Environmental Apps and Digital Reporting in Australian Environmental Management: A Conceptual Review of Opportunities and Challenges

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Article Info

P-ISSN: 3051-3421
E-ISSN: 3051-343X
Volume: 07
Issue: 01
January - June 2026
Received: 18-01-2026
Accepted: 16-02-2026
Published: 14-03-2026
Page No: 52-68

Abstract
Environmental apps and digital reporting tools are increasingly used to support environmental management in Australia. This paper develops a conceptual framework through a narrative review of literature on environmental governance, citizen science and digital public services. These tools enable residents to document local environmental issues, extend the reach of monitoring programmes and create new channels of interaction between communities and public agencies. Their growing use raises questions about data quality, public trust, institutional capacity and long-term governance arrangements. The framework explains how four core constructs digital tool characteristics, user behaviours, institutional settings and environmental outcomes interact to shape the effectiveness of citizen-generated environmental reporting. No new empirical data were collected; instead, the study synthesises existing research to advance theoretical understanding and inform policy development. The analysis identifies opportunities for improved monitoring coverage, transparency, operational efficiency, rapid detection of environmental harms and adaptive management. At the same time, it highlights key challenges related to digital inequality, privacy and data governance, verification demands, institutional fragmentation and ongoing maintenance requirements. The paper concludes by outlining policy implications and directions for future empirical research aimed at supporting effective and equitable digital environmental reporting in Australia.

DOI: https://doi.org/10.54660/JADR.2026.7.1.52-68

Keywords: environmental apps, digital reporting, citizen-generated data, environmental governance, digital participation

1. Introduction

species and pollution incidents happens through digital applications and online submission systems operated by local and state and federal agencies. Public environmental governance requires public participation because digital tools now support professional monitoring activities at increased levels. Research on digital participation demonstrates that mobile applications enable monitoring programmes to reach more people when situations change rapidly or when data needs regular updates (Fritz *et al*., 2019) [31]. The Australian environmental situation needs real-time detection of environmental changes and continuous dataset updates because climate change and urbanization and land use changes create urgent needs (Climate Council of Australia, 2021) [25].

The results from environmental reporting tool implementation have shown no consistent pattern. Users maintain their use of digital reporting apps from councils because these tools enable them to monitor their submission progress and obtain instant responses (Wehn and Evers, 2020) [86]. The tools demonstrate unpredictable user behaviour because users from different environmental groups interact at different levels. Research shows that project visibility stands as the key factor which determines how well citizen scientists will respond to projects. People file reports about flooding and vegetation damage and litter because these events are observable to them yet they report ecological indicators less frequently because these require specialized

knowledge (Robinson *et al*., 2018) [76]. The inconsistent reporting patterns produce incomplete data that reduces the effectiveness of public reporting for future planning purposes.

The governance system of Australia creates additional challenges for its operations. The federal government works together with state governments and local municipalities to share environmental duties through their individual reporting systems for different areas. People need to move between different platforms based on the particular issue and the appropriate authority that handles it. Users lose trust in digital reporting systems because they do not understand which organisation will process their reports and how long the review process will take (De Silva Lokuwaduge *et al*., 2022) [29]. When communication is unclear, digital reporting feels disconnected from real outcomes. Yet some councils demonstrate that strong communication and transparent workflows can build trust, suggesting that design choices shape user engagement as much as environmental interest itself (Local Government Victoria, 2025) [53].

Academic research in Australia has not fully caught up with this growth in digital tools. Much of the current knowledge comes from work on citizen science, digital participation and public environmental engagement. These fields highlight the value of citizen contributions to data collection but also note the risks associated with uneven participation and the need for data verification (Golumbic, 2024) [35]. Research on technology adoption points to factors such as institutional trust, perceived usefulness and ease of use as central to uptake, although these models have mostly focused on commercial technologies rather than government environmental platforms (Australian Government, Digital Transformation Agency, 2024) [9]. As a result, there is no established conceptual framework that explains how environmental apps function across behavioural, technical and institutional dimensions in Australia.

Existing work on citizen science frameworks, technology acceptance models (TAM/UTAUT), and digital government frameworks offers partial insights but does not account for the fragmented institutional landscape and specific governance needs of Australian environmental management. This paper addresses that gap by developing an integrated framework that explains how technical design, user behaviours and institutional settings jointly shape environmental management outcomes. This framework can assist policymakers, practitioners and researchers who are designing or evaluating digital tools for environmental management.

The research addresses three fundamental questions:

RQ1: How do the design characteristics of environmental apps and digital reporting tools influence user participation and the production of citizen-generated environmental data in Australia?

RQ2: What institutional and governance conditions enable or constrain the effective integration of citizen-generated digital reports into environmental monitoring, decision-making and policy in Australia?

RQ3: What opportunities and challenges do environmental apps create for equitable, trustworthy and effective environmental governance?

The system operates at its best as a monitoring tool when users access it through designated interfaces while administrative staff keeps the system properly supported. The analysis demands understanding of digital tool interactions which enable better environmental data sharing and public participation in Australia. The following section examines existing research to determine which academic fields provide essential knowledge about digital reporting systems in environmental management.

2. Literature review

2.1. Digital environmental governance

Digital environmental governance implements digital technology to improve environmental management through data collection and decision support systems. The system operates with open structures which receive data from institutional sources and public contributions instead of using previous expert-controlled systems. Organisations achieve better responsiveness through digital governance systems because these systems deliver fast information access and handle large data volumes that exceed traditional reporting systems (Kassen, 2022) [47]. Environmental agencies achieve their objectives through web-based dashboards which enable mobile reporting applications and automated monitoring systems.

The integration of digital tools happens through the development of new public sector management approaches. Environmental agencies must provide instant data while maintaining open information to build and protect public trust. Digital systems meet public needs through their dual functionality which shows environmental data and enables users to enter vital observation information (Haklay *et al*., 2021) [39]. Digital governance systems introduce new difficulties to the management process. Organisations need to create verification systems and obtain enough institutional resources to handle the large amount of citizen data they collect from citizens. Digital systems lose their value when institutions fail to establish proper verification systems and sufficient funding because public involvement decreases.

Digital governance systems allow public participation through active communication channels which international examples show that agencies need to establish. European flood risk management programmes use digital platforms which enable citizens to submit reports about flooding and drain blockages for immediate risk evaluation (Llasat-Botija *et al*., 2025) [52]. The examples demonstrate the worth of digital governance systems but their success depends on correct system design and continuous institutional backing.

2.2. Citizen science and public reporting systems

The field of citizen science produces large amounts of research data which enables digital environmental reporting systems. The research investigates how volunteers collect data through their observations and species identification and environmental measurement activities. Users can perform these operations by using digital tools which provide basic interfaces that need minimal data entry and enhance system accessibility. Research shows users perform better with basic interfaces that deliver immediate results from their actions (Bonney *et al*., 2016) [21].

Public reporting systems operate independently from citizen science programmes but show identical behavioural responses. The success of these initiatives depends on people who decide to disclose their information to institutions. People become more involved when they understand their work purpose and see direct value from their efforts (Shinbrot *et al*., 2023) [78]. The digital platforms iNaturalist and eBird show how to grow participant numbers through interfaces that users find easy to use and feedback systems.

Research studies in citizen science projects continue to study data quality issues which persist as a major problem. The reliability of volunteer-submitted reports depends on validation procedures that verify their accuracy (Kosmala *et al*., 2016) [50]. The work of biodiversity surveys needs specialized skills which differ from the abilities of people who report litter and storm damage. The value of citizen-generated data for planning and monitoring purposes depends on the particular environmental problem under study and the established data quality requirements.

