Vol 28 (2)

Ingeniería y Competitividad
Vol 28 (2) 2026 doi: 10.25100/iyc.v28i2.15488

ISSN
0123-3033
e- 2027-8284

Original Article

Sara - system for the administration of rural communities supported by a cloud architecture

Sara -sistema para la administración de comunidades rurales soportado por una arquitectura de nube

Urbano Eliécer Gómez-Prada[1]

[1] Escuela de Ingeniería de Sistemas, Universidad Industrial de Santander, Bucaramanga, Colombia.

Abstract

Introduction: The management of rural community projects faces limited local planning capabilities. In this context, SARA was developed as a system aimed at improving traceability, transparency, and efficiency, based on the analysis of the organizational dynamics of rural communities and the management processes within local governments.
Objective: To develop a system for managing rural community projects that contributes to improving traceability, transparency, and efficiency in management processes.
Methodology: The system development was based on a hybrid methodological approach integrating exploratory-descriptive research with Design Science Research (DSR) and the Rational Unified Process (RUP), enabling iterative artifact construction and evaluation. SARA was implemented as a cloud-based architecture comprising a web application, a REST API, a mobile application, and IoT devices.
Results: The results obtained in a pilot context revealed a positive user perception regarding usefulness and ease of use, as well as its potential to support the management of community projects. Unlike other solutions focused on agricultural productivity, SARA emphasizes local governance, transparency, and social sustainability.
Conclusions: SARA represents an alternative for strengthening public management in rural environments and contributing to digital transformation processes, in line with the Sustainable Development Goals (SDGs) and digital governance policies in Colombia.

Keywords: Cloud computing, community project management, rural communities, local governance, digital transformation, Design Science Research.

Resumen

Introducción: La administración de proyectos comunitarios rurales enfrenta limitadas capacidades de planificación local. En este contexto, se desarrolló SARA, un sistema orientado a mejorar la trazabilidad, la transparencia y la eficiencia, a partir del análisis de las dinámicas organizativas de las comunidades rurales y de los procesos de gestión en las alcaldías.
Objetivo: Desarrollar un sistema para la administración de proyectos comunitarios rurales que contribuya a mejorar la trazabilidad, la transparencia y la eficiencia en la gestión.
Metodología: El desarrollo del sistema se fundamentó en un enfoque metodológico híbrido que integró investigación exploratoria-descriptiva con Design Science Research (DSR) y Rational Unified Process (RUP), permitiendo la construcción iterativa y la evaluación del artefacto. SARA se implementó como una arquitectura en la nube compuesta por una aplicación web, una API REST, una aplicación móvil y dispositivos IoT.
Resultados: Los resultados obtenidos en un contexto piloto evidenciaron una percepción positiva por parte de los usuarios en términos de utilidad y facilidad de uso, así como su potencial para apoyar la gestión de proyectos comunitarios. A diferencia de otras soluciones centradas en la productividad agrícola, SARA se enfoca en la gobernanza local, la transparencia y la sostenibilidad social.
Conclusiones: SARA constituye una alternativa para fortalecer la gestión pública en entornos rurales y contribuir a los procesos de transformación digital, en coherencia con los Objetivos de Desarrollo Sostenible y las políticas de gobernanza digital en Colombia.

Palabras clave: Sistemas orientados a servicios, computación en la nube, comunidades rurales, gestión de proyectos comunitarios, gobernanza local, transformación digital, investigación basada en diseño.

How to cite?

Gómez-Prada UE. Sara - system for the administration of rural communities supported by a cloud architecture. Ingeniería y Competitividad, 2026, 28(2) e-20115488

