

A technology-driven architecture for sustainable Barangay digital governance in Nueva Vizcaya

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ABSTRACT

The Philippines has prioritized the digitalization of government agencies, including local government units (LGUs), to improve service delivery and enhance transparency through e-government initiatives. Despite these national efforts, many Barangays in Bayombong continue to rely on manual processes, resulting in challenges related to data management, recordkeeping, and client transaction efficiency. This study developed a technology-driven framework to strengthen Barangay-level digital governance through the design and implementation of the integrated computer-based Barangay information system (iCBISys). Deployed in Barangay Busilac, the system features four core modules: digital logbook, resident profiling, certificate issuance with payment collection, and file complaint (e-Blotter). iCBISys was developed using the DevOps SDLC model to support iterative development and long-term sustainability, utilizing Laravel framework for backend development and Bootstrap 5 for the user interface. A quantitative research design was employed, supported by survey questionnaires for evaluation. System performance based on the ISO/IEC 25010 software product quality model yielded a mean score of 4.45 (Strongly agree) from 20 evaluators. End-user training assessed through the ADDIE model obtained a score of 3.99 (Agree), while the impact of the system achieved a mean score of 4.37 (Strongly agree). Findings indicate that iCBISys significantly streamlined Barangay operations and demonstrates strong potential to advance grassroots e-governance.

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1. INTRODUCTION

Electronic governance (e-Governance) is broadly defined as the application of information and communication technologies (ICTs) to improve public service delivery through the integration of various stand-alone systems that facilitate government-to-citizens (G2C), government-to-business (G2B), and government-to-government (G2G) interactions [1]-[6]. Initially, e-government focused on using ICTs to enhance administrative efficiency and deliver services online; however, its scope has expanded to include digital citizen engagement, open government data, and ICT-enabled innovations that promote transparency,

participation, and responsiveness in public administration [7], [8]. Despite global advancements in digital governance, unequal access to ICT infrastructure and digital skills, particularly in developing countries, continues to limit inclusive participation in e-government systems, underscoring the persistent challenge of the digital divide [9]-[11]. This divide, shaped by socio-economic and geographic factors, highlights the importance of inclusive ICT initiatives and sustained capacity-building efforts to ensure equitable adoption of digital public services [12]-[14].

In today's information-driven environment, e-government is increasingly recognized as a critical enabler of sustainable development and a key contributor to the achievement of the United Nations Sustainable Development Goals (SDGs). Its ability to streamline public-sector processes, improve administrative efficiency, and strengthen citizen-government interactions positions e-government as a strategic driver of social and economic progress. Successful implementations in several Asia-Pacific countries, including the Republic of Korea, demonstrate how digital governance can advance development even under challenging conditions [15]. Moreover, e-government initiatives have been shown to significantly contribute to the attainment of the SDGs by improving service delivery mechanisms, expanding access to online public services, and fostering more inclusive digital interactions that generate broad socio-economic benefits [16], [17].

In the Philippines, e-government development emerged from post-EDSA institutional reforms and early automation initiatives led by the national computer center, followed by policy-driven efforts such as the e-commerce act of 2000, e-LGU programs, and the e-government master plan (EGMP) [18]-[21]. These initiatives aim to modernize government operations, strengthen interoperability, and enhance transparency across agencies. The gradual progress of the country is reflected in its improved standing in the United Nations e-government development index (EGDI) from 2014 to 2024 [5], [6]. More recently, legislative proposals such as the e-governance act reinforce the national agenda toward integrated, standardized, and scalable digital government systems [22]. As these policies expand, local government units (LGUs), including Barangays, are mandated to adopt ICT-driven solutions to improve service accessibility, operational efficiency, and accountability [4], [23]-[25].

Despite these national initiatives, the adoption of e-governance at the community level remains uneven. Many Barangays continue to rely on manual, paper-based processes that hinder efficient recordkeeping, data accuracy, and timely service provision [26], [27]. This situation is evident in the Municipality of Bayombong, Nueva Vizcaya, where Barangays such as Busilac experience fragmented workflows, redundant data encoding, limited ICT infrastructure, and insufficient digital literacy among staff. These challenges constrain effective governance and underscore the need for integrated information systems that can support data-driven decision-making and sustainable local administration. Prior studies on Barangay-oriented ICT solutions, including BMIS, BIMS, BIPS, e-Barangay, Balangay, and OneBarangay, demonstrate the potential of tailored digital systems to improve administrative efficiency, reporting accuracy, and service delivery at the grassroots level [28]-[33]. However, these studies also highlight the continuing demand for unified, scalable, and sustainable architectures that address both technological and human-capacity dimensions of Barangay governance.

To address these gaps, this community extension project introduced an ease-of-doing-business framework and developed the integrated computer-based Barangay information system (iCBISys) to support Barangay-level digital governance in Nueva Vizcaya. The project aimed to streamline administrative processes, centralize data management, automate routine transactions, and enhance transparency and accountability at the grassroots level. Aligned with SDG 9 (industry, innovation, and infrastructure) and SDG 11 (sustainable cities and communities), the initiative contributes to building digitally empowered LGUs capable of responsive and efficient governance. In addition, capacity-building interventions were implemented to improve ICT literacy among Barangay officials and staff, supporting SDG 4 (quality education). Through this integrated technological and human-centered approach, the study presents a sustainable model for community-level e-governance and demonstrates how localized ICT solutions can significantly enhance public service delivery.

2. RESEARCH METHOD

This study adopted a structured and systematic research methodology to support the design, development, implementation, and evaluation of a technology-driven architecture for sustainable Barangay digital governance in Nueva Vizcaya. Anchored on a quantitative and developmental research approach, the methodology integrates system development, capability building, and implementation assessment to ensure both technical robustness and practical relevance at the community level. The research framework combined a DevOps-based software development life cycle (SDLC) with established evaluation models to assess system quality, user preparedness, and operational impact. The following subsections describe the conceptual

framework, research design, development process, study locale and participants, data collection instruments, procedures, and analytical techniques employed in validating the proposed system.

The study followed a systematic and sequential procedure to ensure methodological rigor and replicability. The process consisted of: i) requirements gathering through on-site observations and stakeholder interviews, ii) system design guided by the conceptual framework, iii) development using the DevOps software development life cycle (SDLC) model, iv) deployment of the iCBISys in Barangay Busilac, v) implementation of end-user training using the ADDIE model, and vi) system evaluation using ISO/IEC 25010, training assessment, and impact evaluation surveys. This structured approach ensured that both technical and human factors were addressed throughout the research process.

2.1. Conceptual framework

This study is anchored on a conceptual framework, as shown in Figure 1, that illustrates the logical relationships among the inputs, processes, system components, and outputs involved in developing a technology-driven architecture for sustainable Barangay digital governance. The framework synthesizes concepts from e-government, digital transformation, and information systems literature, emphasizing the integration of ICT resources, human actors, and system modules to improve Barangay-level service delivery.