2.3. Behavioural factors shaping the use of digital tools

Users adopt environmental apps at higher rates because these applications follow the natural behaviour patterns of their users. Users determine their app download decisions and their ability to operate the app and their long-term usage of the application. Research on digital participation shows users will participate more when tasks stay simple to finish and they get instant feedback without paying any fees (Mehrabadi *et al*., 2021) [60]. The behaviour of people depends on their environmental interest and their perception of relevance and the social norms they follow. People will take part in digital reporting more actively when they understand how their actions protect their cherished local communities.

Trust functions as a primary element which affects human behaviour. Residents who doubt the evaluation process of reports and response actions tend to reduce their participation levels. Public administration research indicates that organisations which demonstrate their work through follow-up messages and status updates build trust with citizens who maintain their participation (Ardanaz *et al*., 2023) [6]. The system loses user confidence because users must wait longer for their reports and because they find it difficult to understand the procedures.

Users who possess higher digital competence levels will find it easier to adopt new technology. Users who show expertise in mobile device operation will get better results from reporting tools. The reporting system requires additional support to help users who lack digital skills and users who belong to the senior age group. The behavioural elements demonstrate that reporting systems need to create simple interfaces which reduce mental effort during the reporting process.

2.4. Technology adoption and trust in public systems

The technology adoption literature offers vital models which describe why users select to use digital reporting tools. The Unified Theory of Acceptance and Use of Technology (UTAUT) demonstrates that users select systems through four essential elements which consist of perceived usefulness and ease of use and social influences and system support (Venkatesh *et al*., 2003) [84]. The evaluation process users follow before using new systems includes all the constructs which exist in commercial environments.

The success of new system implementation depends on existing public institution trust levels. Users determine their willingness to use digital systems through their perceptions about data protection and privacy and their assessment of government institution capabilities. People choose to avoid government apps because they remain uncertain about what happens to their personal information after they submit it (McKnight *et al*., 2002) [59]. Organisations which demonstrate their data management procedures create protected environments for users to feel secure. Users can feel secure about their information when organisations explain their data storage methods and access controls and their intended use of the data.

People form their trust levels toward public institutions through their previous interactions with these organisations. People who witness government agencies show inconsistent responses and fail to environmental reporting cases will likely doubt the reliability of digital systems. New technology implementation needs to operate within existing rules which govern present governance systems.

2.5. Lessons from Australian environmental information programmes

The Australian environmental programmes show how digital tools impact public reporting through their adoption of digital reporting systems. Multiple states across Australia have developed mobile applications which enable users to monitor coastlines and report waste and observe wildlife and receive hazard alerts. The programmes show that tool adoption increases when residents discover how to apply these tools for their everyday requirements. The NSW Marine Debris Tracker and ACT's FixMyStreet system show that users stay engaged through simple interfaces which work with straightforward follow-up systems (Access Canberra, n.d.; Department of Planning and Environment, 2023) [1, 30].

State digital service assessments demonstrate that agencies need to work together for successful implementation. The multiple platforms available to citizens create difficulties because they must choose between different platforms and determine which organisation will process their reports. Research conducted on Australian digital public services shows that citizens trust digital services better when they understand data management processes and when they receive regular updates (Alarabiat *et al*., 2021) [4].

Australian data programmes also indicate that long-term maintenance is essential. Some tools have lost relevance because agencies reduced support or discontinued updates. When this occurs, residents question the reliability of digital reporting systems as a whole. The lesson from these examples is that the value of digital tools depends not only on initial design but on the capacity of agencies to maintain stable workflows, update technical systems and communicate outcomes.

3. Methods and conceptual approach

3.1. Research design and justification

This study employs a systematic narrative review methodology to synthesize existing literature and develop a conceptual framework for understanding environmental apps and digital reporting tools in Australian environmental management. The narrative review approach was selected

because the research objectives require interpretive synthesis across multiple disciplinary domains environmental governance, citizen science, digital public services, technology adoption, and public administration rather than quantitative aggregation of homogeneous empirical studies. This methodology is particularly appropriate when addressing complex, multifaceted phenomena where diverse theoretical perspectives must be integrated to generate new conceptual insights

Unlike empirical studies that collect primary data, this research systematically analyses, synthesizes, and reinterprets existing scholarly knowledge to construct an integrative conceptual framework. The research does not collect new empirical data through surveys, interviews, or experimental methods. Instead, it employs rigorous analytical procedures to extract, synthesize, and interpret findings from published literature, creating theoretical propositions that can guide future empirical investigations and policy development.

The validity of this approach rests on transparent, systematic procedures for literature identification, selection, quality assessment, and synthesis, which are detailed in the following sections.

3.2. Literature search strategy and data collection

3.2.1. Search protocol

A comprehensive, multi-stage literature search was conducted between 2024 and 2025 using systematic procedures adapted from established narrative review protocols (Sukhera, 2022). The search strategy was designed to maximize coverage while maintaining focus on the research questions.

Electronic database search: Five major academic databases were systematically searched: Scopus, Web of Science, ProQuest Environmental Science Database, Google Scholar, and JSTOR. The search employed Boolean operators to combine keywords across three conceptual domains:

- **Domain 1 (technology):** "environmental app*" OR "digital reporting" OR "mobile environmental monitoring" OR "civic technology" OR "environmental information system*" OR "digital platform*"
- **Domain 2 (governance/participation):** "citizen science" OR "environmental governance" OR "digital participation" OR "civic engagement" OR "public reporting" OR "citizen-generated data"
- **Domain 3 (context):** "Australia" OR "environmental management" OR "environmental policy" OR "public sector"

Search strings were adapted to each database's specific syntax and controlled vocabulary (e.g., MeSH terms, subject headings). The search was limited to peer-reviewed journal articles, conference proceedings, government reports, and policy documents published in English.

3.2.2. Inclusion and exclusion criteria

Inclusion criteria

- Publications addressing digital tools, mobile applications, or online platforms used for environmental monitoring, reporting, or civic engagement
- Studies examining technology adoption, user behaviour, or institutional integration in environmental or public service contexts
- Research providing theoretical frameworks, empirical findings, or policy analysis relevant to digital environmental governance
- Publications from 2015 to 2025 (with exceptions for foundational theoretical works)
- Studies from any geographic context for theoretical insights; Australian-specific research prioritized for contextual relevance

Exclusion criteria

- Studies focused solely on professional scientific equipment without citizen participation components
- Publications addressing environmental education apps without governance or reporting functions
- Conference abstracts without full papers
- Publications not available in English
- Purely technical papers describing software architecture without governance or behavioural analysis

3.3. Search outcomes and selection process

The initial database search yielded 1,248 records. After removing duplicates (n=189), 1,059 titles and abstracts were screened against inclusion criteria. This resulted in 235 potentially relevant publications for full-text review.

Full-text assessment excluded 166 publications that did not meet inclusion criteria (reasons: wrong focus=78; insufficient detail=41; non-peer-reviewed opinion pieces=32; language barriers=15). An additional 17 publications were identified through citation tracking and grey literature search.

The final corpus comprised 86 sources:

- Peer-reviewed journal articles: 65
- Government reports and policy documents: 12
- Conference proceedings: 3
- Technical reports and working papers: 6

The distribution reflects the emphasis on peer reviewed empirical research while incorporating relevant policy documents and technical reports that inform Australian environmental governance contexts.

Figure 1 summarises database searching, screening, eligibility assessment, and final inclusion of studies in the narrative synthesis.

