned and reviewed websites are provided below, along with key parameters, as shown in Table 1.

The analysis of knowledge platforms suggests a few online sources for e-mobility data. However, a comprehensive website for sustainable clean transportation in India is unavailable.

4.3 Feature Matrix

A matrix having various functionalities and functions was prepared before designing the layout of the DLGM portal. The functionalities, as shown in Table 2, were incorporated to optimize user requirements.

4.4 Technology and Metadata Standard

The DLGM portal has been developed using MVC (Model- View- Controller) architecture and coding best practices have been followed. The benefits of using the MVC architecture are that the source code is modular, easy to reuse and extend.

Open-source technologies have been used to develop both Front-end website and Admin Panel for the portals. Dublin Core Metadata standards is followed for description of each knowledge item.

4.5 Design the Portal

Information architecture in the form of a prototype depicting screens, features and functionalities of the platform was developed, and the actual portal was designed according to architecture and inputs received from various stakeholders

5. ABOUT DIGITAL LIBRARYON GREEN MOBILITY (DLGM)

5.1 Objectives and Scope

DLGM has been developed under the India component of the NDC-TIA programme, which has been initiated to promote a comprehensive approach to decarbonizing Transport in India, Vietnam, and China. The NDC-TIA India Component intends to support the development of policies, strategies and regulations to encourage EV charging infrastructure uptake, facilitate wide-scale adoption of EVs in India, and promote outreach and upscaling of low-carbon transport among the public. Thus, DLGM was conceptualised with the following objectives:

- To consolidate scattered information on electric vehicles and low-carbon transport in a single platform
- Provide facility for knowledge sharing for collective content co-creation
- To align with the Government of India's plan of reducing GHG emissions from the transport sector through the promotion of E-mobility and other low-carbon technologies
- To provide knowledge support for policy formulation, research, and business inputs
- To raise awareness by improving knowledge flow to decision-makers, information-seekers, educators, scholars, and general audiences, enabling them to apply the knowledge gained for promoting low-carbon transportation

DLGM caters to diverse stakeholders and aims to offer a forum for various organisations and institutions from India and outside engaged in low-carbon transportation to exchange concepts, information, and draught agreements. It also intends to provide researchers, academics, people, and enterprises access to material such as standards, case studies, policy instruments, reports, articles, and books. DLGM resources give users access to the most recent information on low-emission transportation issues in general and e-mobility in specific India. This information includes news, policies, strategies, reports, interviews, documents, research papers, government notifications, etc. Several searchable databases and links to different stakeholder organisations have been created on DLGM Website and are regularly updated. One of the key benefits of DLGM is permitting the stakeholders to share pertinent resources that can be published on the Internet.

LGMwebsite can be accessed from the URL: https://greenmobility-library.org (Fig. 2). The home page provides access to all the resources/knowledge items arranged based on the nature of the contents. Users can access all resources uploaded on DLGM without registering. However, users need to log in/register to download the full-text reports and documents and share their content on the DLGM website.

5.2 DLGM Resources/Knowledge Items

DLGM contains around 3000 knowledge items and other resources for various stakeholders working in the green mobility and EV sectors. These resources can be

Table 1. Key parameters to determine the user-centric approach

Key parameters	URLs
• Basic information about users with the registration facility • Sections to highlight electric mobility, benefits of joining the website • Sections should be database and menu-driven with robust search mechanisms, including filtering options following exhaustive inbuilt thesaurus or taxonomy structure • Availability of important knowledge repositories on government policies, strategies and regulations, standards, government notifications, success stories, e-mobility data, skill development options, research areas (including projects), books, research articles, journals, forthcoming events, data dashboard, news and blogs, technology development, industry linkages, videos, podcast, links to other portals, and many more. • Directory of organizations, individuals, collaborators, and partners of e-mobility • Other user services include FAQs, query desk, on-demand web services, knowledge sharing options, etc. • Provision for Facebook, LinkedIn, and Twitter connectivity • RSS Feeds based on interest areas or news • Links to funders, collaborators, Government, multilateral, and bilateral organizations • A platform for visionaries and decision-makers to exchange ideas on contemporary mobility, develop ideas together, and explore advanced technologies.	1. https://www.changing-transport.org https://emobility.araiindia.com/ 2. https://saemobilus.sae.org/help/open-access/ 3. https://ntl.bts.gov/ 4. https://www.tuvsud.com/en-in/resource-centre 5. https://www.pluginindia.com/evcategory.html 6. https://www.eon.com/en/private-customers/emobility/electrified-talk.html 7. https://fame2.heavyindustry.gov.in/

