



Designing a Knowledge-Based Smart Community System to Strengthen Community Governance

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ABSTRACT

The growing need for transparent, participatory, and data-oriented community governance underscores the importance of effective digital solutions at the residential level. In practice, many communities still depend on manual and fragmented administrative processes, leading to inefficiencies and limited citizen involvement. This study aims to develop and implement a knowledge-based Smart Community Platform to enhance administrative transparency and community participation in the Paguyuban Arcadia community. The study adopts a participatory Rapid Application Development (RAD) approach, involving users throughout the stages of requirement identification, system design, iterative development, and evaluation. The proposed platform integrates data management and knowledge management into a unified system tailored to the specific needs of the community. The findings indicate that the platform improves the transparency of administrative processes, increases the efficiency of data management, and encourages higher levels of community participation. Based on User Acceptance Testing (UAT), the system achieved a conformity score of 85%, which is categorized as “very feasible,” reflecting a high level of user acceptance. This study contributes by demonstrating how the integration of data and knowledge management, supported by a participatory development approach, can effectively address community-level governance challenges. The results highlight the potential of context-based digital solutions as appropriate technology for supporting sustainable community governance.

1. Introduction

The development of digital technology has brought significant changes to community governance and public administration [1], [2]. The concept of a smart community has evolved as an approach that emphasizes the use of information systems, data management, and knowledge management to increase transparency, administrative efficiency, and citizen participation in decision-making [3]. Globally, community digitalization is seen as a crucial strategy for strengthening participatory governance and building trust between community managers and residents, particularly in residential areas with complex administrative and social needs.

However, numerous problems persist in community management practices, particularly at the local level [4], [5]. Community administration is often carried out manually or

using unintegrated digital media, such as instant messaging apps and separate record-keeping. This situation results in limited transparency, delays in information delivery, difficulties in managing citizen data, and low community participation in community activities and decision-making [5]. These problems reflect the gap between the potential of digital technology and its effective utilization at the community level.

The research object of this article is the Paguyuban Arcadia community in the G-Land Arcadia area, Cikoneng, Bojongsoang District, Bandung Regency. This community is a residential community with an internal organizational structure and routine administrative needs, such as managing resident data, disseminating information, and reporting community finances. In practice, administrative management at the Arcadia

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Community still faces various limitations due to the lack of an integrated, data-driven digital system.

Specific problems encountered include late payment of resident dues, manual submission of financial reports through informal communication channels, uneven distribution of information, and incompletely integrated resident data collection. This situation results in low administrative transparency and limited community participation in community activities. Therefore, a technological solution is needed that is appropriate to the community's context and capacity, easy to use, and capable of supporting sustainable administrative management.

Several previous studies have examined the application of digital technology in the context of smart cities, e-government, and community information systems. These studies have shown that utilizing digital platforms can improve public service efficiency, administrative transparency, and public access to information [6], [7]. Several studies also emphasize the importance of knowledge management in supporting decision-making and organizational learning in the public and community sectors [8], [9], [10]. However, most of this research focuses on the city or formal institutional scale, with relatively high system complexity and significant resource requirements. Research on the implementation of smart community platforms at the residential community level, particularly those integrating data and knowledge management as appropriate technology, remains relatively limited. Furthermore, community participation, as the primary users of the system, is often not a primary focus in the development of existing digital platforms.

Research on smart communities and digital governance has predominantly focused on large-scale contexts, such as smart cities and institutional e-government systems, which require complex infrastructures and substantial resources [11]. In contrast, implementation at the residential community level remains limited, where administrative processes are often informal, resources are constrained, and digital literacy varies among users. Furthermore, prior studies commonly treat data management and knowledge management as separate components, with limited integration in community-based systems.

This study addresses these gaps by developing a knowledge-based Smart Community Platform specifically designed for residential communities. Unlike existing approaches, the proposed system integrates data and knowledge management within a single adaptive platform, developed using a participatory Rapid Application Development (RAD) approach to ensure alignment with user needs and local conditions. Accordingly, the novelty of this study lies in three aspects: (1) the integration of data and knowledge management for community-level administration, (2) the application of a participatory RAD approach for iterative, user-driven development, and (3) the design of a community-oriented platform as an appropriate technology suited to local constraints.

