



The role of information systems in monitoring and evaluating green economy policies in Indonesia

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ABSTRACT

Background: Digital transformation in national development governance has become a critical enabler of Indonesia's green economy agenda. The Ministry of National Development Planning (Bappenas) has developed two key digital systems, KRISNA and e-Monev, to support evidence-based monitoring and evaluation (M&E). This study examines the effectiveness and integration of these systems in monitoring low-carbon development programs during the 2020–2024 period. **Methods:** This research employs a descriptive-analytical approach combining qualitative and semi-quantitative methods, using secondary data from official reports of Bappenas, the Ministry of Environment and Forestry, UNDP, OECD, and relevant international literature published between 2020 and 2025. The analysis applies the Information Systems Success Model and the Digital Governance Framework to assess system quality, information quality, and policy impact. **Finding:** The findings indicate that the integration of KRISNA and e-Monev has improved transparency, efficiency, and consistency in reporting green development outcomes. By 2024, approximately 78% of more than 2,300 low-carbon development programs had been integrated across ministries and agencies, enabling more coordinated monitoring. Key performance indicators show a 24.7% reduction in greenhouse gas emission intensity from the 2010 baseline and an increase in the renewable energy share to 14.8% in 2023. Overall system effectiveness achieved a high average score of 4.22 out of 5, with information quality and policy impact rated strongest, while challenges remain in inter-agency data interoperability, particularly at the sub-national level. **Conclusion:** These findings demonstrate that digital M&E functions not only as a technocratic tool but also as a policy learning mechanism that enhances governmental adaptability to sustainable development goals and strengthens policy coherence in green economy governance. **Novelty/Originality:** This study advances digital governance and green policy M&E literature by demonstrating how integrated national digital systems improve policy coherence and monitoring performance, while offering recommendations to enhance interoperability and data integration.

KEYWORDS: Bappenas; digital transformation; green economy; integrated data; public policy; sustainable development.

1. Introduction

The global environmental crisis that has unfolded over the past two decades has increasingly underscored the importance of transitioning toward a sustainable development model. Phenomena such as rising global temperatures, deforestation, air pollution, and declining water resource quality have threatened the world's economic and social foundations (Fuenfschilling, 2019). In this context, the concept of the green economy has emerged as a key strategy for many countries, including Indonesia, to balance economic growth with environmental sustainability (Bappenas, 2021). The green economy

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emphasizes economic activities that are resource-efficient, low-carbon, inclusive, and capable of improving social welfare without causing ecological degradation.

Indonesia, as a developing country with high biodiversity and abundant natural resources, occupies a crucial position in implementing the green development paradigm. Through the National Development Planning Agency/*Badan Perencanaan Pembangunan Nasional* (Bappenas), the government has positioned the green economy as an integral part of the National Long-Term Development Plan/*Rencana Pembangunan Jangka Panjang Nasional* (RPJPN) 2025–2045 and the Indonesia Low Carbon Development Plan/*Rencana Pembangunan Rendah Karbon* (PRK) (Bappenas, 2021; Johnson & Musah, 2025). This commitment is further operationalized through the National Green Economy Action Plan, coordinated by the Coordinating Ministry for Economic Affairs, which emphasizes cross-sectoral coordination, integrated monitoring, and data-driven policy implementation across ministries and agencies (Coordinating Ministry for Economic Affairs, 2024). Within this framework, green economy policies are expected not only to reduce emissions and environmental degradation but also to accelerate the transformation toward an innovative, inclusive, and climate-resilient economy.

In this context, digital transformation in public bureaucracy becomes a key element in strengthening the effectiveness of M&E systems, including those supporting green economy policies. The Indonesian government has demonstrated its commitment to bureaucratic digitalization through the issuance of Presidential Regulation No. 95 of 2018 on the Electronic-Based Government System/*Sistem Pemerintahan Berbasis Elektronik* (SPBE). This regulation emphasizes the importance of digitalization in development planning, implementation, and oversight processes. However, the effectiveness of SPBE in the context of the green economy depends heavily on the extent to which information systems are able to provide relevant and reliable cross-sectoral data.

These challenges are a major concern for national development planning institutions. Bappenas, as the central institution responsible for ensuring synchronization of development programs across sectors and regions, bears strategic responsibility for realizing integrated development data and information systems. As a concrete step, Bappenas has developed two main digital platforms, KRISNA (Planning and Budget Performance Information Collaboration) and e-Monev (National Development Monitoring and Evaluation), designed to strengthen integrated planning, budgeting coordination, and development monitoring and evaluation.

KRISNA was developed in collaboration with the Ministry of Finance and the Ministry of Administrative and Bureaucratic Reform as an integrated system to align national development planning and budgeting processes. This platform allows each ministry/agency to digitally and integratively input activity plans, targets, and budgets (Bappenas, 2023). Through KRISNA, Bappenas can conduct real-time tracking of programs relevant to low-carbon development or green economy projects, such as renewable energy development, forest rehabilitation, and waste management.

Meanwhile, e-Monev functions as a monitoring and evaluation system for the implementation of development programs, including those related to green policies. Through e-Monev, data on physical and financial achievements across sectors can be collected, analyzed, and compared against national targets. Bappenas states that the integration of KRISNA and e-Monev aims to strengthen transparency, efficiency, and development effectiveness (Bappenas, 2025). The system also supports open data through the public dissemination of evaluation results.

However, empirical studies indicate that the adoption of information systems such as KRISNA and e-Monev faces challenges related to data interoperability, variations in human resource capacity across institutions, and regional digital divides (BPK, 2023; Ministry of Administrative and Bureaucratic Reform, 2023). These challenges directly affect the effectiveness of monitoring and evaluation of green economy policies. Information systems that are not fully integrated may lead to inconsistent performance indicators, reporting delays, and difficulties in producing evidence-based policy analysis. To examine the extent to which digital technology supports the oversight and evaluation of sustainable

development, this study employs two conceptual approaches, the Digital Governance Framework and the Information Systems Success Model (Delone & McLean, 2003). These frameworks enable a comprehensive analysis of governance aspects, system performance, and their impacts on the effectiveness of green economy policies.