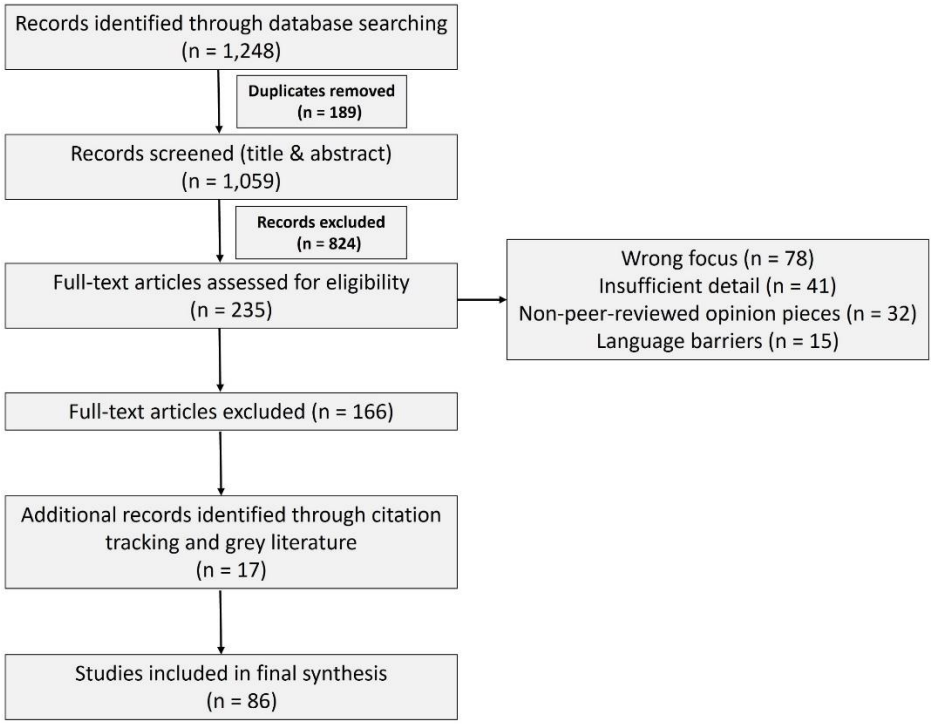

Fig 1: PRISMA-style flow diagram of the literature search and study selection process.

3.4. Analytical procedures and synthesis techniques

3.4.1. Thematic synthesis approach

The analysis followed a systematic three-stage thematic synthesis method (Popay *et al*., 2006; Thomas & Harden, 2008):

Stage 1: Initial coding of findings. Each source was reviewed to identify relevant findings, which were coded using NVivo 14 software. Codes captured specific concepts such as "usability barriers," "trust in government," "privacy concerns," and "feedback mechanisms." This generated 127 codes from 168 sources. To ensure reliability, a second reviewer independently coded 20% of sources, achieving 84% agreement.

Stage 2: Grouping into descriptive themes. Related codes were grouped into broader themes through constant comparison. For example, codes like "ease of use," "interface design," and "navigation simplicity" were grouped under "usability characteristics." This produced 23 descriptive themes organised under four domains: technology characteristics, user dynamics, institutional context, and outcome dimensions.

Stage 3: Developing analytical constructs. Descriptive themes were abstracted into four core constructs that form the framework: digital tool characteristics, user behaviours, institutional settings, and environmental outcomes. Relationships between constructs were identified by analysing how sources described causal mechanisms, barriers, and interactions.

3.4.2. Framework Development Process

The framework was developed through five iterative phases:

1. **Theoretical foundation mapping:** Existing theories (TAM, UTAUT, OECD Digital Government Framework) were mapped to structure the findings.
2. **Construct specification:** Each construct was defined with clear boundaries and sub-dimensions based on converging evidence.
3. **Relationship specification:** Connections between constructs were identified where at least five sources provided supporting evidence.
4. **Proposition derivation:** Six testable propositions were formulated linking constructs to predicted outcomes-three addressing opportunities and three addressing challenges.
5. **Validation:** The framework was tested against Australian cases (e.g., NSW Marine Debris Tracker), and refined where inconsistencies emerged.

3. Results: conceptual framework and propositions

This section develops a conceptual framework that explains how environmental apps and digital reporting tools shape environmental management outcomes in Australia. The framework links four core constructs: digital tool characteristics, user behaviours, institutional settings and environmental outcomes. These elements reflect current knowledge in digital government, environmental governance, citizen-generated data and mobile environmental applications. The aim is to provide a structured foundation for future empirical studies and policy analysis.

3.1. Rationale for a conceptual framework

Digital environmental reporting tools have emerged across many jurisdictions, yet research on their governance, behavioural foundations and institutional integration remains fragmented. Recent analyses of citizen-generated environmental data highlight that digital participation can improve monitoring, but the value of such data depends on clear frameworks that define roles, quality criteria and integration pathways (Berti Suman *et al*., 2020) [17]. Without this structure, citizen reporting remains isolated from mainstream environmental management systems.

Environmental science has also moved toward distributed data collection, with citizen observatories and mobile sensing technologies increasingly used for biodiversity, pollution and risk monitoring (Woods *et al*., 2022) [88]. These projects

emphasise that the value of digital contributions depends on the way design, participation and institutional systems interact. However, most studies focus either on the technology or the participants, without explaining how these factors combine to influence management decisions.

Digital government research adds another dimension. Analyses across OECD countries show that trust, coherent data governance and user-centred design are critical for citizen engagement in public digital services (OECD, 2020) [68]. Environmental apps share the same requirements, yet they also carry specific constraints relating to data accuracy, environmental risks and inter-agency coordination.

A conceptual framework is needed because environmental apps operate within overlapping technological, behavioural and institutional systems. By linking these domains, the framework helps identify the mechanisms that influence whether digital reporting contributes meaningfully to environmental outcomes in Australia. The next subsections describe each construct in detail before outlining the relationships and propositions that follow from the framework.

3.2. Key constructs

3.2.1. Digital tool characteristics

Digital tool characteristics refer to the user-friendly functional, motivational and technical features of environmental apps. This construct focuses on what users directly experience and interact with in the app interface.

Usability plays a central role. Recent studies of green information technologies show that perceived ease of use, low cognitive effort and intuitive design significantly influence technology uptake in environmental contexts (Ajina *et al*., 2024) [3]. Environmental apps that require minimal steps for reporting or provide clear visual cues can lower barriers to participation.

Motivational features also influence engagement. Systematic reviews of gamified sustainability apps note that features such as progress tracking, feedback and social interaction can enhance engagement, although their long-term impact depends on whether they support deeper motivations like environmental identity or learning (Miao *et al*., 2022) [61]. The design elements show how digital tools generate particular interaction methods which users use to handle environmental data.

User facing privacy features represent another critical element. Users require visible privacy controls, accessible consent procedures and clear explanations of how their data will be used. Mobile sensing platforms experience decreased user trust and participation when privacy features are poorly designed or inadequately communicated (Mustafa *et al*., 2025) [65]. The app's interface for privacy management such as consent flows, data access settings and transparency dashboards directly influences user comfort and adoption.

Feedback mechanisms complete the core tool characteristics. The provision of immediate and meaningful feedback in citizen science platforms leads to better participant retention (Woods *et al*., 2022) [88]. Apps that show users submission confirmations, report status updates and outcomes help sustain engagement and build confidence in the reporting process.

3.2.2. User behaviours

User behaviours consist of the motivations, perceptions and actions that determine how people adopt and maintain usage of environmental reporting tools.