Table 2. Functionalities and functions of DLGM

Functionalities	Functions of DLGM
A one-stop knowledge platform	• The website hosts metadata and full-text data under different knowledge components. • All the stakeholders from different tiers can access and share resources from this platform.
Multiple databases of different content types	• Different knowledge-based databases are in place with the appropriate metadata standard.
User subscription facility, User registration, and management	• Users can access all records regularly after registration with minimum data input. • User profiling is to be done per their requirement for the website's green mobility knowledge services.
Robust search interface	• Option for a quick and advanced search facility for document retrieval.
User-friendly display	• The search feature captures and displays results from all repositories as per user requirements. • Contents are displayed category-wise.
Document Access	• All users can access metadata. • Users need to subscribe to download the full-text documents.
Feedback/technical management	• The website can post feedback and queries, which could be technical or content-specific. • Admin to take appropriate actions to resolve the issues, if necessary and inform the member within a reasonable timeframe.

searched and browsed from respective sections. A list of those resources is shown in Table 3.

5.3 Methodology of Knowledge Resource Collection

The following methodology was practised for sourcing and collecting of knowledge resource for uploading on the DLGM website:

- Identify and study the relevant organisations' websites (and digital libraries) carefully on who is active in India in the electric mobility sector;
- Identify experts and resources existing in these organisations;
- Consultation with subject specialists to understand knowledge access points;
- Preparation of controlled vocabulary/taxonomy;
- Sourcing of knowledge resources from organisations websites, databases, and libraries;
- Developing criteria for data selection;
- Collecting unique information resources and data, evaluating the authenticity;
- Selection, analysis, and classification of information/ data as per metadata standard;
- Taking permission of copyright for resources, if necessary;
- Preparing abstracts for collected resources where required;
- Data mapping/visualisation using data tools such as Tableau Public or Power Bi;
- Peer review by subject experts.

Search engine optimisation (SEO) software is used for periodic checks for broken hyperlinks to provide users with seamless access to resources. The broken links are replaced with an active one after due checking.

5.4 Taxonomy Development

Taxonomy is one of the integral parts of any web-based search system. A hierarchical taxonomy framework has been used to organize vast resources logically and consistently into categories and subcategories for better information retrieval. Taxonomy tags have been used to manage content in DLGM to optimize the search and retrieval of information. All information in the portal is tagged with a comprehensive taxonomy of subject terms, making searching and retrieving resources more accurate, relevant, and contextual.

The taxonomy has been classified into themes, sub-themes, and tags or keywords (Fig. 3). A team of subject experts on the electric mobility and clean transportation sector from TERI and GIZ, with support from other research/government organisations and knowledge experts, have developed a three-layered taxonomy structure for DLGM. A pilot study was conducted to measure the effectiveness of information retrieval from databases.