This study contributes to both theoretical understanding and practical application. From a theoretical standpoint, it advances smart community research by highlighting the integration of data management and knowledge management within the context of community-level digital governance. It

also underscores the role of participatory system development, particularly through the Rapid Application Development (RAD) approach, in connecting conceptual governance frameworks with their real-world implementation at the micro level.

In practical terms, this study develops a community-oriented Smart Community Platform that is adaptive, user-focused, and suited to local needs and resource conditions. The system illustrates how appropriate technology can be applied to improve administrative transparency, facilitate more structured data management, and encourage greater community participation. Additionally, the platform may serve as a reference for other communities aiming to implement digital solutions that are both feasible and sustainable.

The objective of this research is to design and implement the Arcadia Smart Community Platform as a digital solution to improve administrative transparency and community participation, and to evaluate its benefits for the community.

2. Research methods

This study utilizes a participatory RAD approach to develop the Smart Community Platform. The selection of RAD is based on its iterative, flexible, and user-oriented nature, which supports continuous interaction between developers and users during the development process [12], [13]. This approach is particularly appropriate for the research context, where the system must reflect the actual needs, capabilities, and limitations of a residential community. By actively involving users at each stage, the development process ensures that the system remains relevant and applicable to real administrative practices [12].

The development process is organized into several interrelated stages (Figure 1). The first stage focuses on data collection, aiming to obtain a comprehensive understanding of current administrative conditions and system requirements. Data are gathered through interviews with community administrators and residents, direct observation of administrative activities, and analysis of relevant documents. This stage helps identify existing challenges, user expectations, and areas for improvement. The next stage involves requirements planning, where system specifications are defined based on the collected data. This includes identifying both functional and non-functional requirements, analyzing stakeholder roles, and mapping existing business processes. These outputs then guide the system design stage, which is conducted using Unified Modeling Language (UML), including use case diagrams, activity diagrams, and database design to represent system functionality, user interactions, and data structures. During the construction stage, the system is developed iteratively, with prototypes continuously refined based on user feedback. This iterative process allows the system to evolve in line with user needs. The final stage consists of implementation and evaluation, where the system is deployed and tested. Testing is performed using black-box testing to ensure functional correctness, followed by User Acceptance Testing (UAT) to assess usability and user acceptance in real operational conditions. This structured and participatory approach enables the system to achieve functional

reliability while maintaining alignment with user needs and contextual conditions.