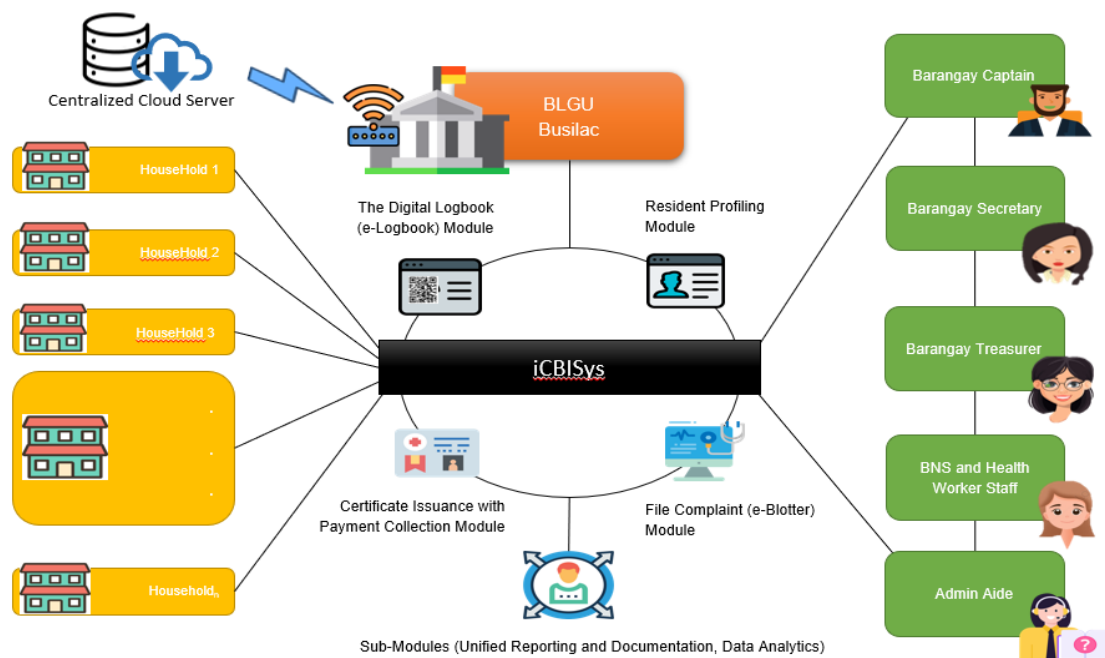


Figure 1. Conceptual framework illustrating the development of iCBISys for sustainable Barangay digital governance

At the input level, resident and household data originating from the community serve as the primary data sources of the system. These data are digitally collected and transmitted to a centralized cloud server through the iCBISys web application, ensuring secure storage, accessibility, and real-time processing. Connectivity between households and the Barangay local government unit (BLGU) of Busilac enables continuous data exchange, supporting efficient administrative and governance functions.

The core process layer is represented by iCBISys, which integrates four primary functional modules: the digital logbook (e-Logbook), resident profiling, certificate issuance with payment collection, and file complaint (e-Blotter). These modules are accessed and managed by authorized Barangay personnel based on defined roles and privileges, including the Barangay captain, Barangay secretary, Barangay treasurer, Barangay nutrition scholar (BNS), health workers, and administrative aide. Supporting sub-modules, such as unified reporting, documentation, and basic data analytics, consolidate system outputs and facilitate monitoring, decision-making, and compliance with reporting requirements.

At the output and outcome level, the framework demonstrates how the integrated system produces digitized records, automated transactions, and consolidated reports that enhance operational efficiency, transparency, and accountability in Barangay governance. By centralizing data management and streamlining

service delivery, the framework supports sustainable digital governance practices aligned with national e-government initiatives and community extension objectives. This conceptual framework guided the system design, development approach, and evaluation methods employed in the study.

2.2. Research design

This study employed a quantitative research approach, using a survey research design as the primary method for data collection and evaluation. Three major evaluations were conducted. First, the overall quality of the iCBISys application was assessed in terms of functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability using the ISO/IEC 25010 [34]–[36], the widely accepted standard for software quality evaluation model. Second, the effectiveness of end-user training conducted under Study 2 of the project was evaluated using the ADDIE model, which consists of five phases: analysis, design, development, implementation, and evaluation [37]. This instructional design framework is widely used in developing effective training programs [38], [39]. Third, a basic impact assessment was carried out as part of Study 3 to determine the effects of iCBISys utilization on Barangay operations. Data for all evaluations were primarily gathered through structured survey questionnaires.

2.3. System development approach

The development of the iCBISys followed the DevOps SDLC model to support automation, continuous integration, and long-term system sustainability [40]. DevOps was selected because it integrates software development (Dev) and information technology operations (Ops), enabling close collaboration between the development team and Barangay stakeholders while maximizing efficiency in software deployment [41], [42]. The model consists of eight iterative phases: planning, coding, building, testing, release, deployment, operation, and monitoring. Each phase involved specific activities to ensure that system functionalities aligned with actual Barangay operational requirements. Both the development team and the operations team, composed of Barangay officials and staff, were actively involved throughout the process, as illustrated in Figure 2. This collaborative and iterative approach enabled timely feedback, incremental improvements, and effective system implementation.