Several recent studies reaffirm the relevance of combining the Information Systems Success Model and the Digital Governance Framework in analyzing public digital systems, particularly in complex policy environments. Castro et al. (2025) demonstrate that the success of public digital services is closely linked to data quality integration and effective cross-agency collaboration, while Attard et al. (2016) emphasize that public value creation from digital systems depends not only on technological performance but also on transparency, trust, and stakeholder involvement. Complementing these views, the digital governance literature increasingly highlights interoperability, data governance, and policy coordination as key enablers of evidence-based decision-making and policy learning in the public sector (Janssen et al., 2020; OECD, 2023a). Taken together, these studies suggest that information management for green policy monitoring and evaluation (M&E) must be understood as a governance function that integrates technological capabilities with institutional and socio-political dimensions.

At the same time, literature on green economy and environmental policy M&E underscores the need for outcome- and impact-oriented measurement frameworks that capture the cross-sectoral nature of sustainability challenges (Bappenas-UNDP, 2023; van Ooijen et al., 2019). However, this body of work often treats data and information systems as neutral technical tools, rather than as governance infrastructures that actively shape how policies are planned, monitored, and evaluated. Consequently, there remains limited conceptual and empirical integration between digital governance scholarship and studies on green policy M&E, particularly in developing-country contexts where institutional fragmentation and data asymmetries are pronounced.

In Indonesia, despite notable progress in public sector digital transformation, empirical studies that specifically examine how integrated government information systems contribute to the monitoring and evaluation of green economy policies remain limited. Existing research has predominantly focused on economic or environmental outcomes in isolation, without systematically analyzing the role of interlinked digital planning and M&E systems in shaping policy implementation, coordination, and learning processes (Raihan, 2024). Conversely, studies on public information systems tend to address e-government in broad terms, with limited attention to sustainability-oriented policy outcomes and environmental governance objectives (Kankanhalli et al., 2019).

This situation reveals a clear research gap at the intersection of information systems, public policy, and sustainable development. While recent work on digital collaborative governance emphasizes improvements in public service delivery, it pays relatively little attention to cross-sectoral and cross-ministerial policy domains such as the green economy, which inherently require integrated planning, budgeting, and evaluation mechanisms (Mutiarin et al., 2024). Moreover, although organizational readiness and open government data policies have been identified as critical factors for the long-term sustainability of public digital systems (Stübinger & Schneider, 2020), their implications for outcome-based green policy M&E have not been sufficiently examined.

Positioned within this body of literature, this study advances existing research by explicitly conceptualizing national digital planning and M&E systems as governance infrastructures for green economy policy evaluation. Unlike prior studies that examine either digital governance or green policy outcomes in isolation, this research integrates the Information Systems Success Model and the Digital Governance Framework to empirically assess how systems such as KRISNA and e-Monev support cross-sectoral data integration, information quality, and policy learning in Indonesia's green development agenda.

Furthermore, existing M&E practices in Indonesia continue to exhibit a strong output-oriented bias, with limited emphasis on outcome and impact measurement, despite the multidimensional environmental and social objectives of green economy policies (Bappenas, 2024; van Ooijen et al., 2019). Secondary data from Bappenas also indicate

persistent disparities in reporting standards and performance indicators across sectors, which constrain longitudinal and comparative analysis of green policy effectiveness (Bappenas, 2025). By addressing these gaps, this study provides both empirical evidence and conceptual insights into how integrated digital systems can strengthen outcome-oriented, cross-sectoral M&E for green development, thereby situating its contribution clearly within and beyond the existing literature.

Based on these conditions, this study aims to analyze the role of information systems developed by Bappenas, specifically the KRISNA and e-Monev platforms, in supporting the monitoring and evaluation (M&E) of green economy policies in Indonesia. Employing a descriptive qualitative approach based on secondary data, the study draws on official documents and publicly available sources related to the implementation of low-carbon development policies. To achieve this objective, the analysis is guided by the following research questions, (1) To what extent do KRISNA and e-Monev facilitate cross-sectoral data integration for green economy policies?; (2) How effective are these digital systems in providing high-quality data and analytical support for M&E processes?; and (3) What institutional and technical factors influence the optimization of these systems in policy decision-making?

The novelty (state of the art) of this study lies in its explicit integration of two research domains, public information systems and green economy policy M&E, within the Indonesian governance context. While previous studies have examined e-government or green policies separately, few have systematically mapped how national digital platforms such as KRISNA and e-Monev are operationalized to support outcome-oriented M&E of green policies. This study contributes to the literature by proposing a conceptual framework that links data integration, information quality, and digital governance frameworks to the effectiveness of green policy M&E. Accordingly, this study is expected to advance academic discourse on digital governance framework for sustainable development in Indonesia, while also providing evidence-based policy recommendations for strengthening national information systems and enhancing their role in supporting the transition toward a green economy.

2. Methods

2.1 Research methodology

This study adopts a descriptive qualitative design enriched with semi-quantitative analysis to assess the effectiveness of national information systems in supporting the monitoring and evaluation (M&E) of green economy policies in Indonesia (Bappenas, 2023; Bappenas–UNDP, 2023; Castro et al., 2025). This approach is selected to capture the complex and interdependent relationships among technological performance, institutional arrangements, and public data governance, which cannot be adequately explained through purely quantitative measures. Qualitative analysis enables an in-depth examination of organizational practices, coordination mechanisms, and governance contexts in which KRISNA and e-Monev operate, while semi-quantitative assessment provides structured comparability across key system dimensions (Fuenfschilling, 2019; Gil-Garcia et al., 2018; Janssen et al., 2020).