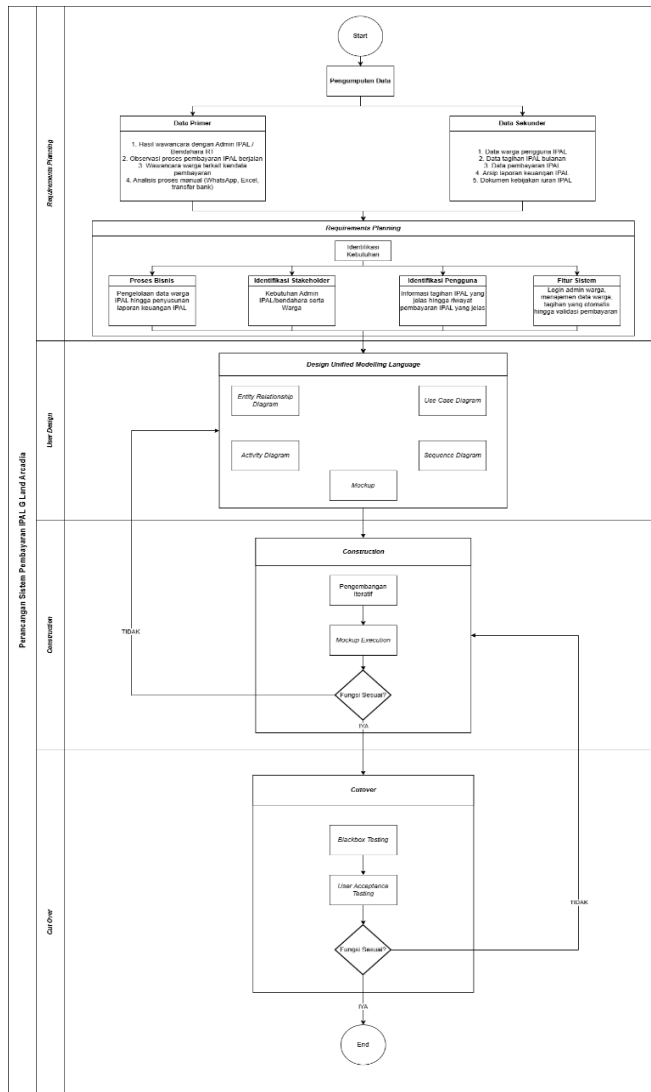


Figure 1 Research Systematics

2.1 Data Collection Stage

The initial stage of the research began with data collection to gain a comprehensive understanding of the existing state of community administration governance at the Arcadia Community. The collected data consisted of primary and secondary data. Primary data were obtained through interviews and direct discussions with community administrators and residents as system users [12]. In addition, field observations were conducted of administrative processes that are still carried out manually, such as recording resident data, conveying information through informal communication media, and managing administrative reports that are not yet integrated [12]. Secondary data were obtained from supporting documents, including resident population data, community administrative archives, and internal community policies related to information management and community activities [12].

2.2 Requirements Planning Stage

In the Requirements Planning stage, system requirements are identified based on data collection. This identification includes an analysis of existing business processes, stakeholder needs (administrators and residents), user needs for information transparency, and system feature requirements. This analysis results in specifications for the system's functional requirements, such as citizen data management, e-administration, information and announcement delivery, a citizen communication forum, and a mechanism for documenting community knowledge.

2.3 User Design Stage

The user design stage aims to transform the identified system requirements into structured models and interface designs [12], [13]. At this stage, the system architecture and user interaction flows are defined to ensure that the platform effectively meets user needs and supports existing operational processes. This stage includes the development of Unified Modeling Language (UML) diagrams, such as use case diagrams, activity diagrams, and sequence diagrams, along with interface mockups to illustrate system functionality and facilitate early validation of user interaction. The results of this stage provide a clear foundation for the construction phase, ensuring that the system development process remains aligned with the established requirements and user expectations.

2.4 Construction Stage

The construction phase is an iterative system development process based on the established design [12], [13]. The agreed-upon mockup is developed into an Arcadia Smart Community Platform prototype using an iterative development approach. Each prototype version is evaluated with users to ensure the system's functionality is appropriate. If discrepancies or additional requirements are identified, improvements and redevelopment are made until the system meets both functional and non-functional user requirements.

2.5 Cutover Stage

The final stage in the RAD method is Cutover, which includes system implementation and testing. Testing is conducted using Black Box Testing to ensure each system function operates according to specifications. Next, User Acceptance Testing (UAT) is conducted with administrators and residents to assess the level of system acceptance and its suitability to user needs. The system is declared ready for use if all functions function properly and are accepted by users. Through the application of the Rapid Application Development method, this research resulted in a Smart Community Platform system that is adaptive, participatory, and relevant to the real needs of the community. The RAD approach is considered effective in supporting the development of appropriate technology based on data and knowledge management to increase administrative transparency and community participation in residential communities.

3. Results and Discussion

3.1 Data Collection

The data collection stage provides a comprehensive understanding of the existing administrative conditions within the Paguyuban Arcadia community in September - October 2025. The findings reveal that community administration is predominantly conducted through manual and fragmented practices, including handwritten records, informal communication via messaging applications, and non-integrated reporting mechanisms.