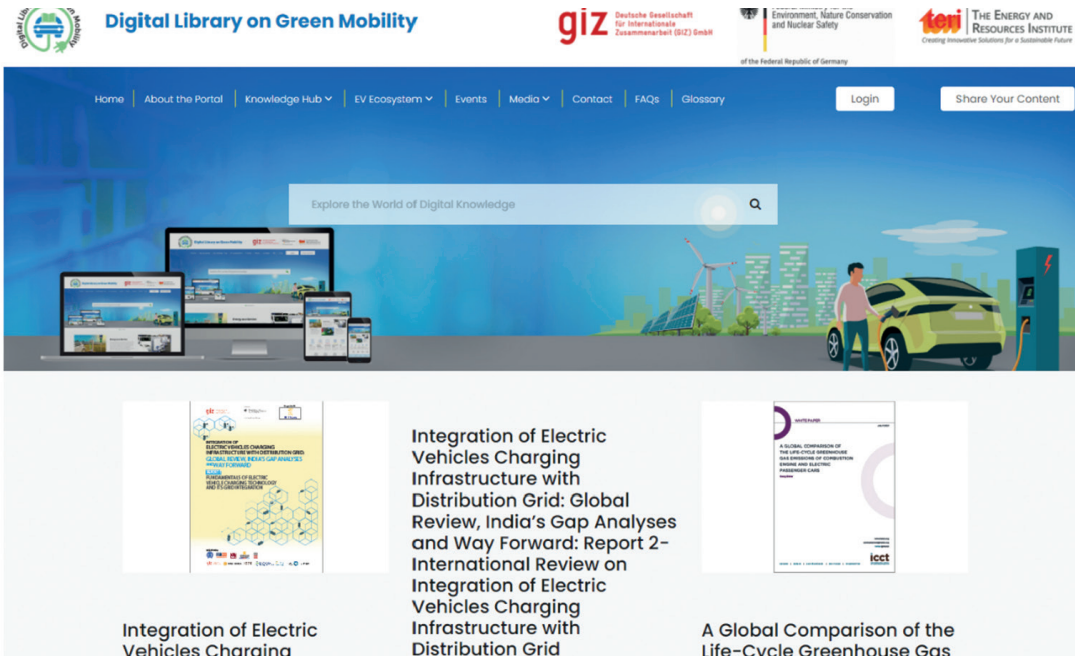

Figure 2. DLGM home page < https://greenmobility-library.org/>

Table 3. DLGM knowledge items

• Books	• Standards
• Case studies	• Theses/Dissertations
• Journals	• Training materials/ manuals
• Opinion/Videos	• EV Commercials
• Policies/Regulations/Strategies	• Linkages
• Reports	• News/Press releases
• Research papers/Articles	• Events
• Working papers/ Policy briefs	• Glossary

5.5 Search Features

DLGM platform provides both simple and advanced search facilities where resources can be searched by putting keywords and filtering the resources with the help of various filters given on the website. Searching by keyword is a free text search without case sensitivity that lets users search for a value across all of your resources' attributes. An example of a simple search window is given in (Fig. 4).

5.6 Searching and Filtering Resources

A search filter is a specific attribute that can be used to improve the search results of a particular resource listing page. DLGM search results can be further refined by selecting year, resource type, country, theme, subthemes, tags, publisher, and organisation. Search results can further be sorted out in ascending and descending order. The end-user can retrieve the most pertinent search results based on their chosen criteria by applying many filters to narrow down a wide range of resources (Fig. 5). This is done to help the DLGM users achieve maximum resource discoverability and reduce navigation friction to select relevant knowledge items.

5.7 Semantic Search of Documents

Semantic search is a method of data searching where a search query seeks to locate keywords and ascertain the intent and contextual meaning of the words a person is used to searching. The DLGM search includes the feature 'Related Documents' whereby users can view and retrieve other documents relevant to their search item from the entire resource database.

5.8 User Trends and Behaviour

The stakeholders of DLGM comprise decision-makers, researchers, academicians, citizens, and businesses involved in the fields related to sustainable

transportation. The usage trend and user behaviour were analysed using Google Analytics. A user feedback analysis of DLGM was carried out from May to June 2021 to assess users' feedback.

5.9 Users' Profile

The knowledge resources in DLGM are used most by researchers/academicians, as this category comprises 53 % of the total users surveyed. Other user categories include administrators and government officials (10 %). The different user categories contain communication and knowledge professionals, consultants and corporate workers, journalists, and editors, including civil society (Fig. 6).

According to usage analytics, most users are from desktop devices. The DLGM Homepage, followed by the Login page, are the most visited pages by users.

5.10 Demographic Metric

Most of the knowledge resources in DLGM are India-centric, so most of the users are from India. As of December 31, 2021, the total number of users from India was 5325. This trend signifies the increasing interest in low-carbon transportation areas by the stakeholders in the country. This is followed by the USA (with 955 users) and Germany (with 248 users).

5.11 Rationale for Using DLGM

Stakeholders visit DLGM for various purposes; however, most users visit DLGM to enhance their knowledge base. Based on the user survey conducted in May-June 2021, over 72 % of the respondents use DLGM for knowledge enhancement. Users have multiple purposes for accessing DLGM resources. 39 % of users visit DLGM for research and academic goals, while 36 % use it for keeping abreast of current news and events. 21 % of users visit DLGM to access government policies, strategies, and notifications, and 9 % visit DLGM for commercial and business purposes (Fig. 7).