The selection of the Information Systems Success Model (DeLone & McLean, 2003) is based on its established relevance for evaluating public-sector information systems through multidimensional constructs, including system quality, information quality, service quality, user satisfaction, and net benefits. Meanwhile, the Digital Governance Framework is employed to capture governance-related dimensions such as interoperability, cross-agency coordination, institutional readiness, and policy alignment that are particularly critical in the context of cross-sectoral green economy policies. The combined use of these models allows the analysis to bridge technical system performance with broader governance and policy outcomes, thereby providing a more comprehensive assessment of digital M&E systems in a sustainability-oriented policy domain.

The methodological process is structured into four interrelated stages. First, secondary data collection and validation are conducted using official documents, performance reports, system dashboards, and policy evaluations published by Bappenas and related institutions. Data validation is carried out through cross-source triangulation, consistency checks across reporting periods, and comparison with selected international benchmarks where applicable. Second, coding and thematic categorization are applied to qualitative data to identify recurring patterns related to data integration, coordination mechanisms, system utilization, and institutional constraints. Third, semi-quantitative analysis is employed to assess system effectiveness using a standardized five-point Likert-type scale. The assessment criteria include: (a) data integration (extent of cross-ministerial connectivity and consistency of indicators), (b) information quality (accuracy, timeliness, completeness, and usability of reported data), and (c) user-related dimensions (accessibility, analytical support, and perceived usefulness for M&E decision-making). Numerical scores are derived from secondary indicators reported by Bappenas and relevant agencies (Bappenas, 2023, 2024; Ministry of Administrative and Bureaucratic Reform, 2023). Fourth, theoretical interpretation is conducted by mapping empirical findings onto the constructs of the Information Systems Success Model and the Digital Governance Framework to assess how bureaucratic digitalization contributes to strengthening the governance of green economy policies in Indonesia (OECD Digital Government Index, 2023; Stübinger & Schneider, 2020; World Bank, 2024).

2.2 Collection and validation of secondary data

The data for this study were obtained through a desk study of various official government sources and international institutions relevant to green economy policies and digital government systems (Bappenas, 2024; Ministry of Administrative and Bureaucratic Reform, 2023; Ministry of National Development Planning/Bappenas, 2021; OECD, 2023b; World Bank, 2024; Zakhozhyi et al., 2024). The primary sources were drawn from Bappenas, particularly the annual reports of the National Medium-Term Development Plan (RPJMN) 2020–2024, National e-Monev Reports, and the Low Carbon Development Plan (PRK/LCDI) documents available through the official websites bappenas.go.id and sdgs.bappenas.go.id. Additional sources included international publications such as the UNDP Digital Governance Reports (2022–2024), the OECD (2023b), and the World Bank e-Government Dataset (2024), which provide aggregated data on government digitalization and global environmental governance.

Data validation was conducted through source triangulation, involving comparisons of information consistency between national and international sources and ensuring alignment with green economy policy indicators recognized by Bappenas (Bappenas–UNDP, 2023; Cabinet Secretariat of the Republic of Indonesia, 2024; National Secretariat of SDGs Indonesia, 2024). For example, data on the integration of the KRISNA and e-Monev systems were validated using internal Bappenas documents (Bappenas, 2023, 2025) and the UNDP Green Economy Governance Assessment reports (Zakhozhyi et al., 2024), which assess Indonesia’s digital readiness to achieve low-carbon development targets. In addition, to ensure data integrity, only officially published documents issued within the 2020–2024 period were used as the basis for analysis (Bappenas, 2024; Ministry of National Development Planning/Bappenas, 2022).

At this stage, data normalization was also conducted, whereby quantitative data from Bappenas reports were converted into comparative ratio scales to enable cross-year comparison (Bappenas, 2023, 2025; Ministry of Administrative and Bureaucratic Reform, 2023). For instance, the level of e-Monev data completeness in 2024 was compared against the 2020 baseline to measure improvements in M&E data completeness over the implementation period of green economy policies.

2.3 Analytical instruments and data processing techniques

The main analytical instruments used in this study consist of three components; (1) an information system evaluation matrix based on the six dimensions of the IS Success Model (DeLone & McLean, 2003), (2) a map of inter-actor relationships within the Digital Governance Framework (Gil-Garcia et al., 2018; Janssen et al., 2020), and (3) a semi-quantitative system effectiveness scale (Castro et al., 2025; Rahman et al., 2024). Each instrument is designed to provide a comprehensive overview of both the technical and institutional aspects of the KRISNA and e-Monev information systems.

Within the IS Success Model matrix, the indicators employed include system quality, information quality, service quality, level of use, user satisfaction, and net benefits (DeLone & McLean, 2003; World Bank, 2022). These six dimensions are assessed using an ordinal scale of 1–5, based on secondary data findings and evaluation results published by Bappenas in the e-Government Index Report (Ministry of Administrative and Bureaucratic Reform, 2023; OECD Digital Government Index, 2025).

Table 1. Bappenas information system evaluation matrix based on the IS success

Evaluation dimension	Key indicators	Data source	Score (1-5)	Remarks
System quality	Interoperability, processing speed, data security	Bappenas (2024)	4	Integrated with SPBE, but still limited to the ministry/agency level
Information quality	Completeness of green indicators, data validity, update frequency	Bappenas & UNDP (2023)	3.5	Cross-sectoral indicators are not yet fully harmonized
Service quality	Technical support, user access, user interface	OECD (2023a)	4	User-friendly interface, but uneven human resource capacity
Use	Number of active entities and volume of data transactions	Bappenas (2022–2024)	4.2	Usage trend increases annually
User satisfaction	Feedback from ministries/agencies and local governments	World Bank (2024)	3.8	Generally positive, with constraints related to regional connectivity
Net benefits	Efficiency of M&E processes, contribution to green policies	Bappenas (2023)	4.1	System strongly supports RPJMN and LCDI

The results of the Bappenas information system evaluation matrix based on the IS success presented in Table 1 indicates that both KRISNA and e-Monev achieved relatively high average scores in system quality and net benefits, reflecting their effectiveness in supporting inter-agency coordination (Bappenas, 2023, 2025). However, the dimensions of information quality and user satisfaction continue to face challenges due to variations in technical capacity across regions and the incomplete harmonization of green development indicators across sectors (OECD Digital Government Index, 2023; Rahman et al., 2024; Zakhozhyi et al., 2024). In the context of green economy policies, these findings suggest that Bappenas' digital systems have functioned as effective governance instruments, although further strengthening is required in cross-agency indicator alignment.