https://doi.org/10.25100/iyc.v28i2.15488

Received: 6/12/25
Reviewed: 06/04/26
Accepted: 20/05/26
Online: 25/06/26

Correspondence

uegomezp@uis.edu.co

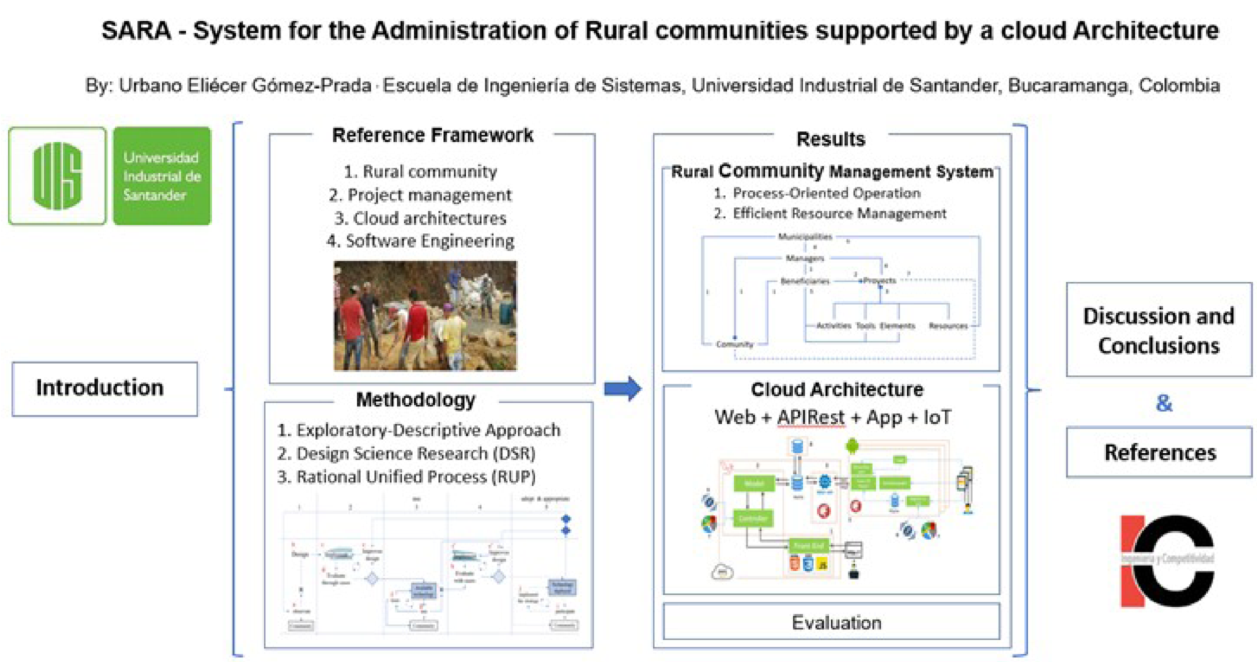
Spanish version

Why was the study conducted?
The study was conducted to design and validate an ICT solution supported by a cloud-based architecture, scalable and of low operational complexity, aimed at improving the management of rural community projects led by Community Action Boards (CABs), while strengthening the registration, monitoring, and control of their activities and resources.

What were the key findings?
The study made it possible to identify and structure a rural community project management model of low operational complexity, oriented to the dynamics of Community Action Boards and materialized in an architecture composed of a web application, a mobile application, and integration services. Preliminary results show that the solution is useful, easy to use, and replicable in other rural contexts with similar needs for traceability, coordination, and control.

What do these findings contribute?
These findings provide a technological tool that strengthens the control, traceability, and coordination of community projects for both Community Action Boards and municipal Infrastructure Secretariats, by facilitating the monitoring of activities, resources, participants, and outcomes, while also offering a scalable technological foundation for adoption in other rural communities.

Graphical Abstract



doi: 10.25100/iyc.v28i2.15488

Introduction

Rural communities face information shortages that hinder the management of their infrastructure projects (1), (2). These communities, generally organized through Communal Action Boards (CABs), often experience limitations in accessing services and technologies that support the management of their activities. In this con-text, Information Technologies (IT) can help bridge these gaps by facilitating the registration, monitoring, and control of projects, while supporting processes of self-sufficiency and sustainability, as suggested in (3).

Within this context, SARA is proposed as a system oriented toward the management of rural community projects, aligned with initiatives that promote the achievement of the Sustainable Development Goals (SDGs), particularly Goal 11 related to sustainable communities (4), (5). As described in (6), the system incorporates software architecture that enhances information traceability in projects supported by territorial entities, contributing to improved control and project outcomes.

Currently, these projects are commonly managed manually, which limits resource control and the monitoring of results. According to (7), this process includes phases such as needs identification, planning, funding requests, approval, execution, and auditing, all of which require adequate information management mechanisms for their successful development.

The development of SARA integrates three methodologies: Exploratory-Descriptive Research, Design Science Research (DSR), and the Rational Unified Process (RUP). The project proposes a process-based system to manage projects developed by rural communities and to guide the use of Information Technologies (IT) integrated into architecture. Its objective is to provide clarity and facilitate the recording of activities associated with these projects.