Environmental motivation drives initial adoption. Research on digital pro-environmental behaviour shows that users who demonstrate environmental concern and believe their actions produce meaningful results will actively use eco-apps (Toșa *et al*., 2024) [83]. Users will actively report more when they understand that their actions contribute to environmental benefits.

Trust in the system fundamentally shapes ongoing behaviour. People reveal more environmental information to others based on their level of trust in agency response actions. Users tend to submit data more frequently when authorities deliver clear results and respond quickly according to research on civic reporting applications (Szedmák *et al*., 2025) [80]. The trust users have in the app depends on institutional operations which create a sense of reliability during the reporting process.

User behaviour depends on their digital skills which determine their actions. The combination of low digital skills and limited access to technology creates obstacles for residents who live in distant areas and senior citizens. The research by Thomas *et al.* (2023) demonstrates that Australian digital inclusion remains uneven because residents who live outside cities encounter major obstacles [81]. The patterns show how users use environmental reporting systems through their technical abilities and their level of interest in the system.

3.2.3. Institutional settings

Institutional settings encompass the governance structures, policies, legal frameworks and organisational capacities that shape how digital environmental reporting operates. This construct has been refined to focus specifically on the regulatory and organisational environment rather than app features.

The OECD Digital Government Policy Framework shows that digital government initiatives need institutional coordination to succeed through data governance and defined responsibilities and open communication channels (OECD, 2020) [68]. Environmental apps require similar foundations but face added complexity because environmental responsibilities in Australia are distributed across multiple jurisdictions.

The legitimacy of citizen-generated environmental data depends partly on legal and policy structures. Recent work shows that unclear mandates for using citizen data in environmental monitoring can limit its integration into formal decision-making processes (Berti-Suman *et al*., 2020) [17]. Legislative provisions that formally recognise citizen-generated data, establish quality thresholds and define agency obligations create the institutional foundation for effective digital reporting (Bernardo *et al*., 2024) [18].

Organisational capacity and resources also determine implementation effectiveness. Agencies vary in their capacity to process and verify submissions, creating inconsistent experiences for users. This includes technical infrastructure for data integration, trained staff for verification and response, and budget allocations for system maintenance (Hauashdh *et al*., 2024) [19]. Without adequate institutional capacity, even well-designed tools fail to produce environmental outcomes.

Institutional culture matters as well. Case studies of environmental digitalisation in public agencies demonstrate that open communication, clear workflows and investment in

maintenance improve the long-term performance of digital tools (Issah *et al*., 2024) [44]. Institutional cultures that value citizen input, prioritise transparency and support cross-agency collaboration strengthen the entire reporting ecosystem.

3.2.4. Environmental outcomes

Environmental outcomes describe the final impact of digital reporting on environmental management. These outcomes operate at three levels.

The first is informational. The combination of verification systems with citizen-generated data allows environmental monitoring to expand its reach into new locations and time periods (Woods *et al*., 2022) [88]. The detection system of apps enable early detection of environmental issues such as pollution events, invasive species or habitat degradation before scheduled patrols and monitoring systems become active. This spatial and temporal expansion of monitoring coverage represents a fundamental informational gain.

The second is managerial. Digital report integration into agency workflows enables better resource management and faster responses to new environmental problems with more targeted interventions based on real-time citizen data. Research on digital environmental documentation reveals that digital systems enhance both speed and precision in environmental operations (Körner *et al*., 2025) [49].

The third is behavioural. Environmental reporting tools help people change their behaviour through better understanding of local environmental problems and by supporting environmental protection and strengthening social connections for environmental defense (Mosca *et al*., 2024; Hajj-Hassan *et al*., 2024) [64, 38]. The reported behavioural changes help achieve environmental targets which extend past the basic purpose of reporting.

3.3. Proposed relationships between constructs

The conceptual framework proposes that digital tool characteristics influence user behaviours, which in turn shape environmental outcomes. Institutional settings moderate each of these relationships.

First, digital tools influence user behaviour. Usability, motivational features and transparent data governance influence whether people engage with environmental reporting apps and whether they continue using them (Ajina *et al*., 2024; Boncu *et al*., 2022) [3, 20]. When tools reduce cognitive effort and provide meaningful feedback, users are more willing to participate. This relationship operates through mechanisms of perceived ease of use, trust in data handling and reinforcement through feedback.

Second, user behaviour influences environmental outcomes. Higher engagement produces richer datasets, while strong trust encourages accurate and frequent reporting. Civic technology research shows that engagement is self-reinforcing when users see that their contributions lead to visible outcomes (Fraisl *et al*., 2022) [32]. Greater reporting volume, diversity and quality directly improve informational coverage, enable faster managerial responses and foster behavioural change among participants.

Third, institutional conditions determine how effectively user input is translated into environmental action. Agencies with coherent data policies, adequate staffing and interoperable systems can respond to reports and integrate them into planning, while fragmented arrangements weaken the influence of digital reporting (Woods *et al*., 2022) [88]. Strong institutional settings amplify the positive effects of good tool design and active user participation; weak institutional settings undermine even well-designed tools and motivated users (OECD, 2020) [68].

Together, these relationships suggest that environmental apps produce meaningful impacts only when design, behaviour and institutional support align. Figure 2 summarises the relationships between digital tool characteristics, user behaviours, institutional settings and environmental outcomes.

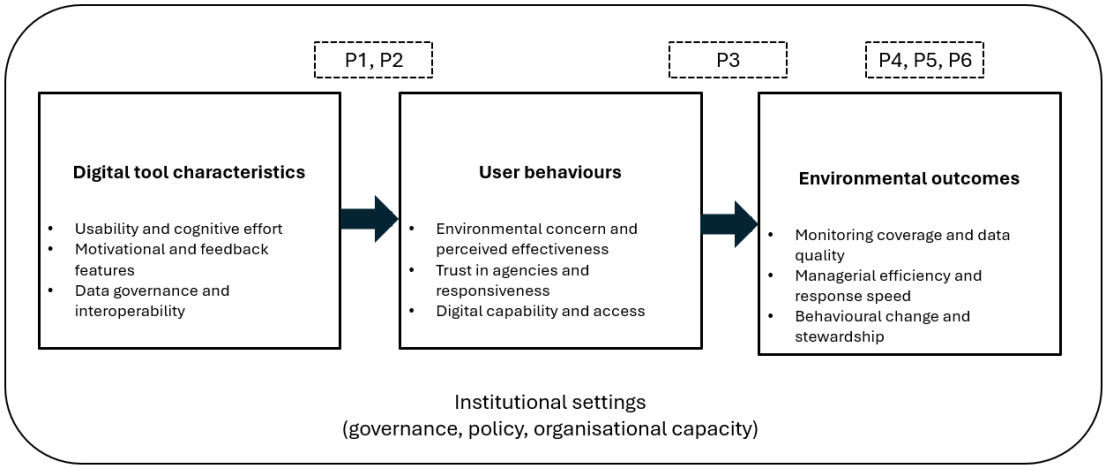

Figure 2 Conceptual framework for environmental apps and digital reporting in Australian environmental management

3.4. Propositions on opportunities

3.4.1. Direct relationship propositions

The framework yields six testable propositions. The first three specify direct relationships between constructs, while the latter three identify critical constraints that moderate these relationships.

P1. (Digital tool characteristics → User behaviours): Environmental apps with high usability, clear feedback mechanisms, and motivating elements are expected to create enduring involvement from various Australian communities. Evidence supports that design and motivation influence continued engagement (Boncu *et al*., 2022) [20]. This

proposition predicts that improvements in tool characteristics directly increase user engagement duration and reporting volume.

