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Citizen Science Practices in Malaysia (2015–2024): A Systematic Literature Review

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Abstract: Citizen science (CS) practices in Malaysia are expanding; however, consolidated knowledge of their scope, contributions, and alignment with the Sustainable Development Goals (SDGs) remains limited. This review aims to: (1) analyse the implementation of CS projects in Malaysia; (2) evaluate their scientific, societal, and governance contributions; and (3) assess their alignment with the SDGs. The analysis focuses on CS projects conducted between 2015 and 2024, drawing on literature published up to April 2025. A total of 24 projects were reviewed using a structured approach guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), based on publications retrieved from Scopus, Web of Science, and Google Scholar. The findings indicate that conservation and ecology dominate the thematic focus of CS projects in Malaysia. Most initiatives rely on primary data collection, although the use of digital platforms for secondary data is increasing, particularly for large-scale ecological and spatial analyses. While scientific contributions are the most prominent, several projects also demonstrate governance relevance, reflecting growing recognition of citizen-generated data in environmental decision-making. The primary SDGs addressed are SDG 15 (Life on Land), SDG 14 (Life Below Water), and SDG 12 (Responsible Consumption and Production). The review further identifies a significant gap in the reporting of CS project alignment with the SDGs, which limits their visibility and policy relevance. Strengthening institutional mechanisms, such as integrating SDG considerations into reporting frameworks and national monitoring platforms, could enhance the contribution of citizen-generated data to SDG tracking. Future research should explore CS contributions to underrepresented social and economic SDGs in Malaysia.

Keywords: Citizen Science; Sustainable Development Goals (SDG); SDG alignment; Systematic Literature Review; Malaysia

1.0 Introduction

Citizen science (CS) is broadly defined as the involvement of individuals without formal scientific training in research activities, typically in collaboration with professional scientists (Eitzel et al., 2017). It refers to the active participation of the public in various aspects of the research process, including data collection, classification, analysis, and dissemination of findings, thereby contributing to both scientific outcomes and public engagement (Bonney et al., 2009; Vohland et al., 2021). Expanding on this, Haklay et al. (2021) highlight that CS encompasses diverse forms of public participation in the production of scientific knowledge. It also intersects with related approaches such as community science, civic science, participatory mapping, and citizen-generated data. Taken together, these efforts demonstrate that CS fosters collaboration between scientists and the public, supporting research while enhancing societal awareness and public involvement.

Nevertheless, public participation refers to the process through which individuals, groups, and organisations actively engage in decision-making that affects them, whereby their concerns, needs, and values are incorporated into governmental and corporate policies and practices (Reed, 2008; Creighton, 2005). In other words, it involves citizens sharing their views, ideas, and concerns. According to Lenart-Gansiniec et al. (2023), crowdsourcing in science is a collaborative online approach in which researchers invite self-selected participants, through Internet- or platform-based calls, to perform specific research tasks. It intersects with public participation but extends further within CS, as non-professionals contribute directly to knowledge production, particularly through digital platforms that engage large groups of volunteers.

Earlier scholars have identified three core purposes of citizen-generated data, namely community engagement, public governance, and scientific research (European Commission, Directorate-General for the Environment, 2018; Kieslinger et al., 2017; Turrini et al., 2018). Building on this, more recent analysis by Ballerini and Bergh (2021) indicates that citizen-generated data are primarily produced for four key purposes: community impact, public governance, scientific research, and statistical applications. With growing recognition of its diverse purposes, CS has expanded globally over the past decade. Earlier studies show that CS was predominantly implemented in industrialised countries such as the United States, European nations, and Australia, before later extending to China and parts of the Global South (Shulla et al., 2020). However, CS remains underrepresented in many developing countries, constrained by issues of accountability, data accuracy, trust, and cultural norms (Pocock et al., 2019). Supporting these observations, Davis et al. (2023) found that North America accounted for nearly half of global CS projects (49.1%), mostly in the United States (85.4%), followed by Europe (13.0%) and Oceania (11.4%). Asia accounted for only 3.2% and other regions 2.0%, while 21.3% were global initiatives.

In terms of disciplinary focus, CS projects span various research fields. Biology dominates the sampled CS projects (65.8%), followed by environmental science (14.2%), astronomy (5.9%), and multidisciplinary sciences (3.9%), with other disciplines each below 3% (Davis et al., 2023). Pelacho et al. (2021) similarly found that CS publications are concentrated in biology and life sciences (44.4%), followed by environmental science (23.1%), computer and information science (9.5%), multidisciplinary sciences (9.4%), and astronomy (5.2%), with smaller shares in engineering, biotechnology, and geography.

Adopted by all UN Member States in 2015, the 2030 Agenda for Sustainable Development sets out 17 Sustainable Development Goals (SDGs) to be implemented between 2016 and 2030. These goals aim to end poverty, improve health and education, reduce inequality, foster economic growth, address climate change, and protect ecosystems (United Nations, 2015). To monitor SDG progress effectively, decision-makers require accurate, timely, disaggregated, and user-friendly data (United Nations Statistics Division, 2017). Recent studies have shown that citizen-generated data can be effectively used for SDG reporting and monitoring (Fritz et al., 2019; Shulla et al., 2020; Voigt-Heucke et al., 2023). According to Fraisl et al. (2020), CS currently supports the tracking of five SDG indicators and has the potential to contribute to an additional 76 indicators, approximately one-third of all SDG indicators.

The evolution of CS in Malaysia is evident through project implementation and the growing role of institutions such as libraries and universities. Studies by Nurfarawahidah et al. (2023, 2024, 2025) show that libraries are shifting from providing educational and data support to becoming transformative actors advancing the SDGs and scientific literacy. Universities are also institutionalising CS, with initiatives such as Universiti Sains Malaysia's Campus Nature Challenge (Che Jaafar et al., 2024) and Universiti Teknologi Malaysia's Citizen Science Bootcamps

(ESTI, 2023). These developments position libraries and universities as key drivers of CS, both as knowledge intermediaries and as leaders of sustainability-focused initiatives.

CS projects in Malaysia are expanding in areas such as conservation, biodiversity, and community engagement; however, consolidated knowledge of their scope, contributions, and SDG alignment remains limited. A systematic literature review (SLR), as emphasised by Pati and Lorusso (2018), offers a rigorous approach to synthesising evidence. Thus, an SLR of Malaysian CS and its SDG alignment (2015–2024) is both timely and necessary. This article seeks to address these gaps by examining and synthesising 24 CS-related studies conducted in Malaysia between 2015 and 2024. Aligned with the research questions and objectives, the review aims to: (1) analyse the implementation of CS projects in Malaysia; (2) evaluate their scientific, societal, and governance contributions; and (3) assess their alignment with the SDGs. By mapping key trends in implementation, evaluating contributions across scientific, societal, and governance domains, and assessing SDG alignment, this article provides a comprehensive understanding of Malaysia's CS landscape and offers insights for future policy, practice, and research.

2.0 Study Area

Malaysia is a country with an extensive coastline, rich natural resources, and diverse marine and terrestrial wildlife. The country covers an area of 330,122.7 square kilometres and has a coastline measuring 8,840 kilometres, encompassing both Peninsular and East Malaysian territories, as well as numerous offshore islands (Department of Statistics Malaysia, 2024). Malaysia was selected as the study area because it is recognised as one of the world's megadiverse countries, ranking among the top twelve biodiversity-rich nations in terms of species richness and endemism. Its biological diversity spans ecosystems, species, and genetic levels, encompassing an extraordinary range of flora and fauna. The country hosts an estimated 15,000 species of vascular plants, including approximately 8,300 species in Peninsular Malaysia and 12,000 species in Sabah and Sarawak. Its faunal diversity includes 306 species of mammals, 742 species of birds, 654 species of amphibians, 506 species of reptiles, and 2,068 species of freshwater and marine fish (Ministry of Natural Resources, Environment and Climate Change [NRECC], 2022). In terms of marine biodiversity, Malaysia possesses approximately 4,006 km² of coral reef area, making it part of the Coral Triangle, a region recognised for having the highest marine biodiversity in the world. More than 550 coral species have been recorded in East Malaysia and over 480 species in Peninsular Malaysia (International Coral Reef Initiative [ICRI], 2025). At the regional level, Malaysia's commitment to sustainability was reaffirmed during the 47th ASEAN Summit held in Kuala Lumpur in October 2025, where ASEAN member states adopted the ASEAN Declaration on the Right to a Safe, Clean, Healthy and Sustainable Environment. The declaration explicitly identifies climate change, biodiversity loss, and environmental pollution as a "triple planetary crisis" for the region (Association of Southeast Asian Nations [ASEAN], 2025). This reinforces Malaysia's regional role and its alignment with both global and ASEAN environmental priorities. Taken together, these ecological and policy attributes underscore Malaysia's significance as a strategic and representative case for examining how CS can support biodiversity conservation and sustainable development efforts in Southeast Asia.