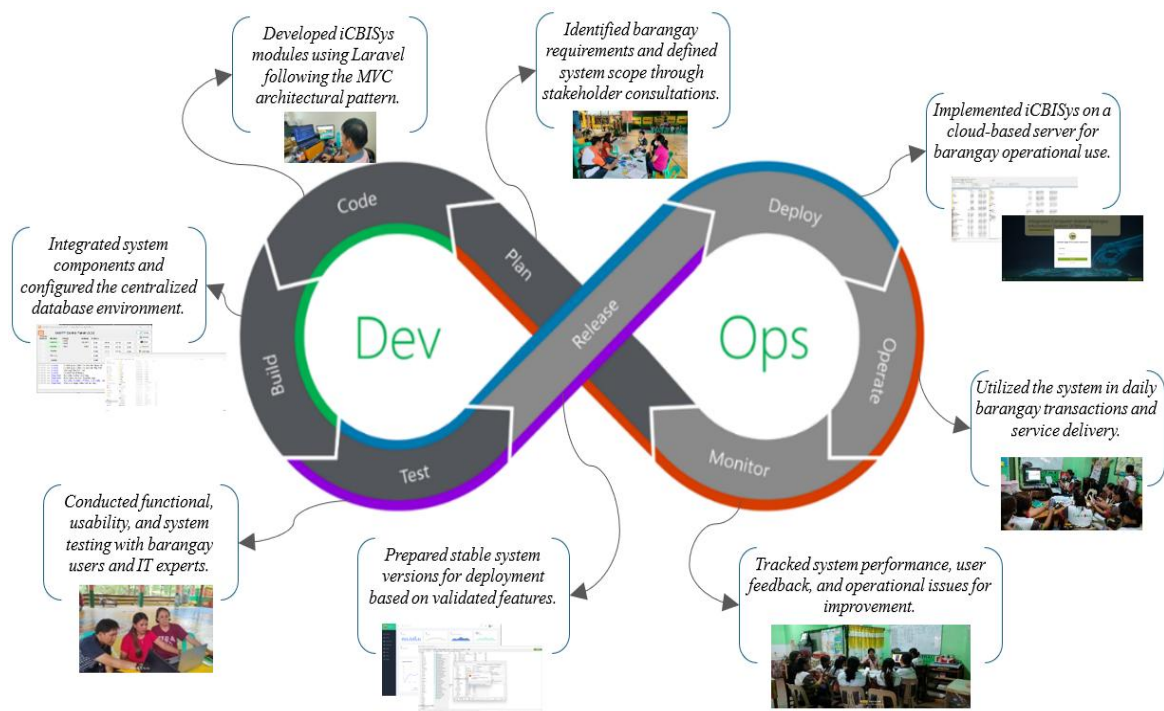


Figure 2. Activities across the eight stages of the DevOps SDLC model

2.4. Population, locale, and sampling technique

The study was conducted in Barangay Busilac, one of the 25 Barangays in the Municipality of Bayombong, located in the lone district province of Nueva Vizcaya. Bayombong is the provincial capital and

the most populous municipality in the province, with a population of 72,890 as of the 2024 census of population [43]. The study participants included Barangay officials, a Barangay nutrition scholar, Barangay health workers, and an administrative assistant/aide, who served as the primary end-users of the system. These participants were selected because they perform most of the administrative and operational functions of the Barangay, as observed during onsite visits and interviews.

Additionally, IT experts, comprising IT faculty members, professionals, and freelancers, were included as participants to evaluate the technical performance of the system using the ISO/IEC 25010 criteria. This group provided professional and practical perspectives from diverse IT backgrounds. A combination of purposive and random sampling techniques [44], [45] was used. Purposive sampling targeted Barangay personnel directly involved in Barangay processes, while random sampling was applied to the pool of IT experts to ensure unbiased selection. The involvement of these participants provided a comprehensive and multi-perspective evaluation of the system.

2.5. Research instrumentation

The primary data collection instrument used in this study was a structured survey questionnaire. The questionnaire comprised two main sections: i) demographic information and ii) evaluation items related to the utilization of the iCBISys web application, the conduct of end-user training, and the impact assessment of the system. A 5-point Likert scale was employed to measure respondents' perceptions, allowing them to indicate their level of agreement with each statement, ranging from strongly disagree to strongly agree [46]. The qualitative interpretation of the scale is presented in Table 1.

Prior to participation, informed consent was obtained from all respondents, and their privacy and confidentiality were strictly maintained throughout the study. The first section of the questionnaire collected demographic information, including age, gender, work position, years of service as a Barangay official or staff member, academic rank, and years of professional experience as IT faculty or personnel. The second section consisted of evaluation items based on the ISO/IEC 25010 software quality criteria, the ADDIE training evaluation model, and basic impact assessment indicators in an open-ended questionnaire relevant to the implementation of iCBISys.

Table 1. Qualitative interpretation of the 5-point Likert scale

Description	Scale	Interval
Strongly disagree	1	1.00 – 1.80
Disagree	2	1.81 – 2.60
Neutral/Neither	3	2.61 – 3.40
Agree	4	3.41 – 4.20
Strongly agree	5	4.21 – 5.00

2.6. Data gathering procedures

Before the conduct of data collection, necessary permissions were secured from the relevant university and Barangay authorities. On-site observations and in-person interviews were conducted to document existing Barangay processes related to resident profiling, certificate issuance, payment collection, and complaint reporting. Internet research and literature review supplemented domain knowledge relevant to e-government and information systems. Survey questionnaires were administered using Google forms during system evaluation, end-user training assessment, and impact assessment. After completion, responses were collated and prepared for analysis. All collected data were securely stored, with identifying information removed to protect participant privacy.

The ISO/IEC 25010 evaluation was conducted after the full deployment of the iCBISys to ensure that respondents assessed the system under actual operating conditions. The ADDIE-based training evaluation was administered immediately after the end-user training sessions to capture participants' learning experiences and readiness. Meanwhile, the impact assessment survey was conducted two months after system implementation to evaluate the initial operational effects of the system in the Barangay. This staged evaluation approach ensured that each component of the study was assessed at the appropriate phase of implementation.

2.7. Data analysis

Data analysis employed descriptive statistical techniques, including the computation of mean scores and frequency distributions, to evaluate the performance of the iCBISys, the effectiveness of end-user training, and the operational impact of the system. Responses collected using a 5-point Likert scale were interpreted based on predefined intervals, where a mean score of 3.40 or higher indicates positive system performance. For each evaluation model of the ISO/IEC 25010 software quality criteria, ADDIE training

assessment, and impact evaluation, multiple indicators were used. The category mean for each criterion was computed by averaging the responses across all corresponding indicators, while the overall mean was derived from the aggregate of all category means. Open-ended responses were analyzed using content analysis to identify recurring themes that complemented the quantitative findings. This qualitative analysis provided additional insights into user experiences, system usability, and implementation challenges.

All statistical analyses and visualizations were performed using Microsoft Excel 365. Results were presented using tables and graphical representations to facilitate clear interpretation. Conclusions and recommendations were derived from an integrated analysis of both quantitative and qualitative data. The mean score was computed using the formula in (1).

$$\mu = \frac{\sum_{i=1}^N x_i}{N} \quad (1)$$

In the formula, μ denotes the mean score, N represents the total number of observations or data points, and x_i corresponds to each response value. No inferential statistical techniques were applied, as the study focused on descriptive evaluation of system performance and user perception.

3. RESULTS AND DISCUSSION

This study investigated the development, implementation, and evaluation of a technology-driven architecture for sustainable Barangay digital governance through the iCBISys. While previous studies have explored Barangay information systems such as BMIS, BIPS, and e-Barangay, these solutions often lack unified, scalable, and sustainability-oriented architectures. This study addresses this gap by proposing and implementing iCBISys as an integrated and extensible platform that combines system development, user capability building, and operational impact assessment within a single framework.

3.1. Development of the iCBISys

This section presents the results and discussion related to the first research objective, which aimed to develop a technology-driven and sustainable architecture for Barangay digital governance through the iCBISys. Guided by the proposed conceptual framework, this section discusses the creation of the Barangay-level framework, the implementation of the core features of the system, and the evaluation of iCBISys performance using the ISO/IEC 25010 software product quality model to assess its effectiveness, quality, and readiness for deployment.