5.12 Rating of DLGM by Users

DLGM features and accessibility are two significant aspects of user access. Survey respondents were requested to rate DLGM in terms of features and accessibility (5 being highest, 1 being lowest). 54.24 % of respondents rated DLGM '5' regarding DLGM features (Fig. 8).

Over 50 % of respondents rated DLGM '5' in terms of accessibility of DLGM (Fig. 9)

The rating by users signified that most users are satisfied with the various features and accessibility to knowledge resources in DLGM.

6. REACHING OUT TO END USERS

Promoting the portal is an essential component of awareness generation amongst potential users of developments in low-carbon transportation. Strengthening the outreach of DLGM amongst the relevant stakeholders through periodic updates and other means promotes knowledge building to make research and policy frameworks more effective in achieving the intended goals.

DLGM was promoted through webinars, promotional emails, flyers, and social media. For promoting DLGM activities such as webinars and new additions to the website, emails were sent to all DLGM registered users and other professionals working on EV/sustainable mobility sector comprising researchers and industry experts. An overview presentation and demo of DLGM was held at the "Global Online Proficiency Improvement Programme" organised by the Automotive Research

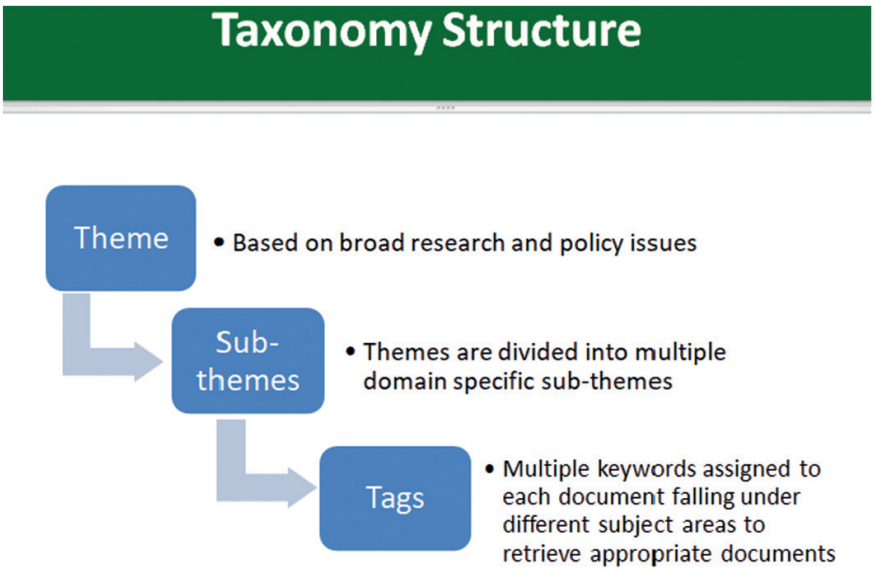

Figure 3. DLGM taxonomy structure.

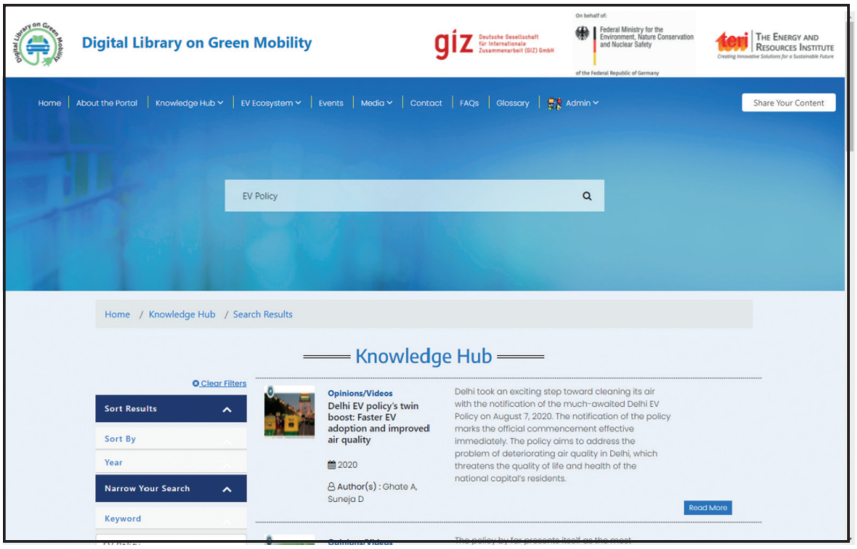

Figure 4. DLGM home page search.