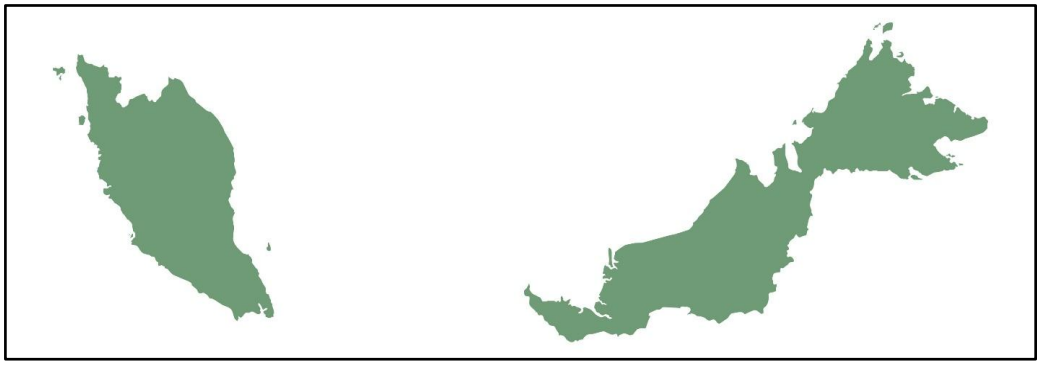

Figure 1: Map of Malaysia.

3.0 Materials and Methodology

3.1 Study Design

This study adopts the Systematic Literature Review (SLR) method. An SLR is a structured and methodical approach to collecting, critically evaluating, synthesising, and presenting findings from multiple research studies that address a specific research question or topic of interest, thereby providing a more comprehensive and reliable understanding than a traditional literature review (Pati and Lorusso, 2018). It enables a comprehensive examination of diverse studies published in scientific journals, revealing key trends and patterns in citizen science (CS) initiatives. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol was adopted to guide the systematic review process (Moher et al., 2009). The review followed four key phases: identification, screening, eligibility, and analysis. The reporting of this review adheres to the PRISMA 2020 guidelines to ensure transparency and reproducibility.

3.2 Research Questions

In this SLR, the study is guided by three research questions structured around key analytical dimensions. The first research question focuses on the project overview and scope by examining the implementation characteristics of citizen science projects in Malaysia. The second research question addresses the key contributions of citizen science projects across scientific, governance, and societal dimensions. The third research question examines the extent to which citizen science projects in Malaysia are aligned with the Sustainable Development Goals (SDGs), categorised as explicit, indirect, or no alignment.

Table 1: Research questions and analytical framework for the systematic literature review.

Inquiry Area	Research Question	Possible Answers
Project Overview and Scope	What are the implementation criteria of CS projects in Malaysia?	• Project theme • Project location Methodology (including data collection methods, data sources, and analysis techniques) • Technology used
Key Contributions	What are the key contributions of CS projects in Malaysia across scientific, governance and societal dimensions?	• Scientific dimension • Governance dimension • Societal dimension
SDG Integration	How are the SDG integrated within CS projects in Malaysia?	Level of SDG Integration: • Explicit integration: SDG goals or targets are clearly stated. • Indirect integration: The study aligns with SDG themes (e.g., marine pollution, biodiversity) but does not mention SDGs explicitly. • No integration: No mention or alignment with any SDG goals, targets, or indicators.

3.3 Identification

At the identification phase, relevant literature was systematically retrieved from Scopus and Web of Science, both renowned for their comprehensive peer-reviewed coverage, while Google Scholar was used as a supplementary source to capture a broader range of scholarly materials. Articles were retrieved between 16 April 2025 and 14 May 2025, covering literature published from January 2015 to April 2025, using database-specific Boolean operator-based search strategies applied separately across Scopus, Web of Science, and Google Scholar, as summarised in Table 2. Although the literature search was conducted up to April 2025, the analytical scope of this review is restricted to CS projects implemented between 2015 and 2024, regardless of publication year. Studies published after 2024 were included only if they reported on projects conducted within this defined period.

The search string for Google Scholar was structured differently because the database does not provide a function to limit searches to the title, abstract, and keywords. Instead, the ALLINTITLE operator restricts the search to titles that contain the specified keywords, ensuring that retrieved studies are highly relevant to citizen science projects in Malaysia. Without this restriction, the search would extend to the full text of articles, including references, resulting in an excessively large number of results. These search combinations were used to ensure that the retrieved studies were relevant to the Malaysian context and focused primarily on CS initiatives. This process resulted in an initial yield of 1,608 articles. The full database-specific search strings, including Boolean operators, are provided in Appendix A.

Table 2: Search strategies in three databases.

Database	Search Strategy	Article
Web of Science	TS= (("citizen science" OR "citizen science project" OR "participatory science" OR "participatory community science" OR "crowdsourcing") AND "Malaysia")	231
Scopus	TITLE-ABS-KEY (("citizen science" OR "citizen science project" OR "participatory science" OR "participatory community science" OR "crowdsourcing") AND "Malaysia")	107
Google Scholar	ALLINTITLE: Malaysia AND ("Citizen Science Data" OR "Citizen Science Project")	1270

3.4 Screening

This phase was conducted to ensure the systematic identification, selection, and inclusion of relevant studies. A total of 1,608 records were initially retrieved from three databases: Web of Science (n = 231), Scopus (n = 107), and Google Scholar (n = 1,270). After removing duplicates (n = 52), 1,556 records remained for screening. Duplicates were identified and removed by comparing article titles, author names, publication years, and source journals. The titles and abstracts of the articles were screened based on predefined inclusion and exclusion criteria (see Table 3), which included resource type, document type, language, access type, publication year, and project location. Articles that appeared to meet the inclusion criteria were retained for further assessment. A total of 1,519 records were excluded for not meeting the eligibility criteria. Exclusions included non-peer-reviewed sources (e.g., proceedings, book chapters, and reviews), non-research formats (e.g., seminar papers, opinion pieces, and taxonomy notes), non-English or non–open access publications, studies published before 2015, and projects conducted outside Malaysia. The screening of title and abstract was conducted by a single reviewer. Articles with ambiguous relevance were retained for full-text assessment to minimise exclusion bias.

Table 3: Inclusion and exclusion criteria for selecting eligible articles

Criteria	Eligibility	Exclusion
Types of resources	Journal	Conference proceedings, review articles, book chapters
Type of document	Research Article	Books, seminar papers, conceptual/opinion papers, short communications, review articles, taxonomy focused articles
Language	English	Other than English
Type of Access	Open Access	Non-open access
Period	2015–2024 (projects implemented); publications searched until April 2025	Published before 2015
Citizen science involvement	Public participation in scientific data collection, monitoring, or validation	Survey-based or awareness studies without citizen involvement in data generation
Location of the CS Project	Malaysia	Projects conducted outside Malaysia

3.5 Eligibility

A total of 37 full-text articles were assessed against predefined criteria, focusing on journal articles published in English, open access availability, and the implementation of CS projects in Malaysia. During this phase, 13 articles were excluded due to limited relevance, lack of open access, taxonomic focus, short communications, or non-journal formats such as book chapters and conference proceedings. Reasons for full-text exclusion included a lack of relevance to CS, absence of empirical data, non–open access availability, and projects conducted outside Malaysia. As a result, 24 articles were included in the qualitative synthesis (Figure 2).