The system is supported by cloud-based architecture, defined by (8), (9) as a flexible and scalable computing service delivered through the Internet that does not depend on local physical servers. In this case, the architecture is composed of a web application, a mobile application, and Internet of Things (IoT) devices. Both the system and its cloud architecture are consistent with the context of rural communities and are intended to support a future adoption phase that promotes an integral, participatory, and sustainable approach, as highlighted in (10) and (11).

SARA is conceived as an accessible, scalable, and flexible solution suitable for rural environments with technological and connectivity constraints. The system centralizes information and facilitates access from different locations, improving project coordination, interaction between community actors and local governments, and accountability processes. Furthermore, it serves as a model that can help other rural communities increase project execution efficiency, improve beneficiaries' quality of life, and strengthen regional development.

The construction of the first version of SARA involved several iterations and case-based evaluations. An adoption process was conducted with one rural community and three municipal government officials, resulting in positive acceptance of the system. Nevertheless, broader implementation will require public policies that encourage its appropriation across rural communities and municipalities in Colombia.

doi: 10.25100/iyc.v28i2.15488

The next phase of the project will seek the participation of additional rural leaders and territorial entities to re-identify and address the barriers to IT appropriation identified in (12) and (13). This feedback process will guide adjustments to the management system and support the incorporation of new functionalities through additional applications that provide access to health, education, and other social programs.

The pursuit of technological appropriation will be based on trust, communication, and beneficiary participation, three essential elements for success in rural environments according to (14). These principles will support the evolution of SARA toward Software as a Service (SaaS) model.

SARA has a direct impact on the capacity of communities to self-manage and improve their participation in development projects. However, its long-term success will require mechanisms that ensure system sustainability and autonomy, as well as strategies to mitigate legal and regulatory limitations.

Methodology

According to (6), the development of SARA is grounded in a hybrid methodological approach that integrates Exploratory-Descriptive Research, Design Science Research (DSR), and the Rational Unified Process (RUP). This approach aims to understand the rural context while iteratively constructing and validating a technological solution in real-world environments.

The understanding of rural communities was supported through exploratory-descriptive research following the approach described in (15), which focuses on analyzing the experiences and meanings attributed by a social group. This process led to the conception of the management system described in Section 4.1.

The construction and evaluation of the prototypes were supported by the integration of Design Science Re-search (DSR) and the Rational Unified Process (RUP). DSR provided the framework for the generation and validation of the artifact, incorporating models, methods, and instances that ensure scientific rigor (16). RUP, in turn, structured the software development process through incremental iterations guided by use cases and continuous feedback. This combination enabled the progressive evolution of the prototypes in response to changing requirements (17), (18), while ensuring both the suitability of the designed solutions and the scientific validity and quality of the resulting artifact.

Following the principles of Design Science Research, the development of SARA was structured as an iterative cycle composed of: (i) problem identification and analysis within the rural context, (ii) design and construction of the technological artifact, (iii) evaluation of the artifact in representative scenarios, and (iv) refinement of the solution based on the feedback obtained.

The proposed methodology is organized into five complementary phases that guide the development and evolution of the system. Phases 1 through 4 have been implemented and evaluated within the study context, while Phase 5 is proposed as a future stage focused on technology appropriation by the communities. Figure 1 provides an overview of these phases, which are described below:

doi: 10.25100/iyc.v28i2.15488

1. Phase 1 illustrates the exploratory approach aimed at understanding the communities through observation (a), defining requirements (R), and designing the system (b).
2. Phase 2 is supported by DSR and RUP and includes implementation activities (c), evaluation through cases or scenarios (d), and design improvement when necessary (e). These activities are performed iteratively based on the feedback obtained during testing.
3. Phase 3 involves the community in training activities (f) and system use (g), allowing requirements (R) to be redefined based on real-world experience. SARA is currently at this stage, and agreements are being established to work with additional communities.
4. Phase 4 is again supported by DSR and RUP, incorporating the adjustments identified during Phase 3. It includes continued implementation (c'), user evaluation (h), and system refinement (e), maintaining an iterative and incremental approach based on continuous feedback.
5. Phase 5 corresponds to a future stage focused on technology appropriation and will involve implementing strategies (i), such as training programs and incentive mechanisms, as well as promoting regional policies that encourage technology use within communities (j).