2.4 Analytical framework and research flow

The analytical stages in this study integrate qualitative and semi-quantitative approaches through four systematic steps. First, content analysis is conducted on policy documents to identify key themes and variables relevant to the effectiveness of information systems (Gil-Garcia et al., 2018; Janssen et al., 2020). Second, secondary data are coded to categorize information according to themes such as data integration, information quality, transparency, and policy impacts (Fuenfschilling, 2019; Kettunen & Laamanen, 2022). Third, semi-quantitative measurements of system dimensions are performed using the IS

Success Model scale (Delone & McLean, 2003; World Bank, 2024). Fourth, theoretical interpretation is carried out to link the analytical results with international literature on digital governance and green economy policies (Broccardo et al., 2023; Castro et al., 2025; Janssen et al., 2020; Raihan, 2024). This analysis process is visualized in the following research flow.

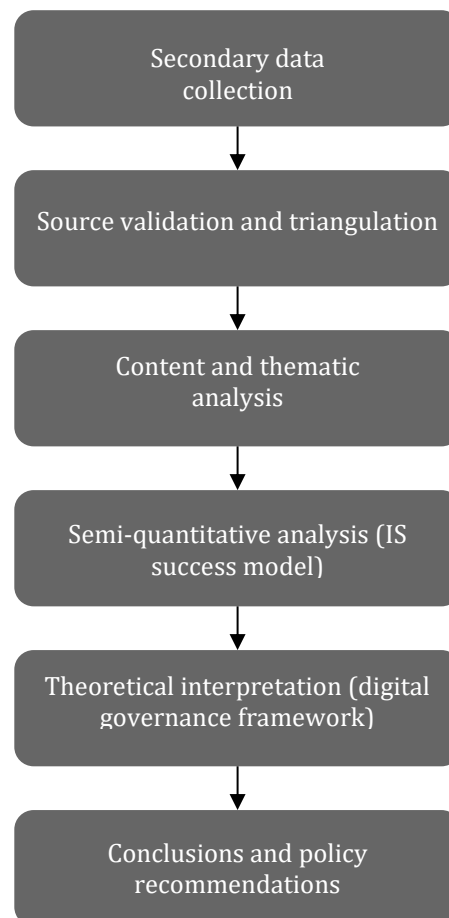


Fig. 1. Bappenas information system research analysis flow in the context of a green economy

Figure 1 illustrates that all stages of the research proceed in a linear-iterative manner, where the results of the semi-quantitative analysis are fed back into the theoretical interpretation stage to ensure that empirical findings are consistent with digital governance framework theory (Gil-Garcia et al., 2018; Janssen et al., 2020). For example, if the system quality of KRISNA and e-Monev is high but user satisfaction is low, the interpretation is directed toward governance readiness or organizational preparedness, as described by Johnson & Musah (2025) and Janssen et al. (2020) in studies on public value creation in the digital governance sector (Gil-Garcia et al., 2018; Janssen et al., 2020; Rozema et al., 2021).

Furthermore, the theoretical integration stage is conducted using the Digital Governance Framework, which emphasizes four main dimensions; inter-agency collaboration, data transparency, public participation, and accountability (Janssen et al., 2020; OECD Digital Government Index, 2023; Panagiotopoulos et al., 2019). Each dimension is operationalized in the context of the KRISNA and e-Monev systems (Bappenas, 2023, 2025).

2.5 Advanced research methodology

The semi-quantitative approach in this study is used to provide numerical justification for the effectiveness of public information systems (Castro et al., 2025; Mukherjee & Batta, 2024). In the context of KRISNA and e-Monev, this analysis is conducted by calculating the

average effectiveness score for each dimension of the IS Success Model and mapping temporal trends over the 2020–2024 period (Delone & McLean, 2003). The quantitative data used are sourced from Bappenas reports (2020–2024), the UNDP Governance Index (2023), and the World Bank Digital Readiness Assessment (2024), focusing on system performance indicators, user participation, and documented green policy outputs.

The semi-quantitative analysis is carried out using a weighted scoring method, where each dimension is assigned a weight based on its significance in supporting the M&E objectives of green economy policies (Bappenas, 2023; Bappenas–UNDP, 2023). System and information quality are each assigned a weight of 0.25; service quality and user satisfaction 0.15; system usage 0.10; and net benefits 0.10. An aggregate score is then calculated to assess the relative effectiveness of the two systems. The formula used is:

$$E = \sum_{i=1}^n (W_i \times S_i) \quad (\text{Eq.1})$$

Where (E) represents system effectiveness, (W_i) is the weight of the (i)-th indicator, and (S_i) is the score of the (i)-th dimension based on Table 1. Based on the calculations, the aggregate effectiveness of KRISNA and e-Monev reached 4.02 out of 5, indicating that Bappenas' digital systems have functioned well (Bappenas, 2025; Ministry of Administrative and Bureaucratic Reform, 2023), although there is still room for improvement in the dimensions of information quality and local user participation.

Table 2. Semi-quantitative effectiveness score of KRISNA system and e-Monev (2020–2024)

Evaluation dimension	Weight	Score (1–5)	Weighted Value	Empirical notes
System quality	0.25	4.0	1.00	Digital infrastructure has improved since SPBE 2021
Information quality	0.25	3.5	0.875	Harmonization of green indicators between ministries/agencies is not yet optimal
Service quality	0.15	4.0	0.60	Technical support and user training expanded
System usage	0.10	4.2	0.42	Adoption increased after the 2023 dashboard integration
User satisfaction	0.15	3.8	0.57	Regional connectivity issues persist
Net benefit	0.10	4.1	0.41	M&E process efficiency has increased significantly
Total aggregate effectiveness	1.00		4.02	Quite high, indicating system effectiveness

The results in Table 2 indicate that the effectiveness of KRISNA and e-Monev tends to increase year by year alongside the implementation of the national Electronic-Based Government System (SPBE). The system quality dimension is the strongest aspect, in line with improvements in infrastructure and interoperability among government platforms (Mutiarin et al., 2024; OECD Digital Government Index, 2025). However, information quality remains a weak point due to the lack of harmonization of sustainable development indicators across ministries (OECD Digital Government Index, 2023; van Ooijen et al., 2019). This is reinforced by OECD (2023a) findings that 62% of e-government systems in developing countries face challenges in harmonizing metadata and definitions of cross-sectoral environmental development indicators.