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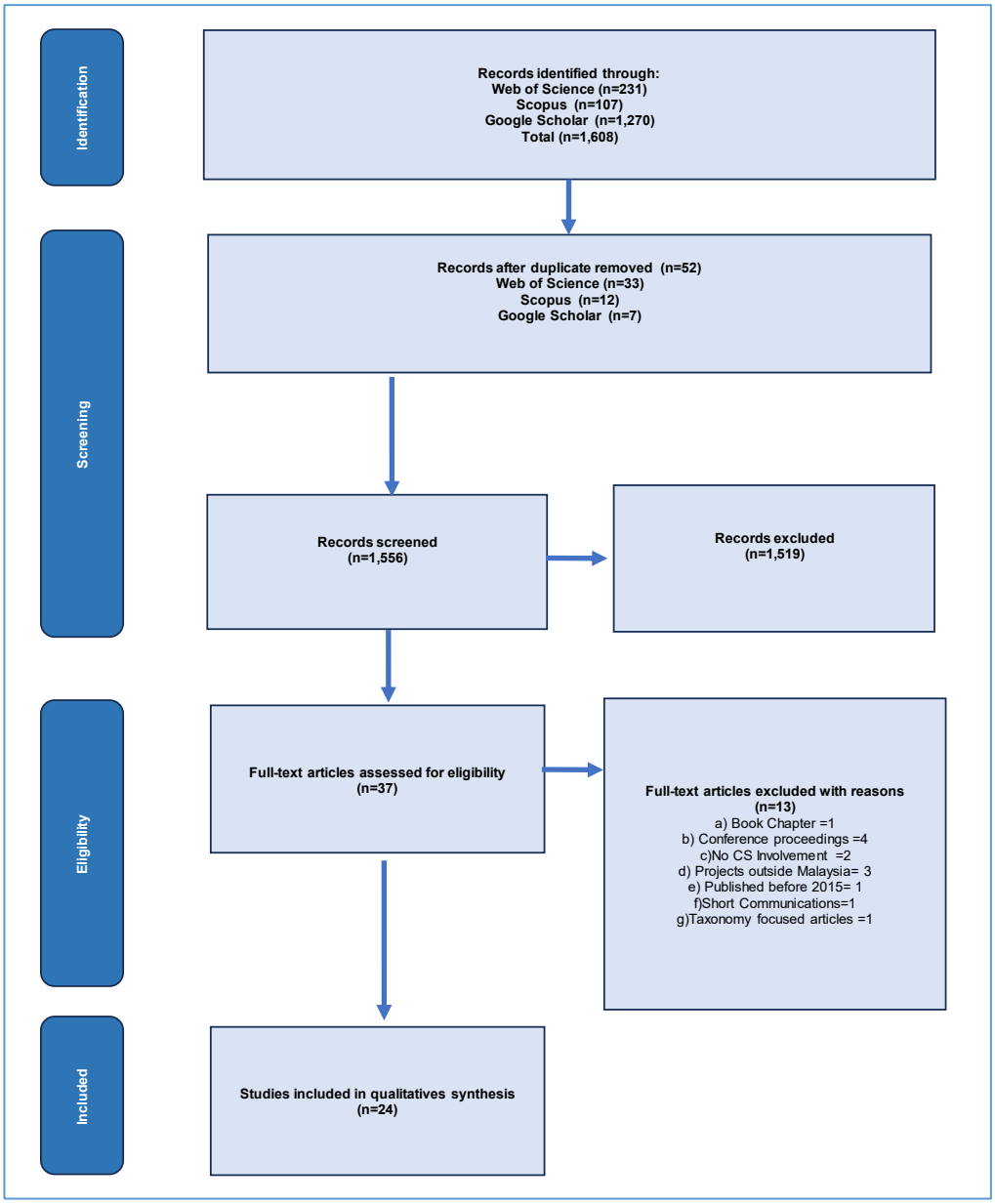

Figure 2: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method

3.6 Analysis

The next steps involved data extraction and synthesis. During data extraction, the selected studies were systematically examined, summarised, and coded to address the research questions. Microsoft Excel was used as the extraction tool, and the following variables were recorded: Author (Year), Project Year, Data Source, Project Theme, Location, Methodology, Technology, Contribution, SDG, SDG Integration Level, Funding Agency, Types of Impact, Main Findings, and Research Gap. For temporal analysis, each CS project was assigned a single "project year" based on the final year of reported data collection or project implementation, as indicated in the source publication or project documentation. When an explicit end year was not stated, the publication year was used as a proxy. This definition was applied consistently across Table 4 and all figures presenting temporal trends. As a sensitivity check, we examined whether using the publication year instead of the project year would change the observed trends. The overall patterns in data collection methods remained similar, and the main descriptive conclusions were unchanged. The extracted information was compiled into Table 4, which presents the 24 CS projects in Malaysia (2015–2024), categorised by project scope, contribution type, and SDG integration. Visual summaries of descriptive characteristics are provided in Figures 3 to 14. Data synthesis was then conducted by integrating findings across the studies to identify patterns, highlight contributions, and draw conclusions relevant to the research objectives. The analysis combined descriptive and thematic approaches. Descriptive analysis was used to present the distribution of studies by year, theme, location, data source, methodology, technology, contribution, SDG integration, and funding source (Figures 3–14). Meanwhile, thematic analysis was applied to interpret patterns and explain underlying factors, such as the dominance of primary data projects, the prevalence of scientific contributions, and the limited explicit integration of SDGs within CS projects in Malaysia.

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Table 4: List of 24 Citizen science projects implemented in malaysia (2015-2024) categorized by project scope, contribution type, and SDG Integration.

No.	Author (Publication Year)	Project Year	Data Source	Project Theme	Location	Methodology	Technology	Contribution	SDG	SDG Integration Level
1	Wilson et al., 2015	2015	Primary	Conservation	Peninsular Malaysia	Observation	GIS & Spatial Tools	Scientific	15	Indirect
2	Puan et al., 2015	2015	Secondary	Conservation	Sabah Sarawak	Secondary Data Analysis	GIS & Spatial Tools	Scientific	15	Indirect
3	Zulhaimi et al., 2017	2017	Primary	Pollution & Waste Management	Sabah	Observation and Survey	Survey-based Tools	Societal	12	Indirect
4	Ng et al., 2017	2016	Primary	Conservation	Sabah	Observation	Mobile & App-based tools	Scientific	14	Indirect
5	Long et al., 2017	2016	Primary	Marine	Terengganu	Observation and Photo from Public	Molecular/Imaging Tools	Scientific	14	Indirect
6	Zauki et al., 2019	2016	Primary	Marine	Kelantan	Observation	Mobile & App-based tools	Scientific	14	Indirect
7	Puan et al., 2019	2019	Primary	Urban Ecology	Selangor and Kuala Lumpur	Observation	GIS & Spatial Tools	Scientific and Governance	15	Indirect
8	Lau et al., 2019	2018	Primary	Marine	Pahang	Observation	GIS & Spatial Tools	Scientific and Governance	14	Indirect
9	Rameli et al., 2020	2020	Secondary	Conservation	Peninsular Malaysia	Secondary Data Analysis	Molecular/Imaging Tools	Scientific	15	Indirect
10	van Emmerik et al., 2020	2020	Primary	Pollution & Waste Management	Selangor	Observation	Mobile & App-based tools	Scientific	14	Indirect
11	Mansor et al., 2021	2016	Primary	Urban Ecology	Peninsular Malaysia	Observation	Mobile & App-based tools	Scientific	15	Indirect
12	Lim et al., 2021	2020	Primary	Conservation	Sabah	Observation	GIS & Spatial Tools	Scientific and Governance	14	Indirect
13	Oram et al., 2022	2020	Primary	Conservation	Sabah	Observation and Interview	Survey-based Tools	Scientific and Governance	15	Indirect
14	Idris et al., 2022	2021	Primary	Environmental Education	Malaysia	Observation	Mobile & App-based tools	Societal	15	Explicit
15	Arazmi et al., 2022	2022	Secondary	Urban Ecology	Peninsular Malaysia	Secondary Data Analysis	GIS & Spatial Tools	Scientific and Governance	15	Indirect