Interviews and observations indicate that three primary user roles are involved in community governance: administrators, treasurers, and residents. Each role has distinct responsibilities and information needs. Administrators are responsible for managing community data and system operations, treasurers handle financial records, and residents primarily access information and participate in community activities. However, the absence of an integrated system results in several problems, including inconsistent resident data, delays in information dissemination, and lack of transparency in financial reporting. These findings highlight the need for a centralized platform that accommodates multiple user roles while ensuring efficient data management and communication.

3.2 Requirements Planning

Based on the identified problems, system requirements were formulated by considering the specific roles and interactions of the three user groups. The system is designed to support role-based access and functionality to ensure that each user interacts with the system according to their responsibilities. The functional requirements are categorized as follows:

- a. Residents: access information and communication, view resident data, view financial information, and access administrative information.
- b. Treasurers: manage financial data, including input, edit, and delete financial records, while also accessing resident and administrative information.
- c. Administrators: perform full system control, including managing resident data (input, edit, delete), managing information and communication (add and delete information), accessing financial data, and configuring system settings.

In addition, all users share common functionalities such as login authentication, password verification, error notification handling, and logout processes. This role-based requirement structure ensures that the system supports both operational efficiency and data security by restricting access according to user responsibilities.

3.3 User Design

User design stage translates the identified system requirements into structured models and interface representations, ensuring alignment with user needs while maintaining clarity in system functionality and interaction flow [14]. This stage serves as a critical link between requirement specification and system implementation.

To support this process, UML diagrams including use case, activity, and sequence diagrams were developed to systematically represent system behavior [12]. Use case diagrams define user roles and their interactions with system functionalities, ensuring that each feature aligns with user responsibilities. Activity diagrams illustrate process workflows and task sequences, enabling a clear understanding of operational logic. Sequence diagrams depict interactions between system components over time, highlighting the flow of data and execution processes.

The resulting design establishes clear and structured interaction patterns, allowing users to perform their tasks efficiently. Interface mockups were developed to visualize system features and facilitate early usability evaluation, ensuring that the platform remains intuitive and accessible for users with varying levels of digital literacy.

Based on the use case analysis, the system involves three primary actors residents, administrators, and treasurers each with defined roles and access rights. This role-based structure ensures clear responsibility separation, enhances security, and supports controlled system access.

3.3.1 Residents

Residents interact with the system primarily for information access. After successful login and password verification, residents can navigate the main menu to:

- a. view information and communication,
- b. view resident data,
- c. view financial information, and
- d. view administrative information.

Their access is limited to viewing functionalities, ensuring simplicity and ease of use. The following Figure 2 shows the use case for user residents.

3.3.2 Treasurer

The treasurer has extended access compared to residents, particularly in financial management. In addition to viewing information and resident data, the treasurer can:

- a. input financial data,
- b. edit financial records, and
- c. delete financial data.

This role ensures that financial management is handled by a dedicated user while maintaining controlled access. The following Figure 3 shows the use case for user treasurer.

3.3.3 Administrator

The administrator has the highest level of access and system control. The administrator can:

- a. manage information and communication (add and delete information),
- b. manage resident data (input, edit, delete),
- c. access financial data, and
- d. configure system settings.

This role is responsible for maintaining system integrity and ensuring that all administrative processes are properly managed. The following Figure 4 shows the use case for user administrator.