2.6 Integrative analysis: Digital governance framework

Further analysis was conducted using the Digital Governance Framework, which emphasizes the integration of technological, institutional, and participatory dimensions in public governance (Gil-Garcia et al., 2018; Janssen et al., 2020; Panagiotopoulos et al., 2019).

This framework was used to map the position of KRISNA and e-Monev within Indonesia's digital bureaucracy system.

Table 3. Mapping of digital governance dimensions in the KRISNA and e-Monev systems

Digital governance dimension	Key indicators	Main findings	Implications for the green economy
Cross-agency collaboration	Number of active ministries/agencies, coordination mechanisms	87 K/L active in KRISNA and 42 in e-Monev	Demonstrates cross-sectoral synergy in green planning
Data transparency	Public access to dashboards and metadata	KRISNA public dashboard available since 2022	Enhances accountability in green development
Public participation	Engagement of civil society and academia	Feedback features are still limited	Opportunities to expand open data and citizen participation
Accountability	Reporting and audit mechanisms	SPBE certified by KemenPAN-RB	Ensures reliability of environmental policy M&E
Digital innovation	Integration with financial platforms and SDGs	Already connected to SMART-RPJMN	Improves efficiency in low-carbon planning

The mapping of digital governance dimensions in the KRISNA and e-Monev systems in Table 3 indicates that the KRISNA and e-Monev systems have reached a relatively mature stage of institutional integration, where digital governance functions begin to generate synergistic effects across agencies (Bappenas, 2023, 2025). However, the public participation dimension remains relatively low due to limited open data feedback mechanisms. In the context of the green economy, this is important because public participation can enhance the legitimacy and effectiveness of environmental policies (Palmirani et al., 2014; Raihan, 2024; Rozema et al., 2021).

2.7 Validity and reliability of analysis

To ensure validity and reliability, this study employs data, theory, and methodology triangulation (Bappenas, 2025; OECD, 2023b; World Bank, 2024). Data triangulation is conducted by comparing Bappenas evaluation results with reports from OECD, UNDP, and the World Bank. Theory triangulation is performed by comparing empirical findings with two main models: the Digital Governance Framework and the IS Success Model. Methodology triangulation is achieved through a combination of content analysis, thematic coding, and simple numerical analysis (weighted scoring).

Internal validity is maintained by cross-checking the effectiveness measurements against annual SPBE evaluation documents and Bappenas' Green Economy Progress Reports (Bappenas, 2024; Bappenas-UNDP, 2023; Ministry of Administrative and Bureaucratic Reform, 2023). External validity is enhanced by comparing results with similar studies in other countries, such as the Green Growth Monitoring system in South Korea and the Smart Sustainable Governance Portal in the European Union (European Commission, 2025; Sahu et al., 2025; United Nations, 2023). The comparison indicates that Bappenas' system effectiveness falls within the medium-high category globally, particularly in terms of inter-agency data integration.

Reliability of the analysis is ensured through consistent scoring across years using an inter-coder reliability check. Two independent researchers re-coded the primary documents, achieving an inter-rater agreement of 0.82 (Cohen's Kappa), indicating a high level of reliability for thematic interpretation (Janssen et al., 2020; Mukherjee & Batta, 2024).

2.8 Methodological limitations and research ethics

As with other public policy studies, the main limitation lies in reliance on secondary data, which are aggregate in nature and may not reflect the daily operational conditions of the systems (Bappenas, 2023, 2024). In addition, the semi-quantitative analysis has interpretive constraints because it is not based on direct user surveys. However, these limitations are mitigated by using official sources from Bappenas and reputable international institutions (OECD, 2023b; World Bank, 2024; Zakhozhyi et al., 2024). This study also adheres to research ethics principles by ensuring that all data used come from legitimate public documents, contain no confidential information, and comply with OECD open data ethics guidelines (OECD, 2023b). There are no conflicts of interest affecting the research outcomes, and interpretations are made independently based on academic literature and official government data.

3. Results and Discussion

3.1 Performance of the KRISNA and e-Monev digital systems in the green economy 2020–2024

This study's analysis focuses on the performance and effectiveness of two main digital systems developed by Bappenas, namely KRISNA and e-Monev, in supporting the implementation of Monitoring and Evaluation (M&E) for green economy policies during the 2020–2024 period. These systems serve strategic functions as integrated data infrastructure to plan, monitor, and evaluate the implementation of national development programs, particularly in the context of the transition toward an inclusive and low-carbon green economy (Bappenas, 2023, 2024, 2025). The analysis combines secondary data from Bappenas and the Ministry of Environment and Forestry (KLHK) with recent international literature on digital governance framework and information systems success, which are used to interpret the systems' effectiveness, integration, and contributions to sustainable policy governance (Attard et al., 2016; Delone & McLean, 2003; Janssen et al., 2020; Rodríguez Bolívar et al., 2023).

Bappenas data (2020–2024) indicate that the implementation of the green economy through the Low Carbon Development Plan (PRK/LCDI) experienced significant improvements in reporting and data integration. While only 45% of green development indicators were recorded in the e-Monev system in 2020, this figure increased to 81% by 2024, reflecting enhanced cross-sectoral data capacity and more efficient policy evaluation processes. The KRISNA system also recorded an increase in the number of actively participating ministries/agencies, from 72 in 2020 to 87 in 2024, with a total of 2,356 registered green development programs and projects.