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No.	Author (Publication Year)	Project Year	Data Source	Project Theme	Location	Methodology	Technology	Contribution	SDG	SDG Integration Level
16	Catarino et al., 2023	2022	Primary	Pollution & Waste Management	Sabah Sarawak	Survey	Mobile & App-based tools	Scientific and Societal	14	Explicit
17	Madi et al., 2023	2023	Secondary	Urban Ecology	Selangor, Kuala Lumpur, Putrajaya	Secondary Data Analysis	GIS & Spatial Tools	Scientific and Governance	15	Indirect
18	Tolohah et al., 2023	2023	Secondary	Conservation	Peninsular Malaysia	Secondary Data Analysis	GIS & Spatial Tools	Scientific	15	Indirect
19	Mohamad Safawi et al., 2023	2023	Secondary	Conservation	Perak	Secondary Data Analysis	GIS & Spatial Tools	Scientific and Governance	15	Indirect
20	Muhammad et al., 2023	2023	Mixed	Conservation	Peninsular Malaysia	Specimen Examination and Secondary Data Analysis	Molecular/Imaging Tools	Scientific	15	Indirect
21	Fauzi et al., 2024	2022	Primary	Conservation	Perak	Observation	Mobile & App-based tools	Scientific and Societal	15	Explicit
22	Wee et al., 2024	2021	Mixed	Conservation	Sarawak	Secondary Data Analysis and Interview	GIS & Spatial Tools	Scientific	15	Indirect
23	Aqmal-Naser et al., 2024	2024	Secondary	Conservation	Peninsular Malaysia	Secondary Data Analysis	GIS & Spatial Tools	Scientific and Governance	14	Indirect
24	Yong et al., 2025	2023	Mixed	Marine	Pahang	Survey, Observation and Secondary data Analysis	Remote Sensing	Scientific and Governance	14	Indirect

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4.0 Results

This section presents an analysis of 24 selected articles, focusing on three key dimensions, namely project overview and scope, key contributions, and SDG integration (see Table 4). The findings do not represent all CS projects in Malaysia, as the review is limited to published academic literature. For project year classification, primary data studies were dated based on the year in which data collection ended, secondary data studies were assigned the publication year, and mixed-method projects were dated according to the completion of primary data collection.

4.1 Project Overview and Scope

4.1.1 Project themes

Figure 3 shows the thematic distribution of CS projects in Malaysia (2015–2024). The project themes were categorised into five main areas, namely conservation; urban ecology; marine; pollution and waste management; and environmental education. The most prominent thematic focus is conservation-related monitoring, accounting for 12 out of 24 projects. This includes bird monitoring (4 projects), fish monitoring (2 projects), butterfly monitoring (1 project), insect monitoring (1 project), wildlife monitoring (1 project), biodiversity mapping and monitoring (2 projects), and tree inventories (1 project), indicating a strong national emphasis on biodiversity protection, species monitoring, habitat preservation, and ecological mapping. The urban ecology theme (4 projects) focuses on studying birds and their relationships with urban environmental factors such as vegetation cover, water bodies, green spaces, and built-up areas. Marine-related initiatives (4 projects) highlight Malaysia's engagement with coastal and marine conservation under SDG 14 (Life Below Water), including efforts such as identifying individual turtles through underwater photography, monitoring horseshoe crab spawning and supporting beach restoration, mapping coral cover with local divers, and modelling potential coral reef habitats for spatial planning. Pollution and waste management (3 projects) demonstrate efforts to involve citizens in addressing environmental pollution by engaging students to quantify and analyse solid waste, enabling volunteers to report riverine and floating plastic waste using mobile applications, and involving school students in beach sampling to assess macro-, meso-, and microplastics. Environmental education (1 project) reflects an emerging focus on public awareness through tree planting coordinated via the Geo Trees mobile Geographic Information System (GIS) platform, involving teachers and parents.

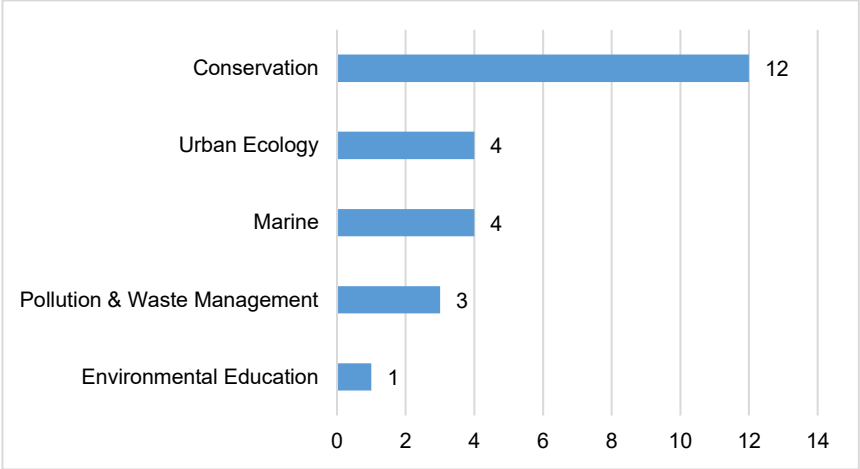

Figure 3: CS projects themes in Malaysia, 2015-2024

4.1.2 Project location distribution

CS projects in Malaysia are distributed across all regions, with seven projects each in Peninsular Malaysia and Borneo, and one national project spanning both regions. Within Peninsular Malaysia, seven projects covered the entire region, while others were concentrated in the eastern (4), western (3), and northern (2) parts (Figure 4).

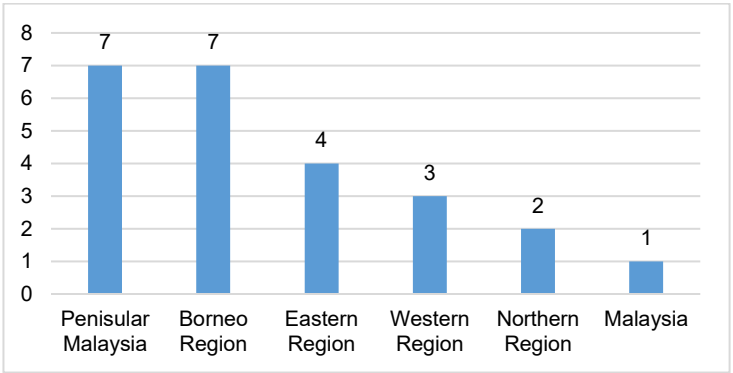

Figure 4: Location of CS projects by region in Malaysia, 2015-2024.

4.1.3 Methodological approaches

CS projects in Malaysia utilised a combination of primary, secondary, and mixed-mode data sources. Primary data collection was the most frequently used approach, accounting for 58% of the projects (14 projects). This was followed by the use of secondary data, applied in 29% of the projects (7 projects), often involving data retrieved from established biodiversity platforms such as eBird and iNaturalist, as well as other open-access sources. Mixed-mode approaches, which combine both primary and secondary data sources, were employed in 13% of the projects (3 projects) (see Figure 5).

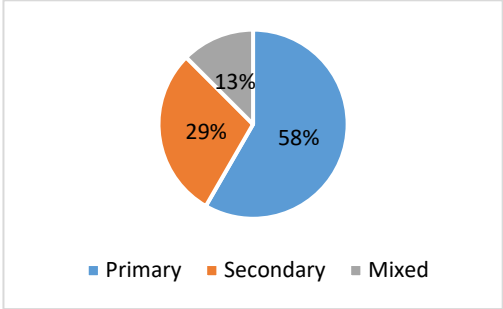

Figure 5: Types of data sources used in CS projects in Malaysia, 2015–2024.

Figure 6 illustrates the relationship between project themes and the data sources used in CS initiatives. Conservation-oriented projects exhibit the most diverse data practices, utilising primary, secondary, and mixed data sources. In contrast, projects focused on pollution and waste management and environmental education rely predominantly on primary data collection. Marine-related projects are also largely based on primary data, with limited use of mixed sources. Urban ecology projects show a more balanced reliance on both primary and secondary data. Overall, these patterns indicate that data source selection in CS projects varies according to thematic focus.