6. Technology adoption and appropriation in rural contexts represent significant challenges due to cultural traditions and resistance to change, factors that have been widely documented in the literature (19). In this regard, several studies highlight the need to promote transformations in user behavior to facilitate the effective incorporation of technological solutions (14), (20), (21). From this perspective, appropriation can be understood as the ability to use technological tools to transform processes, improve product quality, and strengthen outcomes (22).

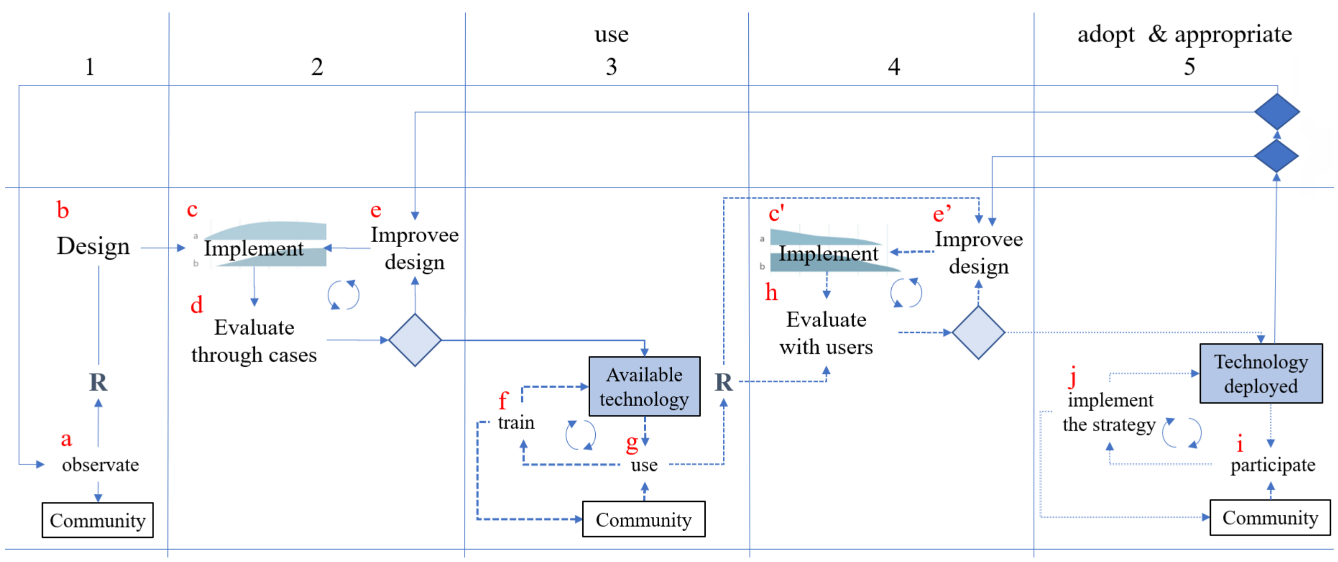


Figure 1. Methodology proposed

Within the context of SARA, these elements constitute the conceptual foundation of the proposed Phase 5, which will focus on designing strategies that foster trust, knowledge, and sustainable technology use within communities. These strategies will include training processes, incentive mechanisms, and alignment with regional policies, consistent with approaches that emphasize the importance of adapting technological design to users' living conditions and the dynamics of their processes (23). This perspective requires the adoption of a systemic view that integrates technical, human, and contextual dimensions into the technology appropriation process.

doi: 10.25100/iyc.v28i2.15488

Reference framework

According to (22), a rural community can be described as a group of people living in territorial areas smaller than a municipality and, according to (24), located in dispersed rural settlements characterized by population densities of fewer than 150 inhabitants per square kilometer. These communities may possess their own cultural identities and expressions, as well as needs. They are generally composed of families engaged primarily in agriculture, livestock, or other activities associated with rural environments. Furthermore, according to (11), their development often requires support from territorial entities.

Cloud architecture refers to the design and structural framework of systems, applications, and services hosted on cloud platforms. It involves the integration of components such as storage, servers, networks, and databases to ensure scalability, flexibility, security, and remote accessibility for both users and organizations (25).

Cloud architecture leverages remote resources provided by vendors such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP), enabling access to computing resources on demand without requiring substantial initial investments in infrastructure (26).