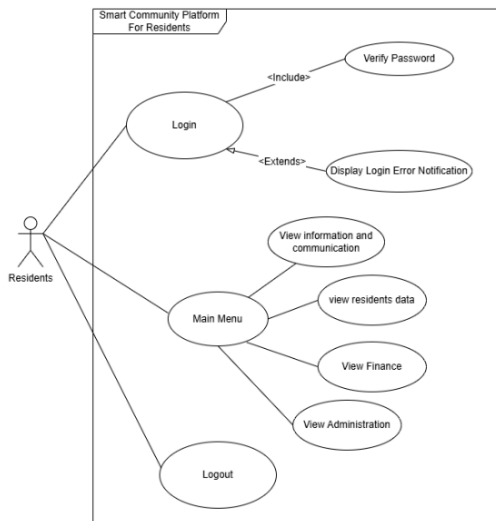


Figure 2 Use Case for User Residents

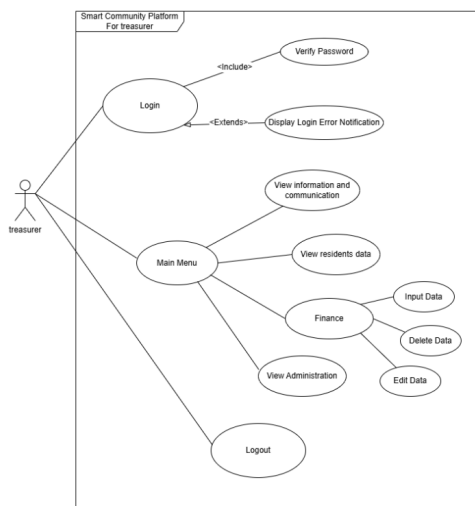


Figure 3 Use Case for User Treasurer

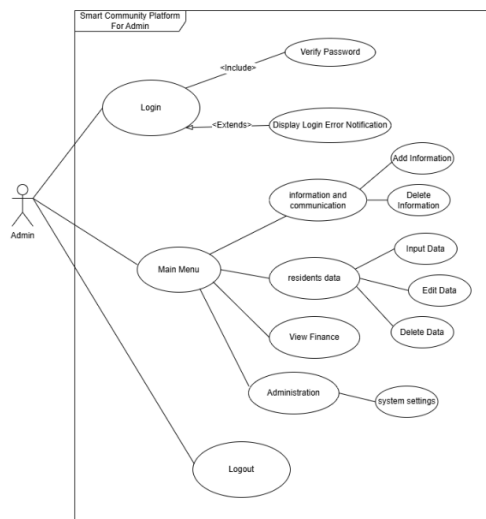


Figure 4 Use Case for User Administrator

Across all user roles, the login process includes password verification (<<include>>) and error notification handling (<<extend>>), ensuring secure system access [15]. The system design demonstrates a clear separation of roles and responsibilities, which enhances usability, security, and operational clarity.

Additionally, interface mockups were created to visualize system features and provide an early representation of user experience. The design emphasizes simplicity and intuitiveness to accommodate users with diverse digital capabilities. Early validation with users indicates that the proposed interface design is understandable and aligns with user expectations, thereby reducing potential usability barriers during implementation.



Figure 5 Design Results



Figure 6 System Dashboard

3.4 Construction

The construction stage resulted in the development of the Arcadia Smart Community Platform as a web-based application. The system was implemented using PHP and MySQL, providing a lightweight and cost-efficient solution suitable for community-level deployment [16].

The platform was developed iteratively, allowing continuous refinement based on user feedback from administrators, treasurers, and residents. This iterative process ensures that the system aligns closely with real user needs and operational conditions [16]. The final system integrates all functionalities into a unified platform, including:

- centralized resident data management,
- structured financial management,
- integrated information and communication features, and
- role-based system access.

Compared to the previous manual system, the platform significantly improves data organization, reduces redundancy, and enhances accessibility. Information dissemination becomes

faster and more transparent, while administrative and financial processes are more structured and traceable.

3.5 Evaluation of System Functionality and Suitability

The Smart Community Platform was evaluated through functional testing or black-box testing and UAT. The UAT was structured based on the ISO/IEC 25010 quality model [17], encompassing six main aspects: functional suitability, usability, reliability, efficiency, security, and compatibility. In total, 18 evaluation indicators were used to assess the system. The evaluation process involved three respondents who represent

key roles within the community, namely the administrator, treasurer, and resident. Each respondent provided assessments using a 5-point Likert scale, resulting in a total of 54 responses (3 respondents across 18 indicators). The results of the evaluation are presented in Table 2.

Based on the quantitative analysis, the system obtained a total score of 229 out of a maximum possible score of 270, corresponding to a conformity level of 85% (see Table 3). According to the defined evaluation criteria, this result is categorized as “Very Feasible,” indicating that the system is highly acceptable and suitable for supporting community administrative activities.