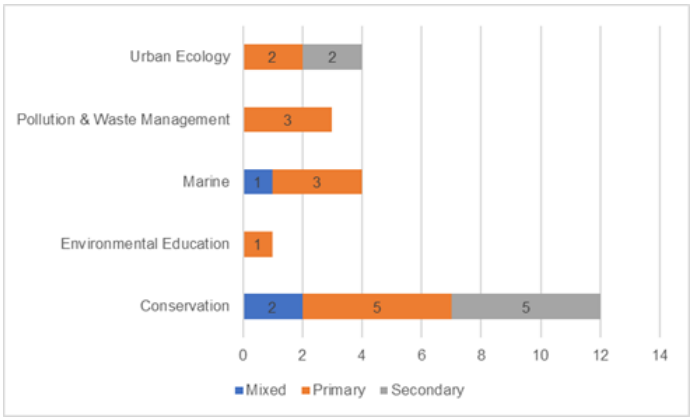

Figure 6: Distribution of CS Project Themes by Data Source, 2015–2024

Implementation trends become clearer when the project year, defined as the final year of reported data collection or project implementation, is examined alongside data collection methods, revealing shifts in methodological preferences over time. From 2015 to 2019, most CS projects relied on primary data, with a steady increase until 2020 (three primary, one secondary). Between 2021 and 2022, methods diversified, combining primary, secondary, and mixed approaches. By 2023, secondary data dominated (three projects), accompanied by two mixed-method projects, while the sole project in 2024 also relied on secondary data. These findings indicate a recent shift towards greater use of secondary data and mixed methods, reflecting the increasing availability and acceptance of citizen-contributed datasets and digital platforms (see Figure 7).

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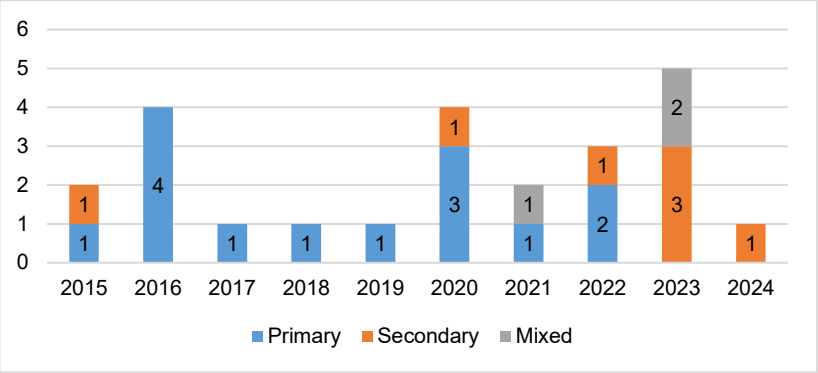

Figure 7: Evolution of Data Collection Methods Used in CS Projects in Malaysia, 2015-2024

Among the methodological approaches, observation was the most common (10 projects), followed by secondary data analysis (7 projects), which utilised platforms such as eBird, iNaturalist, and GIS datasets. Other methods were employed only once each (see Figure 8).

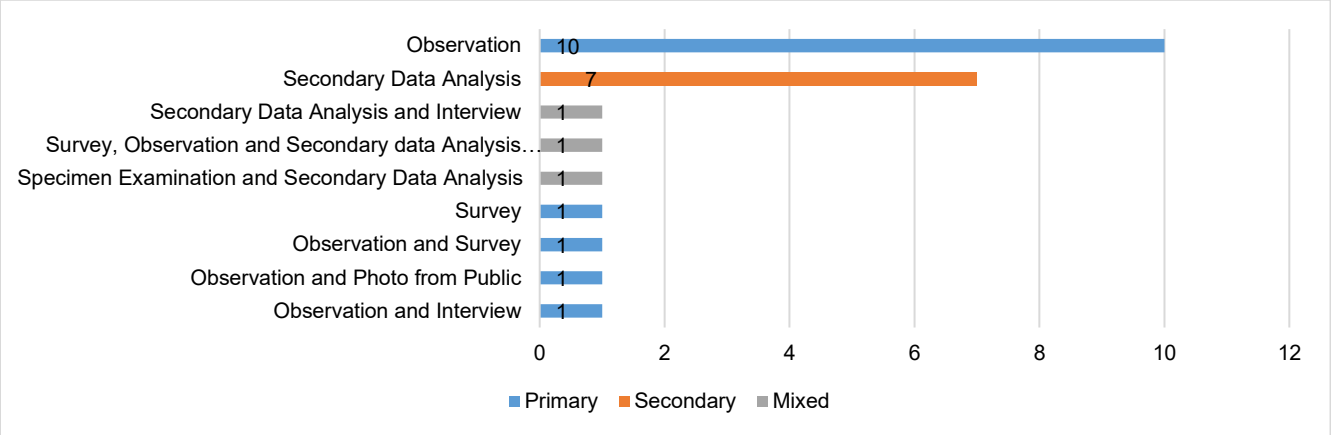

Figure 8: Methodological approaches used in CS projects in Malaysia, 2015-2024.

4.1.4 Technologies used

The most commonly used technologies were GIS and spatial tools, adopted in 11 projects, primarily for bird monitoring (7 projects), and in one project each for biodiversity mapping, butterfly monitoring, fish monitoring, and reef monitoring. This was followed by mobile and app-based tools, utilised in seven projects focusing on marine litter (2 projects), marine monitoring (2 projects), tree observation (2 projects), and bird monitoring (1 project). Molecular and imaging tools were used in three projects involving turtle, ape, and insect monitoring. Survey-based tools were applied in two projects addressing solid waste management and biodiversity monitoring. Only one project employed remote sensing technology, specifically for coral reef assessment (see Figure 9).

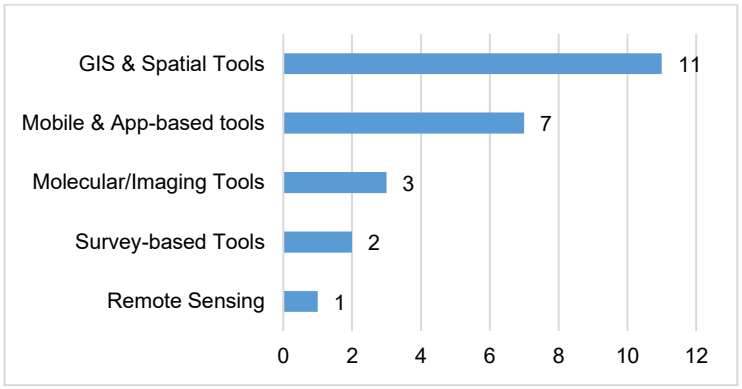

Figure 9: Technologies Used in CS Projects in Malaysia, 2015-2024

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4.2 Key Contributions

The key contributions of CS projects in Malaysia centre on scientific outputs, with 11 projects classified into five categories, namely baseline-forming (Wilson, 2024; Rameli et al., 2020; Ng, 2017), longitudinally relevant (Long and Azmi, 2017; Mansor et al., 2021), ecologically insightful (Puan et al., 2015; Mat Zauki et al., 2019), model-informing (Van Emmerik et al., 2020; Wee et al., 2024), and useful for national biodiversity strategies (Tolohah et al., 2023; Muhammad et al., 2023). This is followed by nine projects that contributed to both scientific and governance outcomes. These projects generated valuable ecological data, such as species distribution, reef health, and invasive species trends, and supported scientific modelling and peer-reviewed outputs (Puan et al., 2019; Lau et al., 2019; Lim et al., 2021; Oram et al., 2022; Arazmi et al., 2022; Madi et al., 2023; Mohamad Safawi et al., 2023; Aqmal-Naser et al., 2024; Yong et al., 2025). At the same time, they informed environmental governance by supporting marine park zoning, urban biodiversity planning, species conservation strategies, and invasive species management, highlighting the dual value of CS in advancing research and shaping evidence-based environmental policies. Additionally, two projects contributed to both scientific and societal domains. The Citizen Observation of Local Litter in Coastal Ecosystems (COLLECT) project (Catarino et al., 2023) and a forest monitoring study (Fauzi et al., 2024) demonstrate that citizen-generated data can address gaps in plastic and forest monitoring while promoting SDG 14 awareness, ocean literacy, and community empowerment in conservation efforts. In contrast, two other projects focused solely on societal impacts. Studies by Zulhaimi et al. (2017) and Idris et al. (2022) demonstrate that CS initiatives involving students can contribute to environmental data collection, such as waste composition and tree planting records, while fostering environmental awareness, geospatial literacy, and responsible behaviour through both on-site and virtual participation (see Figure 10).