3.1.1. Creation of the Barangay-level framework

The thematic analysis of interviews, onsite observations, and document reviews identified the existing Barangay service framework and informed the development of a proposed digital Barangay-level framework, as presented in Figure 3. The figure illustrates a comparison between the current service framework and the proposed digital governance framework designed to support more efficient and integrated Barangay operations. Figure 3(a) depicts the existing Barangay service framework, which relies predominantly on manual processes to support three core services: document requests, complaint or case filing, and basic health services. Residents manually complete request forms that are validated by the Barangay administrative assistant, followed by payment processing by the Barangay treasurer and data encoding and document issuance by the Barangay secretary. Complaint handling involves Barangay tanods or lupon members, with cases recorded in physical logbooks, while health services are delivered through the Barangay health center. Health records were excluded from this study because they are more appropriately addressed through a separate information system.

Although these processes generate important administrative data, the absence of a centralized and integrated system limits efficient data management and utilization for planning and policy formulation. This concern was echoed by the Barangay secretary, who emphasized the need for a computerized system to improve service delivery and establish a centralized database. In response, a Barangay-level digital governance framework was developed (Figure 3(b)), introducing an integrated and resident-centered approach. The proposed framework consolidates resident profiling, requesting and issuance of certificates with payment collection, filing of complaints, and a digital logbook as core system functionalities, all supported by a centralized database. This framework served as the foundation for iCBISys, enabling streamlined transactions, improved data consistency, and enhanced transparency to support sustainable Barangay digital governance.

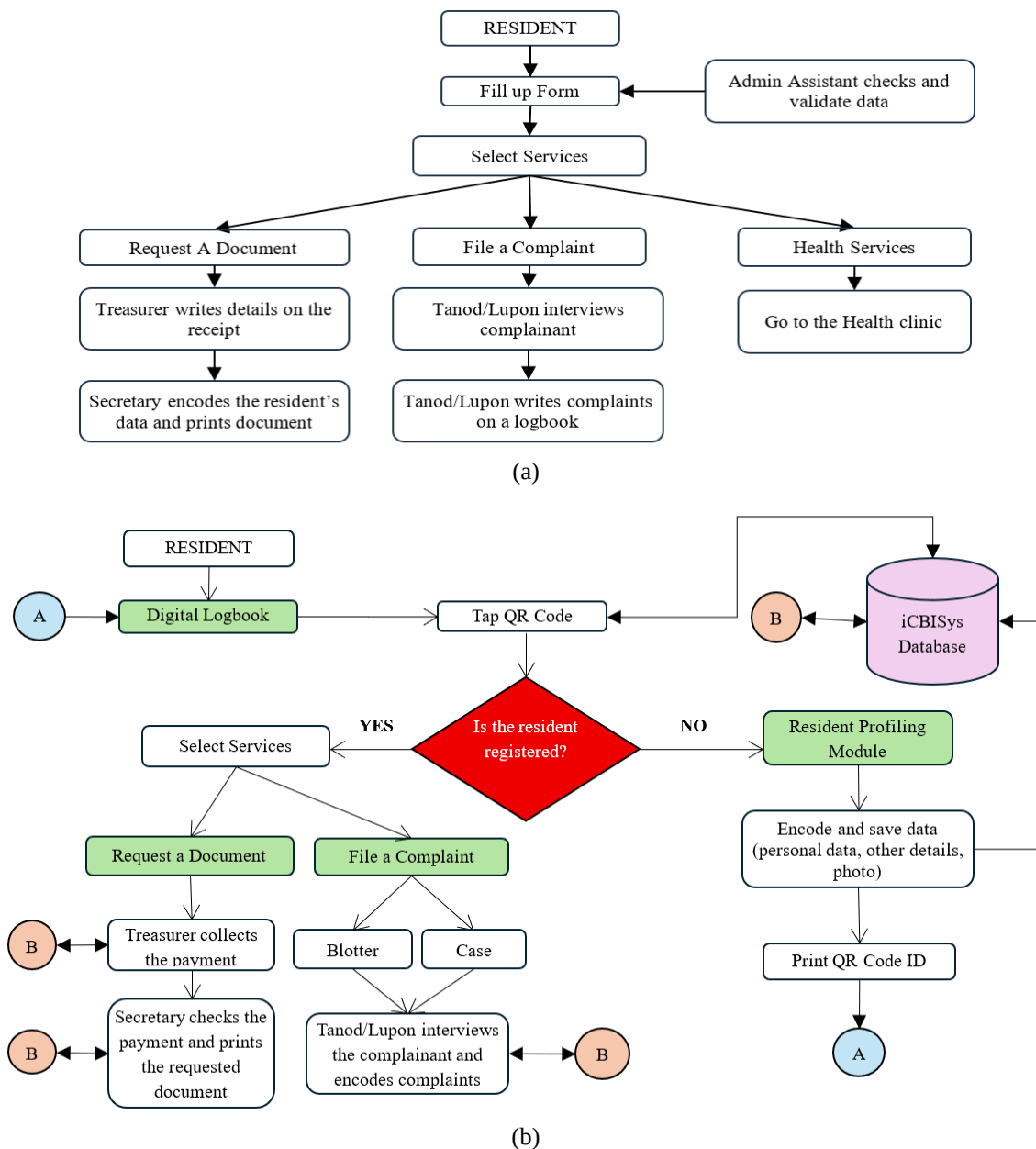


Figure 3. Comparison of (a) the existing Barangay service framework and (b) the proposed digital Barangay framework

3.1.2. Features of the iCBISys

The Barangay-level framework served as the foundation for the development of the iCBISys. Guided by the DevOps SDLC model, the system was developed through continuous integration, delivery, and feedback cycles, resulting in a modular and scalable web-based platform. iCBISys introduces three key system features: centralized management, data integration, and automated document and report generation, which collectively address the limitations of the manual processes in the Barangay.

First, iCBISys functions as a centralized management system that enables authorized Barangay officials and staff to manage records and transactions through a cloud-hosted environment, as shown in Figure 4. Specifically, Figure 4(a) presents access by authorized end-users, while Figure 4(b) shows the web-based system interface. Access is restricted to registered users with role-based permissions to ensure data security and operational control. Account creation and system administration are authorized by the Barangay captain, reflecting governance protocols identified during stakeholder interviews.