Table 1.
User Acceptance Testing (UAT) Results Based on ISO/IEC 25010

Aspect	Code	Evaluation Question	1	2	3	4	5	Score
Functional Suitability	FS1	The system features meet community administrative needs	0	0	0	1	2	14
	FS2	The system supports financial and reporting processes properly	0	0	0	1	2	14
	FS3	The system functions run according to their intended purpose	0	0	0	0	3	15
Usability	US1	The system is easy to use and understand	0	0	0	2	1	13
	US2	The interface is clear and user-friendly	0	0	0	1	2	14
	US3	Users can operate the system without difficulty	0	0	0	2	1	13
Reliability	RL1	The system runs without errors during use	0	0	0	2	1	13
	RL2	The system produces consistent results	0	0	1	2	0	11
	RL3	The system is stable during operation	0	0	0	2	1	13
Performance Efficiency	PE1	The system responds quickly when accessed	0	0	0	2	1	13
	PE2	The system does not lag during use	0	0	0	2	1	13
	PE3	The system performs efficiently under normal usage	0	0	0	1	2	14
Security	SC1	User data is securely stored	0	0	0	2	1	13
	SC2	Access rights are properly managed	0	0	1	2	0	11
	SC3	The system protects sensitive information	0	0	0	2	1	13
Compatibility	CP1	The system can be accessed from different devices	0	0	0	2	1	13
	CP2	The system works well across platforms	0	0	0	2	1	13
	CP3	The system integrates well with user environment	0	0	0	2	1	13
Total Score								229

Table 2.
UAT Score Interpretation Criteria

Eligibility Score	Criteria
$X < 51\%$	Not feasible
$52\% \leq X < 68\%$	Less than worthy
$68\% \leq X < 76\%$	Quite Decent
$76\% \leq X < 84\%$	Worthy
$X \geq 85\%$	Very Worthy

Further examination of each evaluation aspect shows that functional suitability and usability achieved relatively higher scores, suggesting that the system effectively supports administrative processes and is easy for users to operate. Meanwhile, comparatively lower scores were identified in the reliability and security aspects, indicating potential areas for improvement, particularly in maintaining system stability and strengthening access control.

Although the number of respondents is limited, they were selected to represent the primary user roles within the community, ensuring that the evaluation reflects actual system usage. Therefore, the results provide a meaningful initial

validation of system performance and user acceptance. Overall, the findings demonstrate that the Smart Community Platform is both functionally appropriate and practically applicable within the residential community context.

3.6 Smart Community Platform for Appropriate Technology

The findings of this study indicate that the implementation of a Smart Community Platform at the residential community level has significant potential as a form of Appropriate Technology. Unlike the large-scale and complex concept of a smart city, the platform developed in this study is simple,

contextual, and oriented toward the specific needs of the community. This approach aligns with inclusive digitalization principles that place users at the center of system development.

The integration of data management and knowledge management within a single platform enables communities not only to manage administrative data but also to develop a shared knowledge base [10]. Information related to community activities, internal policies, and administrative processes can be systematically documented and utilized as a source of collective learning [18]. As a result, the platform functions not only as an administrative tool but also as a means to strengthen the capacity of community organizations.

From a community participation perspective, the findings show that the availability of transparent and easily accessible information encourages greater involvement in community activities. Information that was previously limited or fragmented is now more openly available, which strengthens residents' sense of ownership and engagement within the community. These results are consistent with previous studies indicating that context-sensitive digitalization can enhance participation and trust.

From a broader perspective, the results of this study are in line with prior research highlighting the role of digital platforms in improving transparency and participation in governance [6], [7]. However, unlike studies that focus on large-scale or institutional implementations, this research demonstrates that similar benefits can also be achieved at the residential community level through a more adaptive and context-oriented approach.

The observed improvements in transparency and participation can be explained by the structured integration of information and knowledge processes within the platform. This approach enables information to be organized, accessed, and shared more effectively, reducing communication gaps and improving coordination among community members. In addition, the participatory RAD approach contributes to higher user acceptance, as the system is developed in close alignment with user needs and expectations [19], [20].