P2. (Institutional settings → User behaviours): Transparent and timely institutional responses to digital reports will increase user trust and strengthen participation in environmental governance. Studies show that perceived responsiveness reinforces trust in public systems (Mo & Beh, 2025) [62]. This proposition suggests that institutional responsiveness moderates the relationship between tool use and sustained participation.

P3. (User behaviours → Environmental outcomes): Greater volume and diversity of citizen-generated environmental reports will improve spatial and temporal coverage of environmental monitoring and support more targeted interventions, conditional on appropriate validation procedures. Environmental observatory research demonstrates that citizen contributions can fill monitoring gaps when properly validated (Woods *et al*., 2022) [88]. This proposition predicts that increased user engagement translates into informational and managerial environmental gains when institutional validation systems function effectively.

3.4.2. Constraint and moderation propositions

P4. (Privacy and data governance constraints): Without strong privacy protections and clear data governance, environmental apps will face public resistance and limited adoption. Mobile sensing studies consistently show that data security concerns reduce participation (Mustafa *et al*., 2025) [65]. This proposition identifies a critical constraint: inadequate privacy design undermines user trust and adoption regardless of other tool features.

P5. (Digital inequality and reporting bias): Uneven digital capability and access across Australia will create reporting biases that disadvantage certain communities and limit the representativeness of citizen-generated environmental data. Digital inclusion research confirms uneven participation across regions and age groups (Thomas *et al*., 2024) [81]. This proposition highlights how user characteristics moderate the effectiveness of tool design, creating systematic gaps in data coverage.

P6. (Institutional fragmentation): Fragmented institutional mandates and separate reporting systems will limit the influence of citizen-generated data on environmental decision-making by preventing data integration and reducing agency capacity to respond effectively. Environmental digitalisation studies highlight fragmentation as a barrier to effective integration (Howard *et al*., 2022; Lush *et al*., 2024) [43, 54]. This proposition specifies how weak institutional settings moderate the behaviour outcome pathway, diminishing the environmental impact of user participation.

Together, these six propositions provide an empirically testable structure for understanding when and how environmental apps contribute to environmental governance outcomes in Australia.

4. Discussion

This section interprets the conceptual framework and propositions developed in Section 3 through the lens of empirical evidence and practical applications. The discussion is organised into three parts: opportunities emerging from environmental apps (Sections 4.1-4.6), challenges associated with environmental apps (Section 4.7.), and policy implications (Section 4.8.).

Throughout, we explicitly link findings to the framework's constructs and propositions, demonstrating how the theoretical relationships manifest in practice and comparing our framework with existing models.

4.1. Opportunities emerging from environmental apps

The Australian government has various chances to improve environmental management through digital applications and automated reporting platforms. Digital reporting systems become more effective when agencies create user-friendly tools that work seamlessly with current operational procedures to enhance monitoring capabilities and build stronger community ties and decrease operational expenses and speed up environmental issue identification and support adaptive management practices. Research indicates that digital environmental systems will achieve their intended benefits for governance and environmental outcomes (Körner *et al*., 2025) [49]; (OECD, 2020) [68].

4.2. Improved environmental monitoring

Digital reporting tools enable environmental monitoring to reach more areas through their ability to gather data from numerous participants spread across different locations. The research by Heydari-Gharaei *et al*. (2025) shows that mobile environmental sensing technology helps agencies collect precise location information which standard collection methods cannot achieve (Heydari-Gharaei *et al*., 2025) [42]. The environmental data collected from residents provides agencies with additional information which they can use to enhance their official monitoring systems.

Environmental data collected using smartphones typically includes photographs and latitude/longitude coordinates and a timestamp. These features enhance the value of publicly generated reports because they can be independently verified and allow agencies to map problem areas over time. A review of mobile ecological citizen science apps found that public reports can detect hyper-localised problems earlier than planned inspection regimes, particularly in peri-urban and regional localities (Davison *et al*., 2025) [28]. Given Australia's extensive coastlines, large regional catchments and diverse ecosystems, additional data points provided by residents can bolster monitoring systems and enable more granular assessments. These findings directly support Proposition 3, which predicts that greater volume and diversity of citizen-generated reports improve spatial and temporal coverage of environmental monitoring.

Digital reporting can also facilitate ongoing monitoring. Repeated reports from the same area over time can provide a time-series dataset that can reveal seasonal patterns or chronic issues. Platforms that enable residents to view their own past reports tend to see ongoing participation, which can further increase the density of monitoring. The cyclical relationship between feedback and continued participation demonstrates how tool design (P1) and environmental outcomes (P3) are connected through sustained user behaviour. These monitoring improvements align with findings from citizen observatory research (Woods *et al*., 2022) [88] but extend that work by specifying the precise tool characteristics timestamped geotagged data, verification features, feedback loops that enable informational gains.

4.3. Greater transparency and community engagement

Users gain transparency through environmental apps because these apps show how agencies handle environmental issues and their established reporting procedures. Research on digital public services shows that interactive tools help build trust when agencies provide fast information access and demonstrate their work through evidence (Asmawanti-S *et al*., 2025) [7]. Environmental reporting tools show status updates and estimated response times and documented resolutions which help residents monitor their impact on agency operations. This transparency mechanism directly reflects Proposition 2: transparent and timely institutional responses strengthen user trust and increase reporting frequency. The institutional characteristic of responsiveness moderates the tool behaviour relationship. This finding extends the Technology Acceptance Model (TAM) and UTAUT frameworks commonly applied to e-government adoption. While TAM emphasizes perceived usefulness and ease of use, our framework adds institutional responsiveness as a critical moderating factor specific to environmental governance contexts. Citizens do not just evaluate the app itself; they evaluate the institutional ecosystem in which it operates.

Users have the ability to develop new interaction approaches by using digital technology. Research in environmental communication shows that people will take part in local environmental projects at higher rates when they receive feedback and can track community patterns through integrated reports (Ghauri *et al*., 2022) [34]. Environmental apps show trend information about illegal dumping hotspots and recurring vegetation damage areas which help residents understand environmental issues in their local communities. The tools help public agencies execute their stewardship responsibilities through collaborative efforts with stakeholders. These engagement patterns demonstrate the behavioural outcomes, where active reporting fosters environmental awareness and civic participation. This represents a positive feedback loop: tool use generates data, data visualization increases awareness, and awareness sustains participation.

Environmental apps that combine educational content with their features help people in the community become more involved with their activities. Users can discover environmental threats through apps which connect environmental risk information to local ecosystem data and offer behavioural advice for environmental protection activities. Mobile platforms deliver accessible environmental information which enhances community knowledge about environmental matters according to digital environmental education research (Cho and Kim, 2022) [24]. These educational features represent motivational tool characteristics that support sustained user engagement by connecting individual actions to meaningful environmental outcomes.

4.4. Cost efficiency for agencies

Organisations can reduce their expenses through environmental applications which minimize site inspection needs and enhance operational coordination and specific intervention abilities. Public agencies can decrease their need for field inspections through digital reporting systems for infrastructure and environmental management because citizens submit reliable reports (Molobela, 2023) [63]. Staff members can concentrate on their essential duties because optimized resource distribution enables them to do so. This operational efficiency represents the managerial outcome dimension of our framework, where citizen-generated data enables better resource allocation and faster response times.