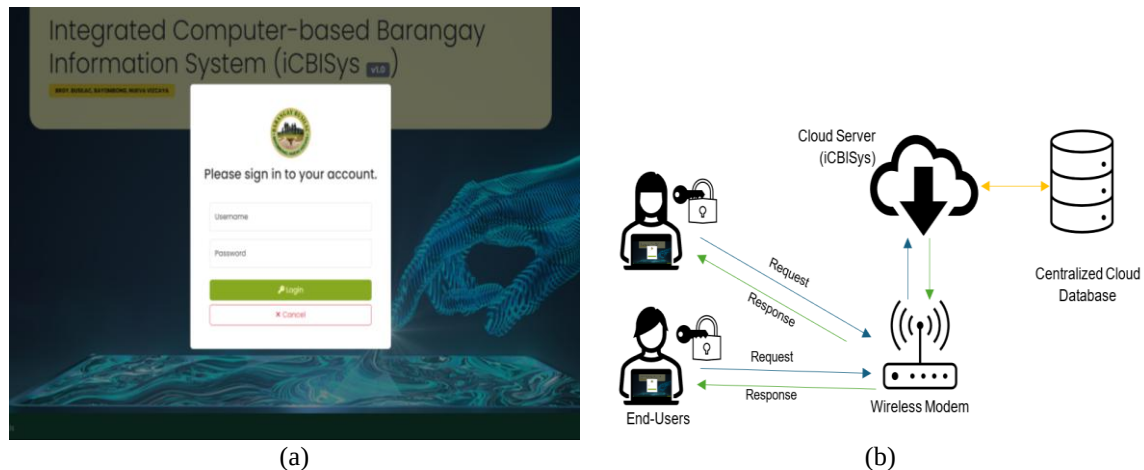


Figure 4. Centralized management of iCBISys showing (a) access by authorized end-users and (b) web-based system interface

Second, the system implements data integration through four core functional modules: the digital logbook (e-Logbook), resident profiling, certificate issuance with payment collection, and e-Blotter modules. Figure 5 presents the digital logbook module, which serves as the entry point for all transactions. Figure 5(a) shows resident validation through QR code–based identification, while Figure 5(b) illustrates the recording of service requests with corresponding timestamps. Other modules are dependent on the availability of resident records, emphasizing data consistency across the system.

Figure 6 presents the resident profiling module. Figure 6(a) shows the collection and storage of resident and household information in a centralized repository, replacing traditional paper-based records. Meanwhile, Figure 6(b) illustrates the generation of unique QR code–based resident identification used for identity verification and subsequent transactions. The dependence of other modules on resident profiling promotes data consistency across the system.

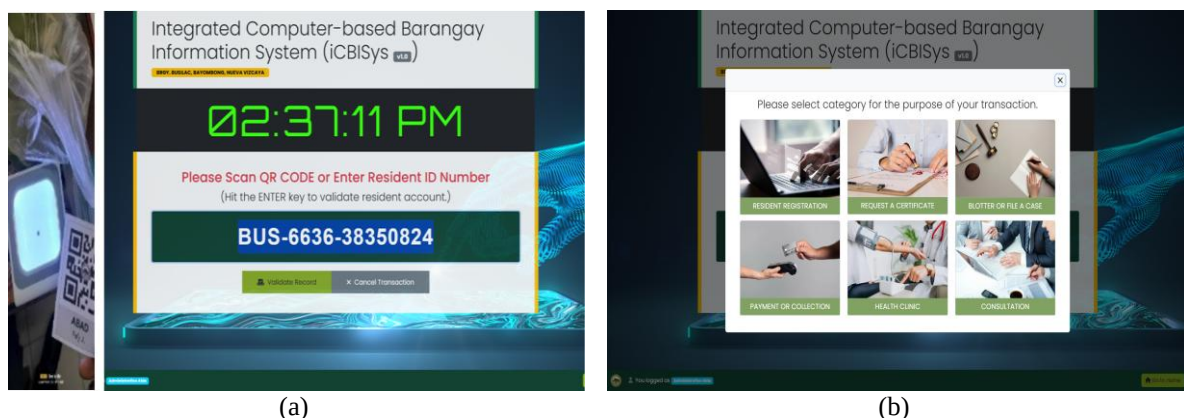


Figure 5. Resident validation and transaction recording in iCBISys showing (a) QR code–based identification and (b) transaction logging through the digital logbook module

Figure 7 presents the certificate issuance with payment collection module. Figure 7(a) shows the monitoring of document requests, payment computation, and electronic receipt generation by the Barangay treasurer, while Figure 7(b) illustrates the tracking and printing of approved and paid certificates by the Barangay secretary. On the other hand, Figure 8 presents additional operational functionalities of iCBISys. Figure 8(a) shows the e-Blotter module, which facilitates the recording and management of reported cases by Barangay lupon members. Figure 8(b) illustrates the supporting submodules for administration, system settings, report generation, and basic data analytics, which enhance monitoring, reporting, and decision-

making. Overall, the integrated features of iCBISys demonstrate its capability to transform fragmented Barangay operations into a unified, technology-driven system that supports efficient service delivery, data accuracy, and sustainable digital governance.

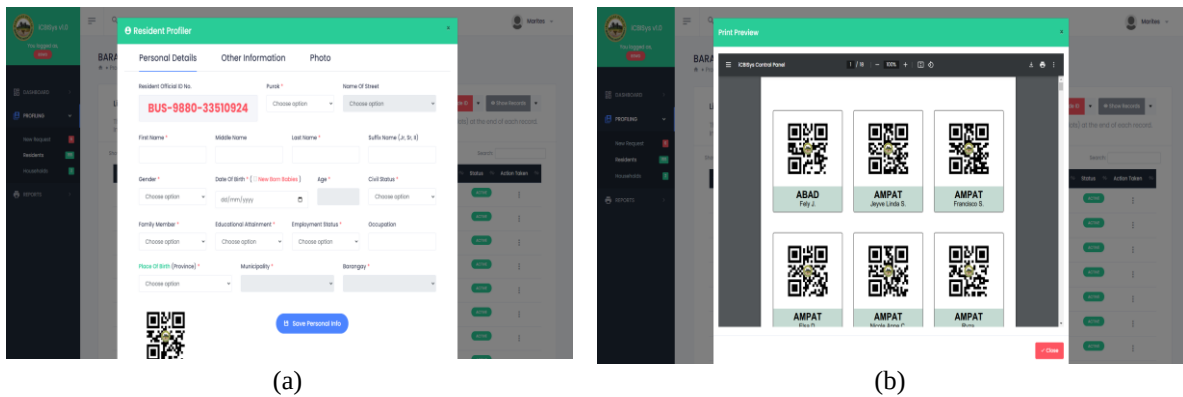


Figure 6. Resident profiling in iCBISys showing (a) collection of resident and household data and (b) generation of QR code-based resident identification