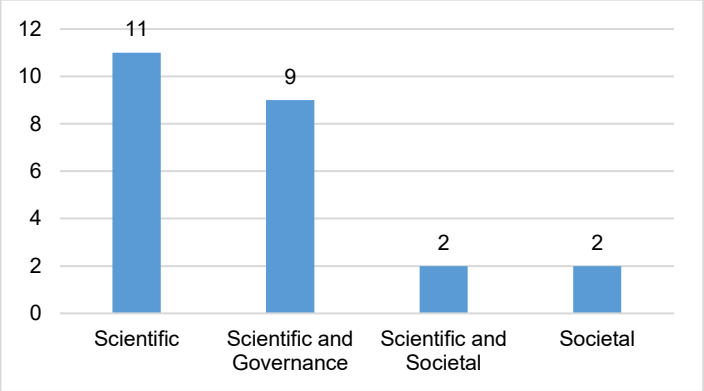

Figure 10: Contributions of CS projects in Malaysia, 2015-2024

4.3 SDG Integration

As shown in Figure 11, most Malaysian CS projects align with SDG 15 (Life on Land) (14 projects), targeting birds (8), trees (2), butterflies (1), grasshoppers (1), apes (1), and orangutans (1). The second most targeted goal is SDG 14 (Life Below Water), with nine projects focusing on fish (2), marine litter (2), reef monitoring (2), sea turtles (1), crabs (1), and biodiversity mapping (1). Only one project aligns with SDG 12 (Responsible Consumption and Production), focusing on solid waste management and reflecting limited engagement with waste and resource sustainability.

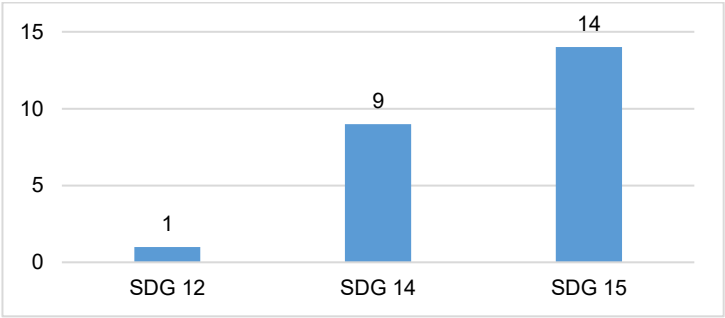

Figure 11: Number of CS projects in Malaysia contributing to SDG goals, 2015-2024.

The scholarly reporting of CS projects in Malaysia reveals limited explicit alignment with the SDGs. Figure 12 shows that, out of the 24 CS projects analysed, only three (12%) explicitly mentioned the SDGs. These projects were aligned with SDG 15 and SDG 14 and focused on themes such as tree inventories (Fauzi et al., 2024), tree planting (Idris et al., 2022), and marine litter (Catarino et al., 2023). Among them, only the study by Catarino et al. (2023) clearly identified the specific SDG being addressed, namely SDG 14, while the other two merely referenced the SDGs in general terms within the introduction sections of their articles.

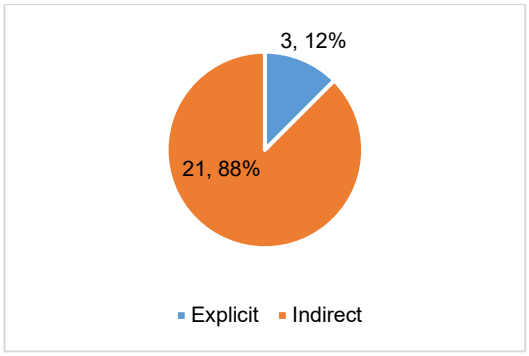

Figure 12: SDG Integration among CS Projects in Malaysia, 2015-2024

Figure 13 presents the distribution of CS projects across regions by SDG focus. Projects in Peninsular Malaysia are predominantly aligned with SDG 15 (six projects), reflecting a strong emphasis on terrestrial biodiversity and conservation-related initiatives. In contrast, projects in the Eastern Region are exclusively focused on SDG 14 (four projects), indicating a clear specialisation in marine and coastal monitoring. The Borneo region demonstrates a more diversified SDG profile, with projects distributed across SDG 15 (three projects), SDG 14 (three projects), and SDG 12 (one project), suggesting broader thematic engagement encompassing sustainable consumption, marine conservation, and terrestrial ecosystems. Western and Northern regions exhibit fewer projects overall, with a continued emphasis on SDG 15. Overall, the figure indicates that CS activities in Malaysia are unevenly distributed across regions, with projects tending to concentrate on specific thematic areas that reflect regional geographical contexts.

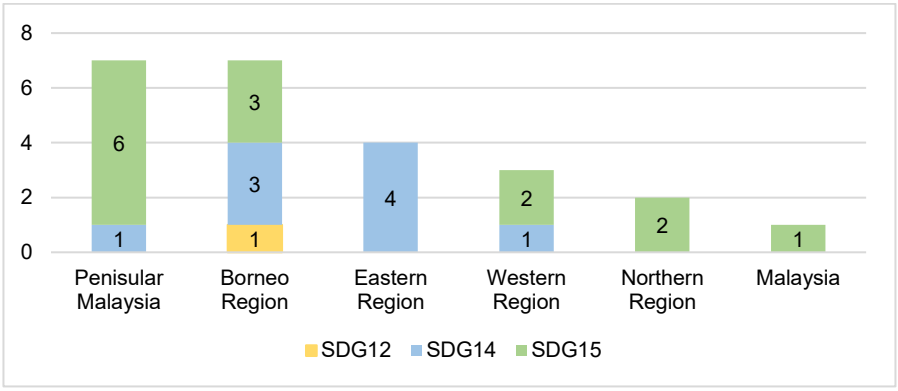

Figure 13: Distribution of CS projects by region and SDG focus in Malaysia, 2015–2024

As illustrated in Figure 14, seven projects were self-funded or had no external funding, while another seven received supports from government or public sector agencies. The remaining ten projects were funded by various sources, including NGOs and civil society organisations (two projects), academic institutions (two projects), and other sources such as international organisations, corporate foundations, private sector actors, and individual donors (one project each).

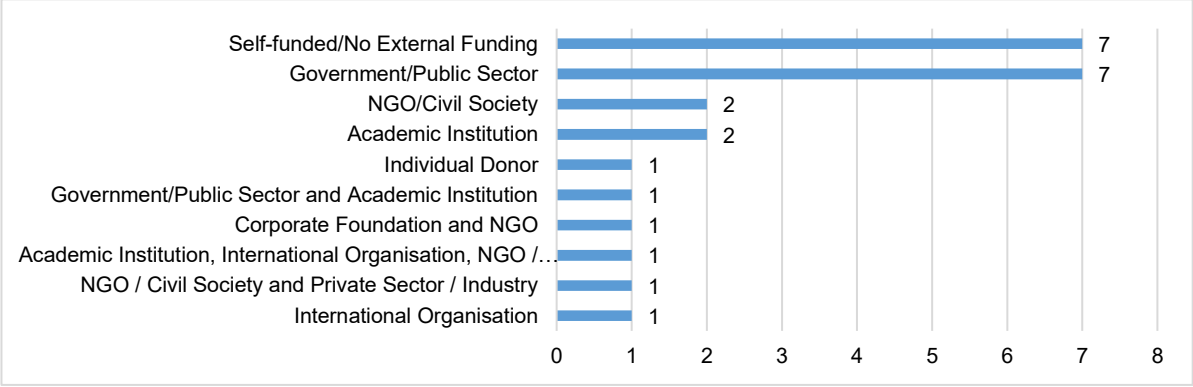

Figure 14: Sources of funding for CS projects in Malaysia, 2015-2024

5.0 Discussion

5.1 Project Overview and Scope

This review identified 24 CS projects in Malaysia between 2015 and 2024, with initial growth observed in 2016, followed by a decline from 2017 to 2019 (with only one project annually), likely due to limited funding, low institutional awareness, and insufficient public outreach. This period was followed by renewed expansion, peaking in 2023. Notably, open science initiatives in Malaysia began with the Ministry of Science, Technology and Innovation (MOSTI) launching the Malaysia Open Science Platform (MOSP) pilot in November 2019 (Academy of

Sciences Malaysia [ASM], 2023). The subsequent increase in projects from 2020 mirrors global growth in CS, driven by stronger SDG policies, increased public engagement, and greater institutional recognition of citizen-generated data.