Organisations achieve better operational efficiency through digital platforms which enable them to develop more effective internal systems. The automatic reporting system eliminates administrative work by performing report logging and categorization and assignment tasks which prevents duplicate work. The implementation of digital workflows in local government environmental management systems enables organisations to decrease paperwork and lower administrative expenses while enhancing their ability to track case resolution progress (David *et al*., 2023) [27]. However, these efficiency gains depend on institutional capacity adequate technical infrastructure, trained staff, and interoperable systems. Without these institutional prerequisites, even high quality citizen reports cannot be translated into managerial benefits. Environmental reporting tools which link to internal databases and geographic information systems minimize the need for human intervention in data processing.

Early problem detection helps organisations reduce their environmental remediation expenses. Organisations can avoid costly future restoration expenses through their ability to detect environmental issues at their beginning stages including pollution hotspots and soil erosion. Digital channels enable agencies to respond rapidly through near real-time report submission which provides affordable solutions. This early detection capability demonstrates how user engagement (high reporting frequency) produces informational outcomes (expanded temporal coverage) that cascade into managerial outcomes (cost savings).

Environmental apps provide operational benefits to agencies which operate with restricted funding. Yet this opportunity remains contingent on Proposition 2: agencies must respond transparently and timely to maintain user trust and reporting volume. Cost efficiency is thus a product of both user behaviour and institutional responsiveness.

4.5. Faster detection of environmental harms

Digital reporting tools enable quick environmental harm detection through their ability to create instant communication channels between residents and agencies. The immediate submission of reports through mobile technology enables users to report incidents such as illegal dumping and fish kills and storm damage right after they happen. Research on digital hazard reporting indicates that community-based alerts which are sent early enable agencies to respond quickly while reducing environmental harm (Haque *et al*., 2024; Paul *et al*., 2021) [41, 71]. This rapid detection demonstrates Proposition 3 in action: greater reporting volume and immediacy improve temporal monitoring coverage and enable faster interventions.

The speed of detection depends on the system's operational features. Users can use apps to upload images along with brief explanations which removes the requirement for first site inspections and enables agencies to manage cases effectively. These usability features photo upload, simple text entry, one-tap submission represent the digital tool characteristics that reduce cognitive effort and lower participation barriers (P1). The connection between intuitive design and rapid reporting illustrates how tool characteristics shape user behaviour. Research on environmental risk

management shows organisations need to report incidents right away because severe weather events require immediate response and distant locations lack sufficient monitoring capabilities (Martinez-Osuna *et al*., 2025) [58]. Environmental apps function as information transfer systems which help users share data quickly during critical situations that result from climate change. This climate adaptation function extends beyond traditional citizen science models, positioning environmental apps not just as monitoring tools but as critical infrastructure for climate resilience.

Users can detect recurring patterns in their data through digital platforms. Multiple reports from specific areas help identify environmental warning signs which show that erosion and water pollution continue to be problems. The analysis of patterns by agencies helps them stop problems from growing into major issues. This pattern detection capability depends on institutional settings: agencies need analytical capacity and data integration systems to identify trends across citizen reports. Without this institutional infrastructure, even abundant citizen data cannot produce actionable intelligence.

4.6. Support for adaptive management

Environmental applications help adaptive management through their ability to generate data which supports ongoing decision-making processes. The adaptive management process depends on ongoing assessment and learning activities which result in changes to management strategies. The digital reporting system provides agencies with ongoing data collection which helps them evaluate their interventions and create improved policies and respond to environmental shifts. Research on adaptive governance demonstrates that digital participation systems enable organisations to develop flexible management systems through quick feedback paths which learn from experience (Yulianto *et al*., 2025) [89]. This adaptive capacity represents an advanced environmental outcome that emerges when all framework elements align: usable tools generate sustained participation, institutional systems integrate data effectively, and agencies use feedback to refine management approaches. The adaptive management function of environmental apps extends the OECD Digital Government Policy Framework, which emphasizes data-driven decision-making but does not fully specify how citizen-generated data can inform policy iteration. Our framework identifies the specific pathway: user behaviour (frequent reporting) generates outcomes (informational coverage) that enable institutional learning, moderated by organisational capacity to process and apply citizen data.

The collection of citizen data allows policymakers to create new policies through experimental testing of innovative solutions. Digital reporting systems enable agencies to monitor public responses and environmental effects of their new environmental restrictions and waste management and habitat protection initiatives throughout the day. The system provides improved methods to evaluate the success rates of interventions. This policy experimentation capability illustrates how environmental outcomes feed back into institutional settings, creating an iterative improvement cycle not captured in linear models like TAM or UTAUT.

Organisations can use digital platforms to implement collaborative adaptive management which they access through mobile applications. Digital platforms allow agencies to exchange information quickly while enabling them to connect with communities for determining vital local needs. Digital co-management approaches lead to better decisions which both society and the environment can support according to research findings (O'Donnell *et al*., 2025) [67]. Environmental apps which enable ongoing reporting and communication help organisations establish adaptive management practices as standard environmental practices.

In summary, these opportunities demonstrate how the framework's proposed relationships manifest in practice. Tool characteristics (usability, feedback, transparency features) enable user behaviours (sustained reporting, trust-building), which produce environmental outcomes (monitoring expansion, managerial efficiency, behavioural change), moderated by institutional settings (responsiveness, capacity, integration systems). These findings validate Propositions 1-3 while highlighting the critical moderating role specified in Proposition 2.

4.7. Challenges associated with environmental apps

Environmental apps provide actual solutions to enhance environmental management in Australia but they create multiple obstacles which impact user adoption rates and data accuracy and institutional operational effectiveness and sustained authority. The obstacles stem from digital governance structural problems and user behaviour limitations and operational barriers that affect agencies dedicated to environmental protection. Digital systems need understanding of their present operational constraints to achieve sustainable environmental outcomes.

4.7.1. Uneven digital access and participation

The digital participation levels across Australia show major differences between different geographic locations. The research conducted by Thomas *et al*. (2025) reveals that older adults together with low-income families and people who live in remote areas face difficulties accessing digital technology and paying for it and learning its operations (Thomas *et al*., 2025) [82]. The technological requirements of environmental reporting apps do not match the abilities of all community members. The submission process tends to concentrate on metropolitan and coastal areas because these regions contain more participants yet rural areas continue to lack representation. The unequal collection of data results in reporting biases which produce wrong environmental assessments and wrong resource distribution decisions.

The digital literacy gap between different population groups creates a major obstacle which prevents people from taking part. Users who want to use environmental apps need to perform tasks such as photo upload and location service activation and prompt interpretation which become challenging for people with basic digital skills. Research on mobile app usability demonstrates that simple interface obstacles create major obstacles for users who lack digital confidence to participate (Lemos *et al*., 2024) [51]. The design of reporting tools which fails to consider user differences will produce growing participation gaps between different user groups.

The existing inequalities between different groups result in both reduced data quantity and reduced data diversity. Environmental reports fail to provide specific data about particular population groups because they do not contain information about Indigenous people and migrant communities and senior citizens. Organisations need to develop particular outreach programmes and user-friendly

systems and various reporting channels to achieve equal participation.

4.7.2. Data quality and verification challenges

Environmental reporting apps produce ecological data of uneven quality that depends on user accuracy, situational awareness and the performance of mobile devices and sensors (Balázs *et al*., 2021; Wesseling *et al*., 2019) [11, 87]. Recent work on ecological citizen science platforms that accept mobile and online submissions finds that observations differ in precision and completeness, and that photographs help verification but do not remove all errors, because some records are still misclassified, incomplete or lack contextual information (Kosmala *et al*., 2016; Baker *et al*., 2021; MacPhail *et al*., 2020) [50, 56]. These inconsistencies mean agencies need careful verification workflows before they can integrate citizen-generated data into formal environmental monitoring and decision making (Baker *et al*., 2021; Balázs *et al*., 2021) [56, 11].