These findings indicate that the effectiveness of digital governance initiatives is not solely determined by technological sophistication, but also by how well the system is adapted to its user context. Therefore, a micro-level and user-centered approach, as applied in this study, is essential for ensuring effective and sustainable implementation in community-level digital governance.

3.7 Implications for Sustainable Community Governance

The findings of this study offer several key insights for advancing sustainable community governance. First, the implementation of the smart community platform shows that digital solutions at the community level can enhance transparency and improve administrative efficiency. This improvement is supported by the availability of organized and easily accessible information, which enables more accountable and responsive governance practices. Second, the application of a participatory Rapid Application Development (RAD) approach indicates that continuous user involvement plays an important role in increasing system acceptance and long-term usability. By integrating user feedback throughout the

development process, the system can adapt to evolving community needs and remain relevant over time. From a broader standpoint, these findings suggest that digital transformation in community governance does not necessarily depend on complex or high-cost systems. Instead, practical and context-oriented solutions can provide meaningful benefits when they are aligned with local conditions and user capabilities [21]. Furthermore, the effectiveness of the system is influenced not only by its technological features but also by how well it is integrated into existing community practices. When the platform becomes part of routine administrative activities, it encourages consistent usage, improves information flow, and supports greater community participation.

The model developed in this study demonstrates strong potential for application in other communities with similar characteristics, particularly those with limited resources but a need for transparent and participatory governance. This highlights the importance of a user-centered and context-driven approach in supporting sustainable digital governance at the community level.

3.8 Research Limitations

This study acknowledges several limitations that should be taken into account when interpreting the findings. First, the research was conducted within a single residential community, which may restrict the applicability of the results to other settings with different characteristics or organizational contexts. Second, the system evaluation was performed over a relatively short timeframe and involved a limited number of participants. As a result, the findings mainly represent initial user acceptance rather than providing insight into long-term system performance or sustained impact. Third, the scope of this study is primarily focused on system development and its initial implementation. More advanced analytical features and longitudinal observations of community behavior were not included in the current research. Future studies are encouraged to involve a broader range of communities, extend the evaluation period, and incorporate additional system functionalities to further assess and strengthen the proposed approach.

3.9 Future Research Directions

Future research can further develop this study through several specific directions. First, longitudinal studies are required to examine the long-term impact of the Smart Community Platform on governance performance, user engagement, and community participation over time. Second, comparative studies involving multiple communities with diverse characteristics are necessary to evaluate the generalizability and adaptability of the proposed system across different contexts. Third, future work may incorporate advanced analytical capabilities, including data analytics and decision support features, to enhance the system's ability to support evidence-based decision-making within the community. Finally, further research could investigate the integration of the platform with other digital governance systems to establish a more comprehensive and interconnected approach to community management.

4. Conclusion

This study aimed to design and implement the Arcadia Smart Community Platform as a digital solution to improve administrative processes and encourage community participation at the residential level. The findings indicate that a context-oriented digital platform can enhance transparency, efficiency, and accountability within community governance. The use of the rapid application development approach proved effective in supporting iterative development and ensuring that the system aligns with user needs. Continuous user involvement throughout the development process contributed to the creation of a system that is both functionally reliable and well accepted by users, as reflected in the UAT results, which demonstrate a high level of feasibility.

In addition, the integration of data management and knowledge management within a unified platform successfully addressed key administrative issues, such as fragmented data handling, limited transparency, and inefficient information dissemination. The centralized system enables more organized data management and facilitates more effective communication among community members. From a theoretical perspective, this study contributes to the development of smart community research by highlighting the importance of micro-level and context-based approaches in digital governance. From a practical standpoint, the proposed platform represents a form of appropriate technology that can be adapted to other communities with similar characteristics.

Future studies are encouraged to conduct longitudinal evaluations, involve a broader range of communities, and incorporate advanced analytical features to further enhance the system's effectiveness and long-term impact.

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