Conservation and ecology emerge as the dominant themes among CS projects in Malaysia, accounting for 67% of the 24 projects reviewed. This finding aligns with Beck and Mitkiewicz (2025), who reported that biodiversity and urban ecological conservation comprised 53% of themes identified in their systematic literature review of CS projects, primarily in Europe within the context of urban studies and regional planning. In contrast, Liu et al. (2023) found that CS contributions to SDG implementation in European cities are largely focused on environmental issues such as pollution, resource monitoring, and climate change. While conservation remains a shared foundation, Malaysian CS projects tend to be more nature-focused, whereas European projects are often policy-driven and urban-environmental in scope. In Malaysia, this emphasis on conservation is strongly linked to funding priorities. The funding analysis indicates that nearly all types of agencies support conservation-related projects, suggesting that conservation is viewed as a national priority. This collective commitment highlights Malaysia's strong focus on biodiversity and natural resources, contrasting with the policy- and urban-oriented emphasis of many European CS initiatives. These differences suggest that CS is highly context-dependent, shaped by local ecological priorities and governance needs.

The geographical distribution of CS projects in Malaysia appears to be influenced by regional environmental characteristics. The eastern region, comprising Kelantan, Terengganu, and Pahang, hosts the majority of SDG 14 projects, reflecting its strong association with marine ecosystems. In contrast, states in the western region, namely Perak, Penang, Selangor, and Kuala Lumpur, predominantly implement CS projects aligned with SDG 15, focusing on urban sustainability and terrestrial biodiversity. Meanwhile, the Borneo region, comprising Sabah and Sarawak, features projects aligned with both SDG 14 and SDG 15, likely due to its unique geographical context encompassing both terrestrial and marine ecosystems.

CS projects in Malaysia predominantly rely on primary data collection, reflecting a strong tradition of field-based research in local universities and research institutions, where hands-on data gathering is emphasised as a core practice. Ten projects employed direct observation methods, supported by diverse funding sources including NGOs, academic institutions, international organisations, civil society groups, and private foundations, collectively addressing multiple SDGs. In contrast, projects based on secondary data are fewer, with seven identified, and are largely concentrated on SDG 15 and SDG 11 (Sustainable Cities and Communities). These projects are typically government-funded and often draw upon existing citizen-reported biodiversity databases, particularly for bird monitoring, applied in urban planning and ecosystem studies. The increasing reliance on secondary data reflects a broader global trend enabled by established digital CS platforms such as eBird, Galaxy Zoo, and Foldit. Since the mid-2000s, these platforms have generated scientifically valuable datasets and contributed to peer-reviewed research (Hecker et al., 2018; Kullenberg & Kasperowski, 2016). This shift towards the use of large-scale datasets complements, rather than replaces, primary data collection efforts.

The majority of CS projects in Malaysia incorporate technology, particularly GIS and spatial tools, followed by mobile and app-based applications. The integration of these technologies has enhanced both the scientific rigour and operational reach of projects, particularly in biodiversity and marine ecosystem monitoring. These findings are consistent with Mazumdar et al. (2018), who emphasised the role of technology in enabling data collection, broadening participation, and supporting diverse governance models in CS. Furthermore, accessible tools for developing websites, applications, sensors, and maps help lower barriers to participation, thereby facilitating both top-down and bottom-up CS initiatives.

Six out of seven CS projects that utilised secondary data were aligned with SDG 15, comprising five bird monitoring initiatives and one ape monitoring project. The bird monitoring studies primarily employed the eBird platform in combination with GIS tools, while the ape monitoring project relied on photographs sourced from social media platforms. The increasing use of eBird in Malaysian CS projects, particularly since around 2021, reflects the influence of global CS practices. Developed by the Cornell Lab of Ornithology and launched in 2002, eBird is an internationally recognised platform that enables the public to contribute bird observations and photographs, which are subsequently made available for scientific analysis. It supports large-scale data sharing and collaborative ecological monitoring, with over five million observations submitted monthly and contributions to more than 90 peer-reviewed publications (Sullivan et al., 2014). In Malaysia, several studies have utilised eBird data to support ecological and conservation objectives. For example, Arazmi et al. (2022) and Madi et al. (2023) used eBird data in urban ecology to model the spread of invasive species such as the Javan Myna and to map urban bird distributions, identifying strong associations with green corridors and water bodies. Similarly, Tolohah et al. (2023) analysed spatial patterns of stork populations, revealing habitat segregation, while Mohamad Safawi et al. (2023) conducted spatio-temporal analyses to identify conservation hotspots in Perak. Collectively, these studies demonstrate the scientific value and versatility of eBird as a secondary data source for avian research and biodiversity planning in Malaysia.

To maximise the utility of citizen-contributed data, several studies have integrated eBird with GIS platforms, enabling more refined spatial analyses for conservation research. Kullenberg and Kasperowski (2016) highlighted a branch of CS research rooted in geographic information science, where citizens actively contribute geospatial data. This approach has been effectively applied in conjunction with eBird datasets. In five reviewed studies, ArcGIS was used alongside eBird data to enhance spatial interpretation. For instance, Puan et al. (2015) utilised GIS-derived environmental variables to model relationships between nocturnal bird species richness and spatial factors such as altitude, land cover, and distance to water bodies in Malaysian Borneo. Arazmi et al. (2022) used ArcGIS to validate long-term spatial distribution data for the Javan Myna, while Madi et al. (2023) and Tolohah et al. (2023) applied it to assess species abundance and spatial distribution. Mohamad Safawi et al. (2023) further employed spatial statistical tools, including Average Nearest Neighbour analysis and Getis-Ord General G, to identify biodiversity hotspots and examine relationships between bird occurrences and land use. These applications demonstrate how GIS technologies, particularly ArcGIS, enhance the analytical value of CS platforms such as eBird by transforming raw observations into spatially explicit insights for biodiversity monitoring and conservation planning.

5.2 Key Contribution

According to Beck and Mitkiewicz (2025), citizen science (CS) empowers individuals to contribute to scientific, governance, and societal domains through research and environmental monitoring, while fostering social responsibility, strengthening community cohesion, and supporting data-driven decision-making. In Malaysia, CS projects are predominantly oriented towards scientific contributions, with 11 projects falling within this category. These include initiatives that generate baseline ecological data, support longitudinal monitoring, and contribute to model development and biodiversity documentation. This scientific emphasis is followed by nine projects that demonstrate both scientific and governance impacts. This pattern reflects trends observed in European contexts, as highlighted by Liu et al. (2023), who found that 21 out of 28 CS projects reported political impacts, ranging from the formulation of action plans to the development or improvement of policies. In the Malaysian context, this suggests a growing recognition among researchers of the value of making citizen-generated data available for governance purposes, as well as an increasing willingness among government agencies to utilise such data to address local environmental issues and inform management strategies.

The widespread use of GIS and spatial tools across the reviewed CS projects indicates a strong emphasis on location-based analysis. Many studies employ GIS to map species occurrences and examine spatial patterns, particularly in bird and biodiversity monitoring. This demonstrates that CS in Malaysia frequently adopts spatial thinking by interpreting environmental data in relation to where observations occur and how they are distributed across space. Several studies further show that GIS-based outputs support planning and management applications, including urban green space design, coral reef zoning, urban biodiversity planning, and invasive species management. Overall, CS contributes not only to data collection but also to the production of place-based knowledge that informs environmental planning and management.

5.3 SDG Integration

There is a notable lack of scholarly reporting on the alignment of citizen science (CS) projects in Malaysia with the Sustainable Development Goals (SDGs). Among the 24 projects reviewed, only three explicitly referenced the SDGs. This finding is consistent with Liu et al. (2023), who, in their study of EU-funded CS projects in urban contexts, reported that only 10 out of 44 projects explicitly mentioned the SDGs. The limited alignment observed in the European context was attributed to the absence of an explicit requirement to address the SDGs in Horizon 2020 (H2020) project application forms. In the Malaysian context, the most explicit alignment was observed in the study by Catarino et al. (2023), which aimed to reduce data gaps by contributing plastic litter data to the United Nations SDGs, specifically SDG 14. In contrast, one project promoted tree planting among schoolchildren through digital platforms during the COVID-19 pandemic (Idris et al., 2022), while another empowered an indigenous community to collect forest biomass data using smartphones (Fauzi et al., 2024). Despite their clear thematic relevance, these projects did not explicitly position their activities within the SDG framework. This does not necessarily imply that the remaining projects lacked SDG relevance; rather, it highlights that systematic analysis and explicit reporting of contributions to the SDGs remain uncommon in Malaysia.