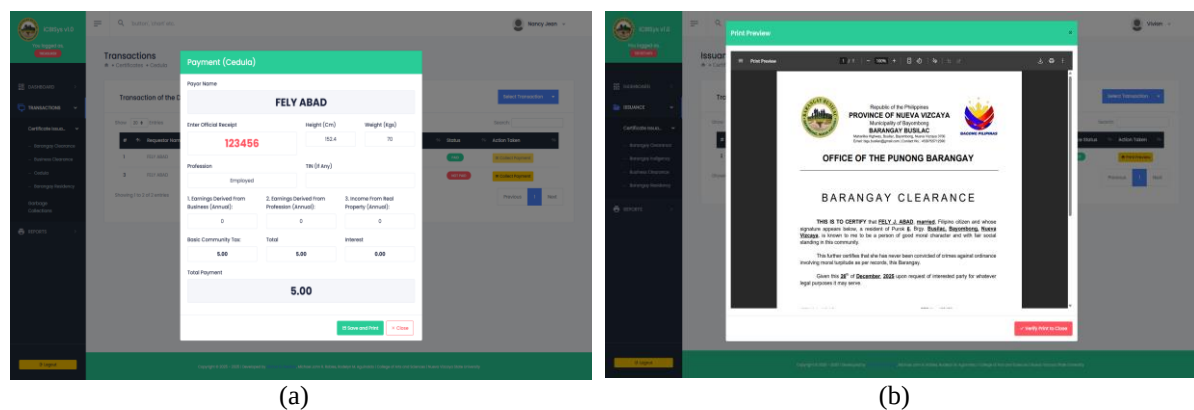


Figure 7. Certificate issuance and payment collection in iCBISys showing (a) monitoring of document requests and payment computation and (b) printing of approved and paid certificates

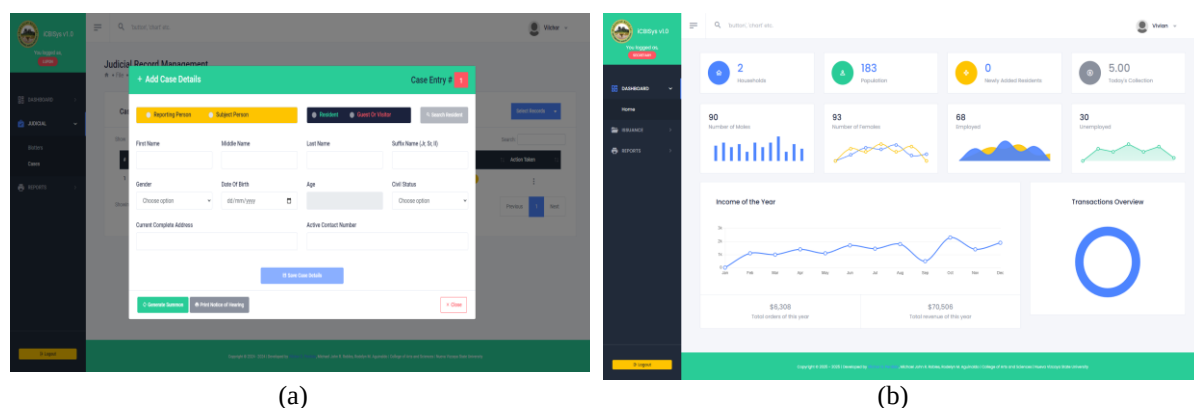


Figure 8. iCBISys modules showing (a) recording and management of reported cases (e-Blotter) and (b) report generation and basic data analytics

On the other hand, the development of iCBISys resulted in a fully functional web-based application implemented using a modern and scalable technology stack, as presented in Table 2. The system was developed with Laravel as the backend framework and Bootstrap 5.3 for the front-end interface, enabling responsive design and consistent user interaction. Core web technologies (HTML5 and CSS3) and supporting libraries, including jQuery, SweetAlert2, croppie, dropzone, TCPDF, Simple Software IO, and spell number, were integrated to support interactive system features, file uploads, document and QR Code generation, and automated data processing. System development and testing were performed using a local server environment powered by XAMPP, Apache, PHP, and MariaDB, while cross-browser functionality was validated using Brave, Mozilla Firefox, and Microsoft Edge, ensuring reliable and consistent system performance across different user platforms.

Table 2. Software specifications for iCBISys development

Software component	Specifications
Backend framework	Laravel 9
Frontend framework	Bootstrap 5.3
Runtime libraries	HTML5, CSS3, JQuery 3.7.1, SweetAlert 2, croppie 2.6.5, dropzone 5.9.3, TCPDF 10, simple software IO 4.2, spell number 3.3
Text or code editor	Microsoft visual studio code version 1.99.3
XAMPP	Apache 2.4 (localhost server), PHP 8.2, MariaDB 10.4
Web browser	Brave browser 1.77.95, Mozilla Firefox 137.0, Microsoft Edge 135.0



3.1.3. System's performance evaluation using the ISO/IEC 25010 software product quality model

The overall performance of iCBISys was evaluated using the ISO/IEC 25010 software product quality model, covering eight quality characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. A structured survey questionnaire employing a 5-point Likert scale was administered online to 20 respondents, consisting of 10 IT experts and 10 Barangay officials, staff, and health workers. Results indicate that iCBISys achieved consistently high ratings across all ISO/IEC 25010 criteria, as shown in Table 3, with category mean scores ranging from 4.37 to 4.60, all qualitatively interpreted as strongly agree. Functional suitability obtained the highest mean score (4.60), demonstrating that the system effectively supports core Barangay operations such as resident profiling, certificate issuance, payment collection, complaint recording, and report generation. Respondents strongly agreed that system outputs, including certificates, receipts, reports, and QR Code Ids, are accurate and reliable, reinforcing trust in the operational integrity of the system.

Table 3. Summary of iCBISys compliance with the ISO/IEC 25010 model

ISO/IEC 25010 Criteria	Category mean	Qualitative description
1. Functional suitability	4.60	Strongly agree
2. Performance efficiency	4.43	Strongly agree
3. Compatibility	4.37	Strongly agree
4. Usability	4.42	Strongly agree
5. Reliability	4.40	Strongly agree
6. Security	4.50	Strongly agree
7. Maintainability	4.47	Strongly agree
8. Portability	4.43	Strongly agree
Overall mean	4.45	Strongly agree

In terms of performance efficiency (mean = 4.43), respondents reported that the system responds promptly to user inputs, handles large volumes of data efficiently, and maintains acceptable page load times, even during peak usage. This level of performance is critical for Barangay environments that require timely service delivery. Compatibility (mean = 4.37) results confirm that iCBISys functions consistently across multiple web browsers and devices and integrates effectively with third-party tools such as QR code scanners and PDF generation utilities.

The usability of the system received a high mean score of 4.42, indicating that the interface is intuitive, user-friendly, and accessible even to non-technical staff. Respondents reported minimal reliance on extensive training due to clear navigation, helpful instructions, and effective error messaging. Reliability (mean = 4.40) findings further indicate that iCBISys operates consistently without frequent failures and can recover smoothly from unexpected disruptions, such as system crashes or power interruptions.