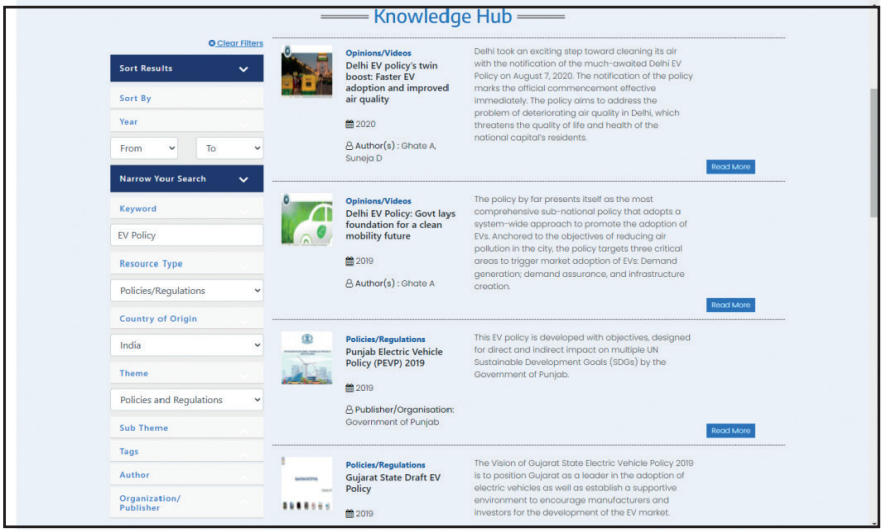

Figure 5. DLGM search filters.

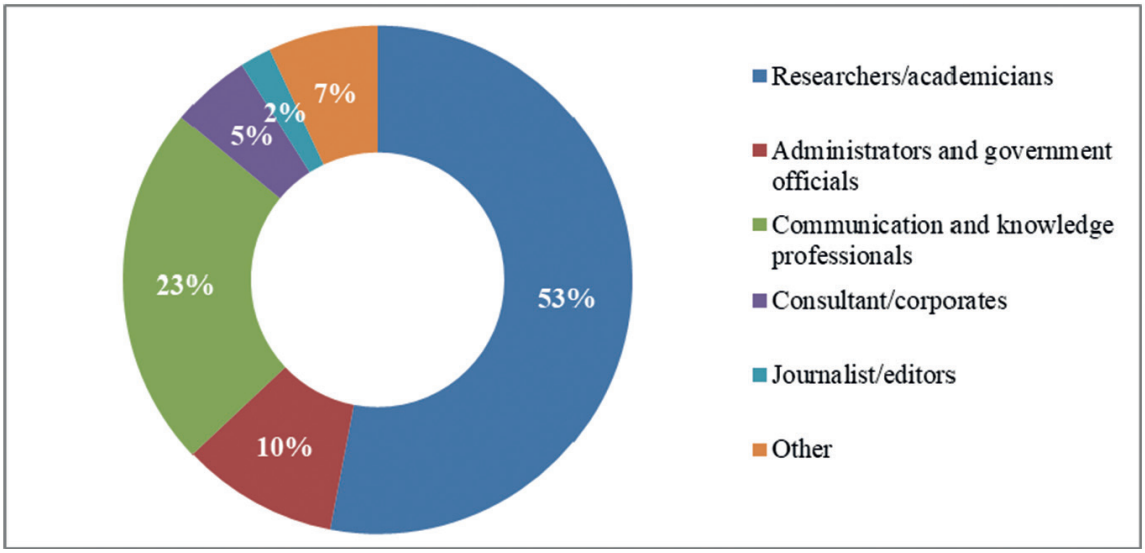

Figure 6. Profile of DLGM users.