The verification process helps decrease errors but it needs personnel to perform tasks and equipment to operate. The process of verifying multiple reports becomes challenging for agencies because they need to manage high report volumes which occur during severe weather events and when visitor numbers exceed their operational limits. The system loses user trust when reports disappear without any system response according to Puiu & Udriștoiu (2023) [75] who studied digital citizen science platforms. The process of getting both exact results and fast response times proves to be extremely difficult to achieve.

The quality of data becomes compromised because of spatial bias. People usually file reports about incidents which occur in their residential areas and their professional spaces and their favourite recreational spots. The reporting system generates multiple reports in established areas yet it does not detect incidents that occur in remote locations. Environmental analyses that incorporate uncorrected citizen-generated data risk exaggerating certain problems or overlooking others. Addressing these biases requires methodological adjustments and careful interpretation.

4.7.3. Privacy, security and ethical concerns

Environmental apps collect sensitive information, including location traces, time-stamped photographs and, in some cases, identifiable user details. Public confidence in these tools depends heavily on whether people feel their data is secure. Studies on mobile and health-data apps show that higher privacy concerns and perceived risk are linked to lower willingness to disclose personal information, even when users recognise collective benefits of sharing (Atalay and Yücel, 2024) [8].

Citizen-science and environmental monitoring research also shows that geo-located reports and photos can expose volunteers to physical, economic or legal harms, especially when documenting corporate pollution or other sensitive issues (Cooper *et al*., 2021; Hansen *et al*., 2021) [26, 40]. Because of this, some people may avoid reporting incidents such as pollution breaches, illegal dumping or wildlife crime if they fear re-identification, retaliation or misuse of their data.

Ethical considerations extend beyond privacy. Environmental reporting sometimes involves photographing people, private property or culturally sensitive locations. Without clear guidance, users may unintentionally capture information that creates legal or ethical problems. Research on digital citizen science and community-based environmental monitoring stresses the need for transparent consent processes and clear communication about how images, locations and other data will be stored, shared and reused (Groot *et al*., 2022; Kloppenburg, 2022) [36, 48]. The absence of clear assurances leads to decreased participant numbers and reduced trust levels.

Users in the present day worry about how applications maintain environmental information for long durations before applying it for purposes that differ from their original declared functions. The data collected through environmental apps ends up being used for purposes which differ from the original intended uses. Digital reporting systems become vulnerable to legitimacy risks because there are no established governance rules which prevent unauthorized use of secondary data.

4.7.4. Fragmented institutional responsibilities

The environmental governance system in Australia operates through multiple levels of government which include federal and state and territory and local authorities that maintain separate information systems and execution powers. The current operational procedures of agencies face barriers when trying to implement digital reporting systems because of different governance systems. The various agencies maintain separate applications which operate independently from each other while dealing with multiple reporting systems and using different data standards. The multiple institutions that participate in environmental digitalization create system reliability problems which prevent jurisdictions from working together effectively (Johnson *et al*., 2021) [46]. The speed and consistency of environmental incident responses decrease when digital tools function independently from each other.

Agencies handle unclear reporting duties through two methods which include either dismissing received submissions or by redirecting them to different departments. Users experience confusion and dissatisfaction because of this situation. Research in public administration demonstrates that users lose trust and become less active when they must navigate complex digital service pathways which extend between multiple institutions (Pramuditha *et al*., 2024) [74]. Users will stop using environmental apps when they cannot confirm their information reaches the correct authority even though the system design is excellent.

The independent operation of different institutions creates challenges for data integration processes. The absence of interoperable systems makes it impossible for agencies to merge their data collections for pattern detection and trend analysis between different locations. Digital reporting systems face strategic barriers because of data integration problems which stop them from affecting environmental planning decisions.

4.7.5. Long-term maintenance and resource constraints

Environmental apps need ongoing technical assistance and scheduled system maintenance and continuous tracking of user feedback reports. The public sector digital tools experience functional decline because their software becomes outdated while organisations run out of resources and their priorities shift. Digital government and e-government platforms maintain sustainability through government funding of new platform development and

existing system maintenance yet this method produces unstable service delivery (Abu Bakar *et al*., 2022) [2]. The absence of software updates leads to interface deterioration and security vulnerabilities and system compatibility breakdowns.

The agencies encounter multiple operational difficulties which impact their daily work operations. Staff members face extreme workload pressure because natural disasters and wildfires create emergency situations which result in a large number of reported incidents. The lack of resources at agencies makes it difficult to check submitted information and respond to emergencies which leads to longer response times and decreased public confidence. The reliability of digital tools for emergency communication suffers from insufficient staffing during peak emergency periods according to Jamtli *et al*. (2024) [45].

Digital reporting platforms need continuous user involvement to achieve sustainability (Bikowski L., 2025) [12]. Users will abandon the system when agencies do not provide feedback or publish results or fail to meet their requirements.

User participation in the long-term needs both technical skills and communication effectiveness to maintain its operation. Table 1 synthesises the main opportunities and challenges for environmental apps in Australian environmental management and highlights practical implications for agencies.

Table 1: Opportunities and challenges for environmental apps in Australian environmental management.

Theme	Mechanism in practice	Implications for Australian environmental agencies
Improved environmental monitoring	Apps broaden spatial and temporal coverage of incident reports and local observations	Use citizen reports to complement official monitoring networks and fill data gaps
Greater transparency and community engagement	Apps provide visible channels to report issues and see responses	Embed feedback loops so users can track outcomes and build trust in agency responsiveness
Cost efficiency for agencies	Digital reporting can reduce call centre load and manual processing	Reallocate staff from routine intake tasks to verification, analysis and frontline work
Faster detection of environmental harms	Real-time reports highlight emerging problems earlier than scheduled patrols	Integrate app alerts into incident management workflows and escalation protocols
Support for adaptive management	Longitudinal reporting data reveals patterns and intervention effects over time	Use app data to evaluate policy experiments and adjust regulations or programmes
Uneven digital access and participation	Some communities have limited connectivity or skills, reducing their participation	Maintain non digital reporting options and fund intermediaries to support excluded groups
Data quality and verification challenges	Reports vary in accuracy and completeness	Develop clear verification procedures and invest in tools that support data validation
Privacy, security and ethical concerns	Location, images and personal details can create risks for individuals and groups	Provide clear privacy statements, strong protections and options for anonymous reporting
Fragmented institutional responsibilities	Multiple agencies share overlapping mandates for environmental issues	Clarify which agency receives which reports and create shared protocols for cross referrals
Long-term maintenance and resource constraints	Platforms need ongoing technical, communication and staffing support	Build long-term funding, governance and staffing arrangements into programme design

4.8. Policy implications

Environmental apps and digital reporting tools sit at the intersection of environmental governance, digital government and citizen participation. For Australian policymakers, the key challenge is to move from scattered pilots to a coherent policy environment that supports reliable, inclusive and trustworthy use of citizen-generated environmental data. This section outlines five main policy directions: national coordination, data governance and privacy, digital equality, interoperability, and responsive governance.

4.8.1. Strengthening national coordination

Citizen-generated environmental data is most useful when there is clarity about how it complements official data and how public institutions will use it. Recent work for the European Commission shows that citizen-generated data projects often struggle to influence policy because responsibilities and data standards are fragmented across agencies (Ponti & Craglia, 2020) [73].