Security emerged as one of the strongest attributes of iCBISys, with a mean score of 4.50, reflecting strong confidence in the authentication mechanisms of the system, role-based access controls, and activity logging features. These safeguards ensure the confidentiality, integrity, and accountability of Barangay data. Maintainability (mean = 4.47) results indicate that the system is designed for easy updates, feature enhancements, and defect correction, supported by adequate documentation. Finally, portability (mean = 4.43) confirms that iCBISys demonstrates deployability across various hosting environments and can be adapted to different Barangay configurations, enhancing its scalability and long-term applicability.

Overall, the findings confirm that iCBISys achieved high levels of system quality, training effectiveness, and operational impact. The system obtained an overall ISO/IEC 25010 mean score of 4.45 (strongly agree), indicating excellent compliance with software quality standards. The end-user training yielded a mean score of 3.99 (agree), reflecting effective knowledge transfer and user preparedness, while the impact assessment achieved a mean score of 4.37 (strongly agree), confirming significant improvements in Barangay service delivery and administrative efficiency.

3.2. Capability building through end-user training

This section discusses the results related to the second research objective, which aimed to enhance the digital competencies and operational readiness of Barangay officials and staff for the effective use of the iCBISys. It presents the implementation of the end-user training program and examines its effectiveness using the ADDIE instructional design model, emphasizing the importance of structured capacity-building initiatives in ensuring the sustainable adoption of community-level e-governance systems.

3.2.1. End-user training program

The end-user training was conducted to ensure that Barangay officials, staff, and selected residents fully understood the features, workflows, and operational procedures of the iCBISys. The training covered key system functions, including resident profiling, certificate issuance, payment collection, complaint filing, report generation, and basic troubleshooting. The proponents conducted the “presentation and implementation of the iCBISys technology with end-user training program: A soft-launch” on July 31, 2024, at the covered court of Barangay Busilac. This activity addressed knowledge gaps associated with the introduction of a computer-based system, particularly among users with limited prior exposure to digital technologies, and aimed to increase user confidence, promote system acceptance, and prevent underutilization. Participants included Barangay officials, staff, and selected residents from the seven puroks of the Barangay.

During the training, the proponents demonstrated the core modules and workflows of iCBISys and facilitated hands-on activities to ensure familiarity with system navigation and real-time operation. Figure 9 presents the end-user training activities conducted to support system adoption and implementation. Specifically, Figure 9(a) shows the mobile-based resident profiling activity, which was introduced to address limited desktop availability and enable Barangay health workers to register and profile residents using mobile devices. Meanwhile, Figure 9(b) illustrates the installation and demonstration of QR code scanners for the Barangay administrative assistant or aide to support resident validation and transaction processing. Prior to the formal training, initial and final system testing and demonstrations were conducted on January 31, 2024, and May 28, 2024, contributing to system refinement, user readiness, and a smoother transition to digital Barangay operations.



Figure 9. End-user training activities showing (a) mobile-based resident profiling and (b) QR code scanner installation and demonstration

3.2.2. Training evaluation using the ADDIE model

The effectiveness of the end-user training program was evaluated using the ADDIE instructional design model, covering the five phases: analysis, design, development, implementation, and evaluation. A structured online survey questionnaire employing a 5-point Likert scale was administered to 10 respondents, composed of Barangay officials, staff, and health workers who directly participated in the training activities. The evaluation aimed to assess training relevance, delivery effectiveness, knowledge acquisition, and post-training readiness for system utilization.

Results presented in Table 4 indicate that all ADDIE phases received positive qualitative ratings, with mean scores interpreted as agree. The analysis phase (mean = 4.00) revealed that participants possessed baseline knowledge of iCBISys functionalities, while also recognizing the need for further training to enhance their competency. The design phase achieved the highest mean score (4.07), indicating that the training program was well-aligned with Barangay tasks and participant expectations. The development phase (mean = 3.93) reflected favorable perceptions of training materials and content relevance, although minor improvements in structure and examples were suggested.

The implementation phase recorded a mean score of 3.90, confirming that training sessions were interactive and effectively facilitated, with sufficient hands-on activities. Slightly lower ratings in this phase suggest opportunities to further enhance trainer responsiveness and clarity during demonstrations further. The evaluation phase yielded a mean score of 4.03, demonstrating that the training successfully improved participants' confidence, independent task performance, and overall satisfaction with the program. Additional indicators on post-training impact further revealed improvements in productivity, regular application of learned skills, and enhanced operational efficiency at the Barangay level.

Overall, the end-user training achieved a category mean score of 3.99, as shown in the summary of evaluation, indicating that the program was effective in building user capability and readiness for iCBISys adoption. These results highlight the importance of structured training in supporting the sustainable implementation of community-level e-governance systems.

Table 4. Summary of mean scores of the end-users' training evaluation using the ADDIE model

ADDIE phases	Indicators/focus of evaluation	Mean	Qualitative description
Analysis	Pre-training knowledge and needs assessment	4.00	Agree
Design	Alignment of training with user tasks and expectations	4.07	Agree
Development	Quality and relevance of training materials	3.93	Agree
Implementation	Effectiveness of training delivery and facilitation	3.90	Agree
Evaluation	Post-training confidence, satisfaction, and usability	4.03	Agree
	Overall mean	3.99	Agree

3.3. Implementation of iCBISys in Barangay Busilac

This section discusses the implementation of the iCBISys in Barangay Busilac, emphasizing the required deployment infrastructure and the initial operational outcomes of the system. It evaluates its practicality, usability, and early impact on administrative efficiency and service delivery at the Barangay level.

3.3.1. Hardware and software requirements for deployment

The iCBISys was deployed in Barangay Busilac using a combination of hardware and software components designed to ensure reliable system operation, accessibility, and sustainability. The deployment requirements were identified based on the actual operational conditions of the Barangay and the technical demands of a web-based information system. The hardware requirements indicated in Table 5 refer to the physical components needed to host, access, and operate the iCBISys effectively. A cloud-based web server was utilized to host the application and centralized database, ensuring high availability and remote accessibility. End-users accessed the system through desktop or laptop computers equipped with either WiFi adapters or LAN cards.

Printing devices were required for the generation of certificates, receipts, and reports, while QR code scanners and webcams supported resident identification and profiling. A stable internet connection was essential to maintain uninterrupted system access and real-time data processing. The identified minimum specifications ensure basic system functionality, while the recommended specifications support improved performance, faster processing, and long-term scalability.