From a funding perspective, six projects were supported by the Ministry of Higher Education (MOHE) under the Fundamental Research Grant Scheme (FRGS), while one project was funded by the Department of Marine Park. According to the Guidelines for the Fundamental Research Grant Scheme (FRGS) issued by the Ministry of Higher Education Malaysia (2025), research proposals are required to align with at least one of the 17 SDGs as a condition for funding. However, the resulting scholarly outputs often do not explicitly map research outcomes to specific SDGs. This disconnect between grant requirements and reporting practices points to a broader gap in integrating SDG framing into the dissemination of research findings. Furthermore, self-funded projects appear to prioritise scientific outputs over alignment with SDG targets, possibly due to the absence of institutional requirements. Overall, the lack of institutionalised mechanisms mandating SDG impact analysis within project planning and reporting processes in Malaysia limits the potential of CS to contribute meaningfully to national and global sustainability agendas. Strengthening national guidelines and embedding SDG requirements within funding frameworks could enhance the visibility and utility of citizen-generated data in official monitoring and evidence-based policymaking.

The primary SDGs addressed by CS activities in Malaysia are SDG 15, SDG 14, and SDG 12. In addition to these core environmental goals, several projects also contribute to related SDGs, including SDG 4 (Quality Education) in three projects, SDG 6 (Clean Water and Sanitation) in one project, SDG 11 (Sustainable Cities and Communities) in five projects, and SDG 13 (Climate Action) in four projects. While this reflects a relatively diverse thematic distribution, several SDGs remain unaddressed within the current CS landscape in Malaysia. These gaps highlight an opportunity for future CS initiatives to expand beyond environmental monitoring. By incorporating social, economic, and governance dimensions, CS could play a more comprehensive role in advancing a holistic and inclusive sustainability agenda aligned with the full spectrum of the SDGs.

5.4 Policy Implications and Recommendations

In countries such as the United States, Canada, and Ireland, governments have established national citizen science (CS) portals to institutionalise public participation and support collaborative knowledge production. The United States has integrated CS into federal initiatives by establishing programmes that invite volunteers to contribute directly to research and monitoring activities (U.S. General Services Administration, 2025). In contrast, Canada's Citizen Science Portal provides a unified platform for initiatives, enabling communities to connect and participate in national scientific efforts (Government of Canada, 2025). Similarly, Ireland's Citizen Science Portal focuses on biodiversity, allowing individuals to upload and review species records through mobile and web-based tools (National Biodiversity Data Centre, 2025). Drawing on these international practices and the empirical findings of this review, several policy-relevant gaps in Malaysia's CS and SDG monitoring landscape can be identified, including fragmented data storage, limited explicit SDG reporting, and uneven regional and thematic distribution of projects.

Although the Malaysia Open Science Platform (MOSP), launched in 2023, represents an important step towards open research data sharing by providing data consolidation, access management, and capacity building (ASM, 2023), its current scope is primarily oriented towards institutional research outputs rather than CS initiatives. As demonstrated in this review, CS data in Malaysia remain dispersed across multiple project-based platforms, with limited standardised metadata and minimal explicit alignment with the SDGs. Expanding MOSP into a dedicated national CS portal could help address these gaps by centralising project registration, standardising metadata fields, including SDG tagging, and integrating citizen-generated datasets within a single interoperable system. This could be achieved while leveraging MOSP's existing infrastructure for data governance and access control. Governance arrangements could involve a lead national agency, in collaboration with research institutions and local authorities, to oversee data standards, quality assurance protocols, and ethical guidelines, while maintaining project-level flexibility to preserve local relevance and participation.

To address the low level of explicit SDG reporting identified in this review, such a portal could incorporate mandatory SDG tagging and reporting fields at the project registration stage, aligned with national SDG indicators. This would enhance the visibility of CS contributions to SDG monitoring and facilitate integration with Malaysia's SDG Roadmap Phase III (2026–2030). From a funding perspective, data-sharing and SDG alignment requirements should be extended to publicly funded research more broadly. Requiring researchers to share data through a national platform and to explicitly articulate SDG relevance not only at the proposal stage, but also in project reporting and scholarly publications, would promote greater transparency, comparability, and policy relevance across the research ecosystem, while strengthening the contribution of research outputs to national SDG monitoring.

At the subnational level, local authorities could be encouraged to adopt citizen-generated data for community-based sustainability initiatives, particularly in underrepresented regions and thematic areas. This approach would help address local data gaps while contributing to national SDG reporting frameworks.

6.0 Conclusions

This article examines the implementation of citizen science (CS) projects in Malaysia, focusing on project scope, including thematic orientation, geographical distribution, methodological approaches, and the use of technology, as well as contributions across scientific, societal,

and governance dimensions and their alignment with the Sustainable Development Goals (SDGs). The findings indicate that conservation and ecology are the dominant themes, accounting for 67% of the reviewed projects, with a strong reliance on primary data collection methods (58%). The geographical distribution of CS projects appears to be shaped by regional environmental contexts, with SDG 14 projects concentrated in the eastern region, SDG 15 projects more prevalent in the western region, and projects in Sabah and Sarawak addressing both goals.

An emerging trend shows a shift from primary data collection towards the use of secondary data from digital platforms for large-scale ecological and spatial analyses. CS projects utilising secondary data are predominantly aligned with SDG 15, particularly in bird monitoring through platforms such as eBird combined with GIS tools. The increasing adoption of these approaches since 2021 reflects the influence of global practices on biodiversity monitoring in Malaysia. Consistently, GIS and spatial tools emerge as the most widely used technologies across the reviewed projects. While most projects emphasise scientific outcomes, an increasing number demonstrate governance relevance, reflecting both researchers' recognition of the value of citizen-generated data for policy and management, and the growing willingness of government agencies to utilise such data in environmental decision-making.

However, the review identifies a significant gap in the scholarly reporting of CS project alignment with the SDGs. The absence of institutional mechanisms for SDG impact analysis limits the contribution of these projects to national and global sustainability agendas. Integrating SDG considerations into funding requirements and reporting practices would enhance the visibility and policy utility of citizen-generated data, thereby strengthening the role of CS in linking knowledge production, civic engagement, and evidence-based policymaking for the 2030 Agenda.

Beyond these empirical findings, the study highlights the need for stronger institutional mechanisms to integrate CS outputs into Malaysia's national SDG monitoring framework. Although CS initiatives are expanding, their policy relevance remains constrained by fragmented data governance and limited interoperability across platforms. Expanding the Malaysia Open Science Platform (MOSP) into a dedicated national CS portal, supported by standardised metadata, mandatory SDG tagging, and structured SDG reporting fields at the project registration stage, could significantly enhance the visibility, traceability, and usability of citizen-generated data. Embedding these governance measures would enable CS to more effectively support evidence-based decision-making and national SDG reporting.

Future research should explore how CS can contribute to underrepresented social and economic SDGs in Malaysia, thereby extending its scope beyond environmental objectives and strengthening its role in advancing a more holistic and inclusive sustainable development agenda.

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Conflicts of Interest: The authors declare that there is no conflict of interest

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Appendix A: Database-Specific Boolean Search Strategies

Database: Scopus
Date Searched: 16 April-14 May 2025
Search Strategy:

```
TITLE-ABS-KEY (
  ("citizen science" OR "citizen science project"
   OR "participatory science"
   OR "participatory community science"
   OR "crowdsourcing")
  AND "Malaysia"
)
```

Database: Web of Science
Date Searched: 16 April-14 May 2025
Search Strategy:

```
TS=(
  ("citizen science" OR "citizen science project"
   OR "participatory science"
   OR "participatory community science"
   OR "crowdsourcing")
  AND "Malaysia"
)
```

Database: Google Scholar
Date Searched: 16 April-14 May 2025
Search Strategy:

```
ALLINTITLE: Malaysia AND ("Citizen Science Data" OR "Citizen Science Project")
```