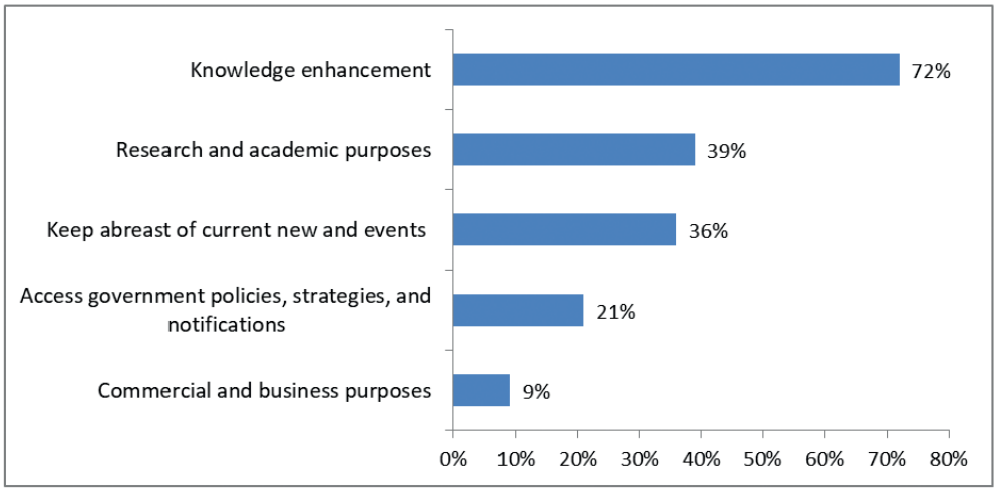

Figure 7. Rationale for using DLGM.

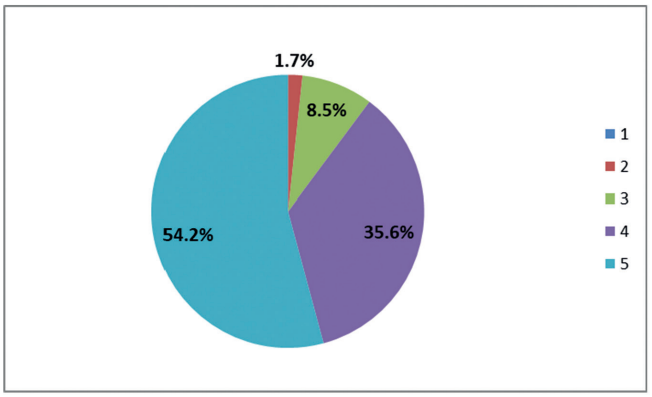

Figure 8. Rating of DLGM in terms of feature.

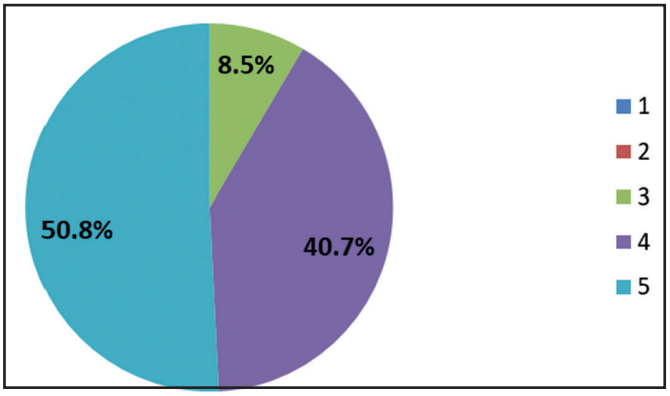

Figure 9. Rating of DLGM in terms of 'Accessibility.