Table 5. List of the hardware specifications needed for the deployment of the iCBISys

Hardware	Technical requirement	
	Minimum specifications	Recommended specifications
Web server	20GB SSD storage, 100GB bandwidth, 99% uptime guarantee, PHP 8.0, MySQL 8.0	50GB SSD storage, Unlimited bandwidth, 99% uptime guarantee, PHP 8.0 – 8.1, MariaDB 10
Computer desktop or laptop with WiFi	Quad-core processor (≥ 2.5 GHz), 4 GB RAM, 15 GB available HDD storage, 15-inch display (1366×768 resolution)	Octa-core processor or higher (≥ 3.0 GHz), 8 GB RAM or higher, 25 GB available SSD storage, 18-inch display or larger (1920×1080 resolution)
Mobile phone	Android OS 10 or higher, 4 GB RAM, built-in camera (at least 8 MP), 6.0-inch display, Wi-Fi or mobile data capability	Android OS 12 or higher, 6 GB RAM or more, high-resolution camera (12 MP or higher), 6.5-inch display or larger, stable Wi-Fi or mobile data connection
Printers	Inkjet or laser printer, dot-matrix printer (printing of receipts)	Inkjet or laser printer, dot-matrix printer (printing of receipts)
QR code scanner	Plug and play, USB Cable	960 * 640 resolution ratio, plug and play, USB cable
Webcam	Full HD 720, 8MP, USB type	Full HD 1080P or higher, 10MP or higher, USB type
Internet connection	At least 10Mbps download/upload speed	At least 20Mbps download/upload speed or higher

On the other hand, the software requirements include the operating systems, web browsers, database technologies, and utility tools necessary for system deployment and maintenance. iCBISys is compatible with widely used operating systems and modern web browsers, ensuring accessibility for Barangay personnel with varying levels of technical resources. PDF reader applications were required for viewing and printing system-generated documents such as certificates and reports. An FTP client was used to facilitate secure file transfers between local machines and the live web server during system updates and maintenance activities. The use of standard, widely supported software platforms contributed to the portability and ease of maintenance of the system.

3.3.2. Basic impact assessment of iCBISys in Barangay Busilac

A basic impact assessment was conducted to examine the initial effects of the iCBISys on Barangay operations and service delivery in Barangay Busilac. Given the relatively short period since system deployment, this assessment provides a preliminary evaluation of system impact. Data were collected through a structured online survey administered to 10 respondents, composed of Barangay officials, staff, and health workers. The survey evaluated five criteria: Usability and learning curve, efficiency in administrative tasks, data management and security, technical support and training, and overall satisfaction and future use, using a 5-point Likert scale.

The summary of results in Table 6 shows that all five criteria received high mean scores, with qualitative interpretations of strongly agree. Usability and learning curve obtained a mean score of 4.34, indicating that end-users found the system easy to understand, intuitive, and usable for daily Barangay tasks with minimal training. Efficiency in administrative tasks achieved the highest mean score (4.44), demonstrating that iCBISys significantly reduced processing time, improved report generation, and minimized manual paperwork, thereby enhancing operational efficiency.

Table 6. Summary of mean scores of the five criteria used in the initial impact assessment

Indicators	Mean	Qualitative description
Usability and learning curve	4.34	Strongly agree
Efficiency in administrative tasks	4.44	Strongly agree
Data management and security	4.42	Strongly agree
Technical support and training	4.26	Strongly agree
Overall satisfaction and future use	4.38	Strongly agree
Overall mean	4.37	Strongly agree

The data management and security criterion recorded a mean score of 4.42, reflecting strong user confidence in the ability of the system to securely store, manage, and protect sensitive Barangay data in compliance with data privacy requirements. Technical support and training obtained a mean score of 4.26, suggesting that while end-users generally perceived training and technical support as adequate and accessible, there remains room for further enhancement through continuous capacity-building initiatives. Finally, Overall Satisfaction and future use achieved a mean score of 4.38, indicating high satisfaction with system performance and strong support for continued use, further enhancement, and potential adoption by other Barangays.

Overall, the impact assessment yielded an overall category mean of 4.37, signifying that end-users strongly agree that iCBISys has positively influenced Barangay operations. These findings suggest that the system effectively supports efficient service delivery, improves data management, and enhances governance

processes at the Barangay level, while also highlighting the importance of sustained technical support and training for long-term success.

The results suggest that the integration of centralized data management, modular system architecture, and user-centered design significantly enhances the efficiency and effectiveness of Barangay operations. The high functional suitability and usability ratings indicate that iCBISys successfully addresses common limitations of manual and fragmented Barangay systems. These findings are consistent with previous studies [28]–[33], which emphasize the importance of digital systems in improving administrative processes and service delivery. However, unlike earlier implementations, iCBISys provides a unified architecture that integrates multiple Barangay services into a single platform, reducing redundancy and enabling more efficient data utilization. Furthermore, the incorporation of DevOps practices contributed to continuous system improvement and adaptability, which are critical factors for sustainable e-governance systems.

3.4. Study limitations

Despite the positive findings, this study has several limitations. First, the system was deployed and evaluated in a single Barangay, which may limit the generalizability of the results to other local government contexts. Second, the impact assessment was conducted over a relatively short period, and long-term effects on governance efficiency and sustainability were not fully examined. Third, the evaluation relied primarily on self-reported data using Likert-scale questionnaires, which may introduce subjective bias. These limitations should be considered when interpreting the results of the study.

3.5. Implications for future research

Future research may focus on the large-scale implementation of iCBISys across multiple Barangays to validate its scalability and adaptability in diverse operational environments. Additionally, integrating advanced technologies such as data analytics, artificial intelligence, and interoperability with national e-government platforms may further enhance system functionality and decision-making capabilities. Longitudinal studies are also recommended to assess the long-term impact of digital governance systems on administrative efficiency, transparency, and citizen engagement.

4. CONCLUSION

This study demonstrated the successful development, capability building, and implementation of the iCBISys as a technology-driven solution for sustainable Barangay digital governance in Barangay Busilac. Anchored on an ease-of-doing-business framework and developed using the DevOps SDLC model, iCBISys integrates core functionalities for resident profiling, certificate issuance with payment collection, complaint filing, and digital recordkeeping. Evaluation based on the ISO/IEC 25010 software product quality model yielded a high overall rating, confirming that the system meets key quality standards in terms of functionality, usability, performance, security, and maintainability. These findings establish that iCBISys effectively enhances efficiency, transparency, and accountability in Barangay operations, contributing to SDG 16 (peace, justice, and strong institutions).

Equally important, the study underscores the critical role of human capacity in digital transformation. End-user training, evaluated using the ADDIE model, produced positive results, indicating that Barangay personnel are adequately prepared to adopt and utilize the system. This supports SDG 4 (quality education) through continuous skills development and improved digital literacy. Moreover, the use of commonly available and cost-effective ICT infrastructure highlights the scalability and replicability of the system across other Barangays, aligning with SDG 9 (industry, innovation, and infrastructure). Overall, the findings confirm that iCBISys represents a viable and sustainable model for advancing grassroots e-governance, with strong potential for broader adoption across Nueva Vizcaya and similar local government contexts. Future enhancements may focus on large-scale deployment across multiple Barangays, integration with national e-government platforms, and the incorporation of advanced analytics to further strengthen decision-making capabilities.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : Writing - **O**riginal Draft

E : Writing - Review & **E**ding

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [VGP], upon reasonable request.

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