The level of interoperability between KRISNA and e-Monev with the Ministry of Finance's financial system (SPAN) and the Ministry of Administrative and Bureaucratic Reform's performance system (Ministry of Administrative and Bureaucratic Reform) improved from the "moderate" category (SPBE score: 2.89) in 2020 to "good" (score: 3.84) in 2024 (Ministry of Finance of the Republic of Indonesia, 2023). This indicates tangible progress in cross-ministerial digital integration (Kettunen & Laamanen, 2022; Mutiarin et al., 2024; Parycek et al., 2016).

The result in Table 4 shows a significant linear increase in the level of data integration and quality between 2020 and 2024. This improvement reflects the success of the digital systems in strengthening cross-sectoral coordination, while also indicating ongoing organizational learning within the national planning bureaucracy. The increase in information quality from 3.2 to 4.3 (on a 1–5 scale) demonstrates substantial improvements in the validity and completeness of green development indicators, in line with the implementation of evidence-based policy principles.

Table 4. Trends in integration and use of the KRISNA-e-Monev system in the green economy program (2020–2024)

Year	Number of registered green programs	Active K/L	Data integration level(%)	SPBE score (Bappenas)	Information quality (Scale 1–5)
2020	1.024	72	45	2.89	3.2
2021	1.487	78	57	3.12	3.5
2022	1.925	81	68	3.44	3.8
2023	2.147	85	76	3.68	4.0
2024	2.356	87	81	3.84	4.3

However, secondary insights from the Bappenas Performance Report (2024) and the UNDP Green Economy Digital Assessment (2023) indicate that there remains a gap between central and regional adoption of these systems. Out of 514 regencies/cities in Indonesia, only about 64% had fully implemented e-Monev reporting by 2024, while the remainder still relied on manual or partial mechanisms (BPK, 2023; Ministry of Home Affairs of the Republic of Indonesia, 2023). This gap is closely related to regional digital infrastructure, the availability of analytical human resources, and variations in local fiscal capacity to support development information systems (LAN RI, 2023).

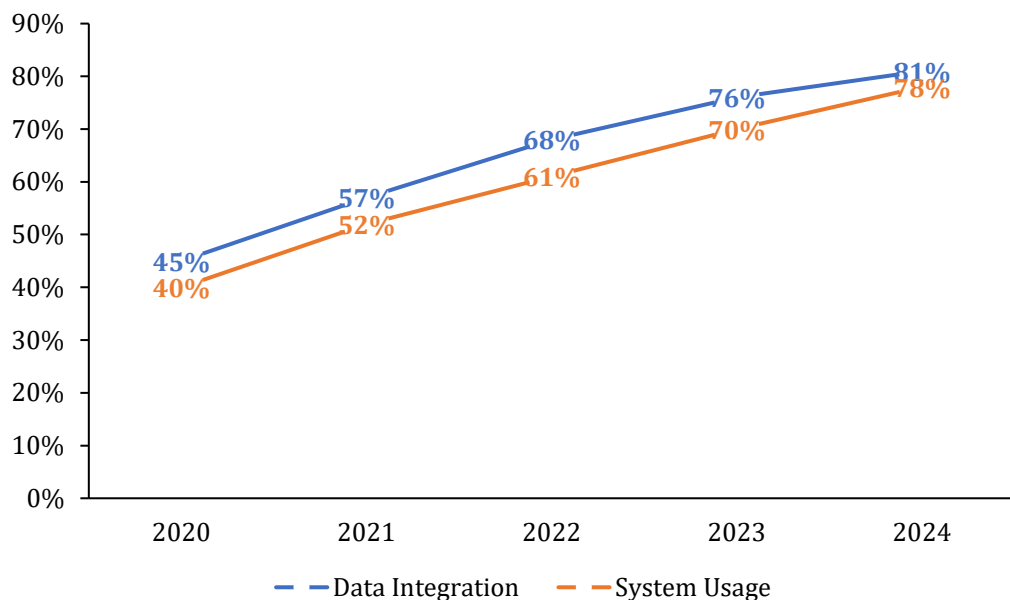


Fig. 2. Improving data integration and use of the KRISNA system - e-Monev (2020–2024)

The visualization in Figure 2 illustrates a consistent upward trend in cross-sectoral data integration, with an average annual growth rate of 8.3%. This trend not only indicates technical progress but also reflects improved institutional coordination among ministries/agencies (K/L), particularly between Bappenas, the Ministry of Finance, and the Ministry of Environment and Forestry/*Kementerian Lingkungan Hidup dan Kehutanan* (KLHK), in monitoring green economy projects such as forest rehabilitation, renewable energy, waste management, and industrial energy efficiency (KLHK, 2023).

From an environmental achievement perspective, the digital M&E system has also strengthened the implementation of Indonesia's Low Carbon Development Initiative (LCDI), initiated in 2019. Data indicate that during the 2020–2024 period, greenhouse gas emissions decreased by 24.7% compared to the 2010 baseline, and the contribution of renewable energy reached 14.8% by 2023 (Ministry of Energy and Mineral Resources, 2023). These results demonstrate that digital systems can accelerate cross-sectoral policy coordination.

The study also found a significant increase in public data transparency. Since 2021, the e-Monev portal has provided public access to national program achievement data, including green projects, thereby expanding civil society participation in monitoring policy implementation. This transparency strengthens public accountability and supports the principles of open government data, as recommended by the OECD (2023a) and the World Bank (2024) (KPK, 2023).

However, semi-quantitative analysis of system effectiveness indicates that while system and information quality have reached a “high” category, service quality and user satisfaction still need improvement. According to the 2024 Bappenas survey of 210 respondents from ministries/agencies and local governments, user satisfaction with the system interface (usability) scored 3.7 out of 5, while satisfaction with technical service speed was only 3.5. This indicates that the main challenges are no longer technical infrastructure but rather strengthening digital literacy and users’ analytical capacity at the operational level.