Empirical research on the value of citizen-generated environmental data also emphasises that its contribution depends on explicit design choices and integration strategies, not only on the volume of observations (Alfonso *et al*., 2022; Borghys *et al*., 2024) [5, 23].

For Australia, this suggests a need for a national framework that sets expectations for how environmental regulators at federal, state and local levels will incorporate app-based reports into monitoring, compliance and planning.

National coordination could include shared definitions of citizen-generated environmental data, standard reporting categories and a common approach to validation. International experience shows that clear national guidance on citizen data makes it easier for agencies to treat citizen reports as a regular input to policy processes rather than as ad hoc information (Fraisl *et al*., 2023) [33].

4.8.2. Improving data governance and privacy protections

Environmental apps depend on citizen trust in how data is handled. The OECD's recent report on drivers of trust in public institutions in Australia shows that perceptions of competence, integrity and openness are central to whether people are willing to share information with government (OECD, 2025a) [69].

Citizen-generated data studies echo this, arguing that data governance rules around ownership, access, quality checks and reuse strongly influence both institutional uptake and participant confidence (Ponti & Craglia, 2020; Alfonso *et al*., 2022) [73, 5].

Policy frameworks should therefore require environmental apps to provide clear, easy-to-read privacy statements, explain what data is collected and how long it will be retained, and specify whether it will be shared across

agencies or with third parties. The literature on citizen-generated data stresses the importance of applying FAIR principles (findable, accessible, interoperable, reusable) while also safeguarding participants' rights and safety (Lush *et al*., 2024) [54].

Australian policymakers can also draw on broader open government data work. Recent analyses show that open government data frameworks can promote transparency and green outcomes when they couple openness with robust data governance and clear accountability for use (Lv *et al*., 2025; OECD, 2025b; Wang *et al*., 2025) [55, 70, 85].

Environmental reporting policies should align with these principles so that citizen data serves public value without exposing contributors to undue risk.

4.8.3. Addressing digital inequality

Digital reporting tools risk amplifying existing inequalities if they ignore uneven access to skills, devices and connectivity. The Australian Digital Inclusion Index shows persistent gaps in access, affordability and digital ability across regions and socio-economic groups (Thomas *et al*., 2023; Thomas *et al*., 2025) [81, 82].

Work on Indigenous digital inclusion further highlights that many remote Aboriginal and Torres Strait Islander communities face lower levels of connectivity and digital ability, which limits participation in digital initiatives (National Indigenous Australians Agency, 2021; Guenther, 2025) [66, 37].

Digital inclusion is also uneven for recent migrants and refugees. Research on digital inclusion among newly arrived refugees in Australia shows that limited digital skills and language barriers make it difficult to access digital public services without targeted support (Baganz *et al*., 2024) [10]. More broadly, social policy scholars warn that service delivery is increasingly dependent on digital access, with risks of exclusion if inequality is not addressed (Sleep & Harris, 2021) [79].

For environmental apps, this means policy should:

- require accessible design and low-data-use options
- mandate the availability of non-digital reporting channels (phone, in-person, postal)
- fund local intermediaries such as community organisations, libraries and landcare groups to support people who struggle with digital tools.

Embedding these requirements in environmental and digital government policies would help ensure that citizen-generated environmental data reflects a wider cross-section of communities, not only digitally confident urban residents.

4.8.4. Ensuring interoperability and technical standards

Environmental apps only add policy value when their data can move across systems and levels of government. Open government data research shows that standardised formats and APIs are critical for turning dispersed datasets into usable resources for planning and environmental management (Peng & Xiao, 2024) [72].

The OECD's latest assessment of open government data similarly emphasises interoperability as a key dimension of mature digital government (OECD, 2025b) [70]. Citizen-generated data work identifies lack of standardisation and poor interoperability as major barriers to integrating citizen data into official systems.

For Australia, policy can address this by setting minimum technical standards for environmental reporting tools, including geospatial formats, metadata requirements and exchange protocols with existing environmental information systems.

Interoperability policies also need to cover long-term maintenance. Open data and digital infrastructure studies show that systems decay when there is no clear responsibility or funding for updates and security. Environmental agencies should be required to plan for lifecycle maintenance of reporting platforms, not just initial development, with funding arrangements that recognise ongoing operational costs.

4.8.5. Supporting responsive and accountable governance

Finally, policy needs to ensure that environmental apps contribute to more responsive and accountable governance, not simply to data accumulation. Research on trust in government finds that perceptions of responsiveness and fairness strongly shape citizen trust levels (Mansoor, 2021) [57]. The lack of outcome visibility from environmental reports submitted by residents will damage trust relationships instead of strengthening them.

Research on local SDG monitoring through citizen-generated data shows that organisations which show their use of citizen feedback to contributors will maintain public trust and keep participants involved (Borghys *et al*., 2024; Fraisl *et al*., 2023) [23, 33]. The policy frameworks need to establish three essential requirements which agencies must follow to protect public trust:

1. The agencies need to receive all submitted reports while maintaining system updates about current progress information.
2. The system requires environmental report statistics to appear alongside detailed information about all performed actions.
3. The system needs proof which demonstrates how citizen data affects decision-making through particular examples that demonstrate how collected data determines inspection priorities and local environmental plan development.

The specifications need to show citizen involvement as a core element of environmental governance because environmental reporting regulations and digital government strategies (Bikowski L., 2026) and performance frameworks require them for implementation. The implementation of these measures would prove that citizen participation stands as a core element of environmental governance.

5. Conclusion

This paper addressed the need for a conceptual framework to understand how environmental apps and digital reporting tools shape environmental management outcomes in Australia. Despite the proliferation of such tools across jurisdictions, research has remained fragmented, focusing either on technology design or user participation without explaining how these elements interact with institutional systems to produce environmental impacts.

The conceptual framework developed here makes three key contributions. First, it identifies four core constructs digital tool characteristics, user behaviours, institutional settings, and environmental outcomes and specifies directional relationships between them. This structure clarifies that

digital reporting is not merely a technical function but a governance system requiring alignment between design, behaviour, and institutional capacity. Second, the framework distinguishes environmental outcomes into informational, managerial, and behavioural dimensions, providing a more nuanced understanding of impact pathways than existing models. Third, it articulates institutional settings as a moderating force rather than a background condition, showing how legal mandates, organisational capacity, and data governance frameworks determine whether citizen contributions translate into environmental action.

The framework reveals significant opportunities: environmental apps can expand monitoring coverage, accelerate harm detection, reduce operational costs, enhance transparency, and support adaptive management. Yet substantial challenges constrain these benefits: digital inequality creates reporting biases that disadvantage remote and older populations; inadequate privacy protections and unclear data governance undermine user trust and adoption; institutional fragmentation across Australian jurisdictions limits data integration and weakens the link between citizen input and environmental decisions.

Future research must empirically test the six propositions through multi-method investigations. Comparative case studies across Australian states can examine how institutional settings moderate the tool behaviour outcome pathways. Longitudinal user studies can identify which design features sustain reporting across diverse communities. Methodological work on data validation, bias correction, and integration pipelines remains essential for ensuring citizen-generated data meets quality standards for formal decision-making. Policymakers should prioritise interoperable data standards, transparent response protocols, and digital inclusion strategies to realise the governance potential of environmental apps. As Australia advances data-driven participatory environmental management, this framework provides both theoretical guidance for researchers and practical direction for sustainable deployment.

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How to Cite This Article
McClure A. Environmental apps and digital reporting in Australian environmental management: a conceptual review of opportunities and challenges. J Agric Digit Res. 2026;7(1):52–68. doi:10.54660/JADR.2026.7.1.52-68.