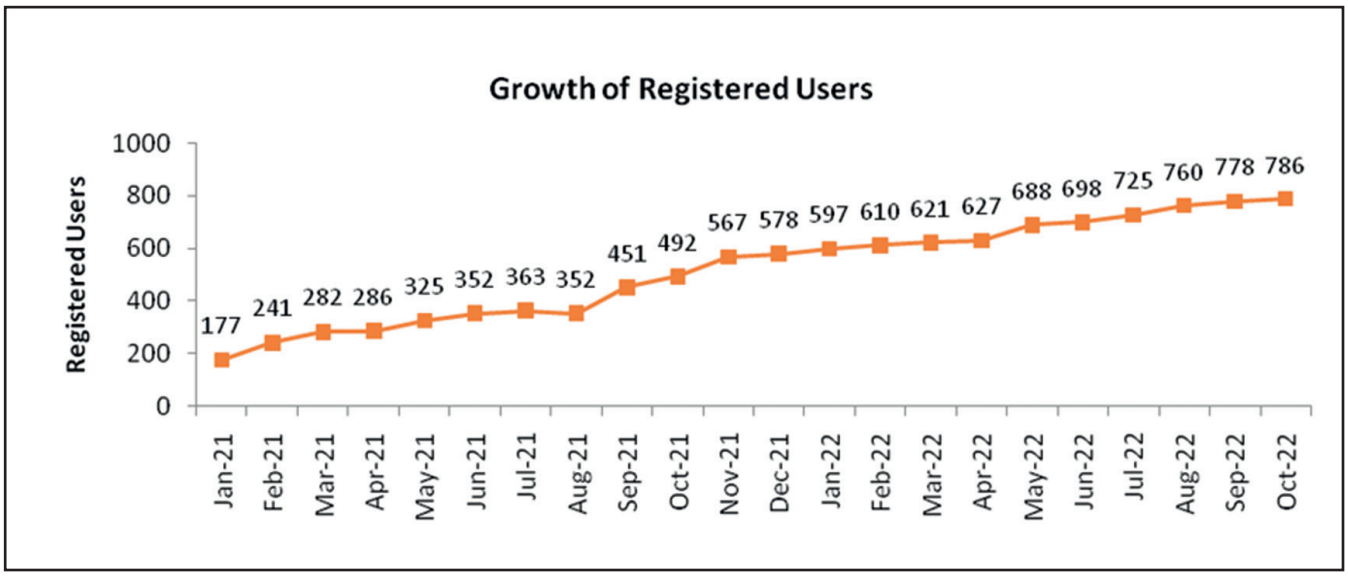

Figure 10. Growth of registered users.

Association of India (ARAI), Pune, on 9 April 2021 where 153 participants attended. GIZ India and TERI organised the "Driving Green Mobility through Knowledge Sharing Platforms" webinar on 22 June 2021 as part of TCC Transport Week 2021.

DLGM uses Google Analytics to evaluate the use of the website. Google Analytics is used to track website activity and key factors such as session duration, pages per session, bounce rate, etc. of individuals using the site, along with the information on the traffic source. Each page of the DLGM website has Google Analytics code installed in the head section allowing the administrator to track every page visit. Additionally, Google Analytics is also tracking the PDF downloads on each page.

By Oct 2022, the website achieved knowledge dissemination to 14814 users with over 78135 cumulative visits. User registration is an essential prerequisite for the success of online knowledge platforms by enabling users to gain access to specific features of websites. DLGM has 786 registered users till October 2022 from 11 countries who have downloaded more than 3000 reports. The growth of registered users, as depicted in (Fig. 10), signifies the gradual increase in usage and contribution of knowledge resources by the users.

Social media engagement is now integral to any promotional strategy as it has become a natural forum for people to share opinions, information, and ideas. Important updates to DLGM were disseminated through social media to reach wider stakeholders. Regular posts on Facebook, LinkedIn, and Twitter have ensured continuous outreach of the updates in DLGM to relevant stakeholders.

7. CONCLUSIONS

As the world moves towards a low-carbon economy and transport system, the significance of a digital platform is reinforced as it facilitates stakeholders to connect with a wide variety of knowledge resources on green mobility. DLGM seeks to help policy and decision-makers, the research and academic community, and civil society to keep abreast of topical and contemporary developments to help them comprehend green mobility issues and their efficacy in different settings. The main benefit of DLGM is the increased awareness and outreach of knowledge on low-carbon transportation that results from the following aspects:

- Organised and structured information which is easy to navigate;
- Quick access to relevant policies, strategies, research and development outputs, case studies and expert viewpoints;
- Enhanced search capabilities that reduce the amount of time necessary to find sought-after information;
- Filtered, targeted, and categorised information, so users receive just what they need; and
- Promotion and advocacy of green mobility.

8. FUTURE PLANS

New technologies and changing consumer preferences will help reshape the automotive industry in the years ahead. The rapid innovation in EV technologies accelerates the outlook for electric vehicles. As electric mobility is an emerging sector, EV technologies are constantly evolving through new innovations. After scrutinizing several digital libraries and portals on contemporary topics and discussions with subject experts, the project team identified that a section 'EV Technologies' would add significant value to the Digital Library as currently there is no such platform where stakeholders can access details on various EV technologies in a single window in India.

The section will consolidate information on all such prevailing technologies to disseminate knowledge for policy formulation by the Government and enable researchers and industry professionals to identify/ comprehend the available technologies.

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