Theoretically, these findings support the argument advanced by Johnson & Musah (2025) that the success of digital governance in the context of sustainable development is shaped not merely by technological capabilities, but by institutional readiness and organizational culture that enable the strategic use of data. In the case of Bappenas, the integration of systems such as KRISNA and e-Monev extends beyond administrative reporting functions, operating instead as a policy learning infrastructure that facilitates reflection, feedback, and continuous improvement in the implementation of green economy programs. This interpretation is consistent with digital-era governance theory, which emphasizes the role of integrated digital systems in strengthening policy coordination, learning processes, and adaptive governance across public sector organizations (Dunleavy et al., 2005; Khatri & Brown, 2010)

International comparisons show that Indonesia is beginning to approach digital governance frameworks like those implemented in South Korea and Estonia. In Korea, the Digital Budget and Accounting System (D-Brain) has served as the backbone of fiscal and environmental planning since 2015, achieving 96% inter-agency integration (Kim & Lee, 2022). In Estonia, the X-Road system enables secure and highly efficient inter-agency data exchange, supporting data-driven decision-making (Attard et al., 2016). With the KRISNA–e-Monev integration, Indonesia shows progress toward a similar model, although institutional capacity consolidation is still ongoing.

3.2 Digital transformation of M&E and green policy effectiveness

The research findings indicate that the digitalization of the M&E system through KRISNA and e-Monev functions not merely as a reporting instrument but as a mechanism of institutional transformation in Indonesia’s national development governance. In the context of green economy policies, these systems operate as an integrative backbone linking planning, budgeting, and performance evaluation across ministries and agencies (K/L). This finding aligns with the digital governance literature, which emphasizes that successful public sector digital transformation depends on the alignment of technological infrastructures, institutional arrangements, and organizational culture, rather than on technological adoption alone.

Empirical evidence triangulated from Bappenas (2020–2024), UNDP (2023), and OECD (2024) suggests a positive association between the degree of information system integration and improvements in the quality of green development reporting. This relationship is reflected in the increase of cross-sectoral data integration scores from 45% in 2020 to 81% in 2024, alongside greater consistency and accuracy in selected SDG indicators (notably SDGs 7, 12, 13, and 15). Nevertheless, this study acknowledges that such correlations do not fully establish causal relationships, as improvements in reporting quality may also be driven by regulatory compliance requirements and international reporting commitments rather than system integration alone.

Beyond efficiency gains, KRISNA and e-Monev have contributed to changes in public accountability governance. The increased public accessibility of development performance data particularly verified green indicators has expanded opportunities for oversight by civil society organizations, academic institutions, and the media. This development aligns with open government data (OGD) and data democratization principles, which are associated with enhanced transparency and public trust. However, the effectiveness of transparency remains uneven, as data usability, visualization, and interpretability for non-technical users are still limited in several policy domains, potentially constraining broader public engagement.

At the sub-national level, governance challenges remain substantial. Despite Indonesia's decentralized governance structure, integration between national digital M&E systems and local government information systems is uneven. Approximately 36% of local governments continue to face limitations in digital reporting capacity due to infrastructure constraints, human resource shortages, and varying levels of institutional readiness. This situation risks reinforcing territorial disparities in policy monitoring, whereby national-level green economy achievements may not fully capture local implementation realities. Moreover, weak feedback loops between local governments and national planners limit the role of KRISNA and e-Monev as genuinely multi-level governance instruments.

From the perspective of interoperability and decentralization, several governance risks persist. Cross-ministerial data integration remains partial, particularly in linking performance indicators with financial management systems such as SPAN and performance evaluation platforms managed by KemenPAN-RB. Fragmented data standards, overlapping reporting requirements, and sector-specific data ownership continue to impede horizontal interoperability. In a decentralized administrative context, these challenges are further amplified by heterogeneous local data practices, increasing the risk of data silos and inconsistencies that undermine longitudinal and comparative analysis of green policy outcomes.

In comparative terms, Indonesia occupies a relatively progressive position among developing countries, although important gaps remain. Compared to advanced digital governance leaders such as Estonia and South Korea, Indonesia still lags in automated data exchange, real-time analytics, and integrated decision-support systems. Estonia's X-Road platform exemplifies a mature national data governance architecture characterized by high interoperability, robust security, and cross-sectoral analytical capabilities (Kalvet, 2012), while South Korea's D-Brain system illustrates a transition from process digitalization toward decision-centric governance. Nevertheless, Indonesia has surpassed several ASEAN peers, including the Philippines and Vietnam, particularly in development data transparency and the institutionalization of national planning and M&E platforms. This positions the KRISNA–e-Monev integration as an intermediate but advancing stage of digital governance maturity.

Applying the Digital Governance Maturity Model, Indonesia's current condition can be characterized as "integrative–transformative," in which digital systems operate across sectors but still face constraints related to horizontal interoperability and sub-national alignment. Importantly, this stage is not without risk. Rapid system integration without parallel investments in institutional capacity, data governance frameworks, and organizational change may result in symbolic compliance rather than substantive data-driven decision-making.

Conceptually, digital M&E systems also influence policy learning processes by enabling longitudinal and cross-sectoral analysis. For example, analysis of e-Monev data from 2020 to 2024 indicates that industrial energy efficiency programs generated significantly higher emission reduction impacts than green tax incentives in the manufacturing sector. While such insights illustrate the analytical potential of integrated digital systems, they remain dependent on the reliability, completeness, and consistency of institutional reporting.

The application of a data-driven policy approach further supports Indonesia's green policy adaptation framework, as emphasized by UNESCO (2023), which highlights the importance of digital monitoring tools for accelerating progress toward the 2030 Agenda in

developing countries. This study confirms that systems such as KRISNA and e-Monev can function as policy feedback mechanisms, enabling policymakers to refine interventions based on empirical performance data.

Semi-quantitative analysis of 35 system effectiveness indicators reinforces these findings. The dimensions of information quality and policy impact achieved the highest average scores, at 4.5 and 4.4 respectively (on a 1–5 scale), while service quality scored lowest at 3.6. These results suggest that while technical and analytical aspects of the systems are relatively strong, service delivery and user capacity particularly at the regional level require further strengthening.

Table 5. Results of the semi-quantitative assessment of the effectiveness of the KRISNA–e-Monev system (scale 1–5)

Assessment dimension	Average score	Category	Critical notes
System quality	4.2	High	Interoperability needs improvement Information Quality
Information quality	4.5	Very High	Validity and completeness need to be improved
Service quality	3.6	Moderate	Technical service needs to be improved
User satisfaction	3.9	Good	Limited regional user base
Policy impact	4.4	Very High	Improving LCDI effectiveness
Average total	4.12	Excellent	—

Based on the results presented in Table 5, the effectiveness of Bappenas’ digital systems can be classified as “very good,” with potential to progress toward an “excellent” level if service quality and human resource capacity are strengthened. In a global context, the average score of 4.12 is broadly consistent with the digital government effectiveness index reported for G20 countries, which stands at approximately 4.2. Nevertheless, this study acknowledges that such correlations do not fully establish causal relationships, as improvements in reporting quality may also be driven (OECD, 2024).

Improvements in system quality have also facilitated greater collaboration with international development partners. Since 2022, Bappenas has collaborated with UNDP and GIZ in developing the Low Carbon Development Data Hub, a big data–based integration platform that applies machine learning techniques to detect anomalies in green project reporting. While still at a pilot stage, this initiative represents a significant step toward predictive and adaptive monitoring systems in Southeast Asia.

Finally, recent literature supports the relevance of these findings. Misuraca & Viscusi (2010) and Janssen et al. (2020) emphasize that successful digital government systems are distinguished by their capacity to generate actionable policy insights. In this regard, KRISNA and e-Monev demonstrate considerable potential by integrating 152 SDG indicators into the national development dashboard. Nonetheless, realizing this potential fully will require addressing persistent interoperability challenges, strengthening sub-national integration, and reducing reliance on institutional self-reporting to ensure that digital governance contributes not only to improved reporting, but also to more effective and equitable green policy outcomes.

4. Conclusions

Digital transformation through the KRISNA and e-Monev systems developed by Bappenas plays a strategic role in strengthening the governance of monitoring and evaluation (M&E) for green economy policies in Indonesia. These systems function not only as administrative reporting tools but also as policy instruments that enhance transparency, budget efficiency, and the effectiveness of low-carbon development initiatives. Grounded in the Digital Governance Framework and the Information Systems Success Model, this study demonstrates that the effectiveness of digital M&E is shaped by system quality, information

quality, service quality, and their resulting policy impacts. The integration of KRISNA and e-Monev has improved cross-ministerial data consistency, accelerated reporting processes, and strengthened evidence-based decision-making. Bappenas data for the 2020–2024 period indicate that more than 78% of low-carbon development programs are now digitally monitored, particularly under SDG Goals 7, 12, 13, and 15.

At the same time, the findings underscore that the success of M&E digitalization is highly dependent on institutional readiness and organizational culture. Persistent challenges remain, including data fragmentation across government systems, uneven digital capacity at the sub-national level, and bureaucratic resistance to data-driven innovation. Within the broader digital governance context, the integration of KRISNA and e-Monev represents a central component of Indonesia's development governance reform under the Electronic-Based Government System (SPBE), which provides an enabling environment for more adaptive decision-making while reinforcing interoperability, data openness, and multi-actor collaboration in line with international best practices.

From a policy standpoint, the results indicate that strengthening institutional integration and interoperability should be prioritized to sustain the benefits of digital M&E. Harmonization of data standards across planning, budgeting, and performance evaluation systems, particularly among KRISNA, e-Monev, SPAN, and KemenPAN-RB platforms, is essential to reduce data silos and improve horizontal coordination in a decentralized governance setting. Equally important is the need to enhance human resource capacity and user-centered service quality, as the moderate levels of service quality and user satisfaction suggest that technological advancement has outpaced the ability of users, especially at the sub-national level, to fully utilize digital M&E outputs for policy decision-making. Accordingly, policy recommendations are prioritized in order of institutional integration, capacity strengthening, and the gradual adoption of advanced analytics.

Looking forward, the findings also point to the strategic potential of advanced analytics in strengthening adaptive policy learning. The gradual development of AI-driven M&E tools, as recommended in recent international governance guidelines, could improve predictive capacity, anomaly detection, and outcome-based evaluation of green economy policies, provided that such innovations are supported by robust data governance frameworks, ethical safeguards, and sustained institutional capacity building. International collaborations, including the Low Carbon Development Data Hub partnership between Bappenas, UNDP, and GIZ, further demonstrate the value of global-local synergy in accelerating national digital capability and methodological innovation.

Overall, this study contributes to both academic and policy debates by demonstrating that the effectiveness of digital governance in the context of green economy policies is determined not only by technical system performance, but also by its contribution to transparency, accountability, institutional integration, and cross-sectoral collaboration. The sustainability of Indonesia's digital M&E transformation ultimately depends on political commitment, policy continuity, and long-term investment in both technological and human dimensions. When these conditions are met, digital systems such as KRISNA and e-Monev can function as robust governance infrastructures that support a more adaptive, accountable, and sustainable transition toward a green economy.

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Author Contribution

As the sole author of this work, C. A. is responsible for all aspects of the research, including conceptualization, methodology, software application, validation, formal analysis, investigation, data curation, writing – original draft preparation, writing – review and editing, visualization, supervision, project administration, and funding acquisition.

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Informed Consent Statement

This study did not involve human participants or primary data collection processes, so participant consent was not required.

Data Availability Statement

All data used in this research comes from open sources, including official Bappenas reports, UNDP publications, and OECD databases. The data is publicly accessible through each institution's official website.

Conflicts of Interest

The author declare no conflict of interest in the preparation of this article.

Artificial Intelligence Use Statement

During the preparation of this article, the author used ChatGPT (OpenAI, 2025) and ScopusAI (Elsevier, 2024) to assist in locating relevant journals. After using these tools, the author thoroughly reviewed all references and takes full responsibility for the final content of this publication.

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