SARA provides rural communities with a cloud-based architecture to support the management of community projects, aligning with the need to improve productive and economic outcomes, as well as the quality of life of rural inhabitants, through Information Technologies (IT), as highlighted by the Colombian Ministry of Information and Communication Technologies (27) and the Strategic Development Plan of Santander (22).

The incorporation of cloud-based architecture to optimize agricultural activities has become increasingly common, and several experiences demonstrate their potential. Some examples include:

1. In Colombia, the National Federation of Cereal and Legume Growers (FENALCE) and the International Center for Tropical Agriculture (CIAT) developed an ICT platform based on data collected through sensors, satellite imagery, and predictive models. This information is analyzed to provide personalized recommendations to farmers through a mobile application. The platform employs machine learning algorithms focused on climate, soil, and crop management variables in maize production to reduce the risk of losses (28).
2. Another Colombian example is Agrocraft (29), a web and mobile software platform that facilitates agricultural commercialization between previously associated producer and consumer organizations. Within this system, consumers register projected demand, while producers provide information about their crops through mobile devices. Based on this data, the software estimates harvest dates and production volumes, increasing certainty regarding available supply and reducing the gap between supply and demand.
3. In Ecuador, (30) presents a web and mobile system that generates geographic information about the natural and cultural heritage of rural communities, increasing its visibility and recognition among citizens.
4. In Brazil, (31) developed AgroAPI, a platform that provides agricultural data and models through different APIs. This tool focuses on variables such as productivity, planting dates, and climatic conditions, facilitating decision-making and contributing to the achievement of the Sustainable Development Goals (SDGs). The authors highlight the potential of digitalization to

doi: 10.25100/iyc.v28i2.15488

promote sustainable agriculture while recognizing the need to advance the digital transformation of the sector through more efficient management of sensor-generated data, despite the challenges that remain.

5. In Nigeria, (32) reports a study conducted in 95 villages involving 1,044 adults who had recently learned to use mobile phones, taking advantage of the growing telecommunications coverage in rural areas. The results demonstrated that mobile device usage improves regional productivity by facilitating access to agricultural credit and markets for the commercialization of agricultural products.

Within this context, cloud architecture emerges as a relevant technological alternative. This design model enables the development, deployment, and management of applications and computing resources with flexibility and scalability through the Internet, rather than relying on local physical servers (8).

Results

This section presents the results of the development of SARA, a management system for rural communities focused on projects that support self-management. It includes the system architecture, its main components, and the functionalities implemented through the web application, REST API, mobile application, and IoT devices, as summarized in (6).

From an implementation perspective, the system was built using web and mobile technologies that enable its operation in heterogeneous environments. The web application was developed in PHP using the Laravel framework (33) and supported by a MySQL database. The REST API and the mobile application were implemented in RAD Studio (34) using Delphi and DataSnap technology, which enables the development of web services and communication between client and server applications (35), (36).

The following subsections describe the system components and their operation, as well as the results obtained from their implementation and use within the evaluated rural context.

Rural Community Management System

The proposed system is based on an understanding of how rural communities operate and how project management processes are conducted in collaboration with municipal governments. Based on this analysis, a process-oriented structure was defined to articulate the interaction between communities and municipal representatives. The structure involves community members, who may assume roles as beneficiaries or managers, and projects, within which activities are carried out using tools, consuming resources, and acting upon infrastructure elements or community assets.

Some of the terms highlighted in italics in the previous paragraph correspond to the elements defined in the system structure illustrated in Figure 2. This structure, previously introduced in (6), constitutes the foundation for the design of architecture and its components. The system structure can be described according to the numbering shown in Figure 2 as follows:

doi: 10.25100/iyc.v28i2.15488

1. Municipalities are composed of communities, which in turn consist of community members. These members may act as community development managers and beneficiaries and must designate a community representative.
2. Beneficiaries require projects that address their needs.
3. Projects involve activities performed using different tools, benefiting specific infrastructure elements while consuming resources.
4. Projects require the support of a municipal representative, who is generally the Secretary of Infra-structure or an equivalent municipal official.
5. Beneficiaries assign activities, tools, and infrastructure elements that require attention.
6. Municipal governments allocate resources to rural communities. The municipal representative is responsible for overseeing the resources executed by the community and must have access to information that enables effective project monitoring and control, ensuring that project outcomes benefit the community.
7. Projects generate benefits for the community.

The system is aligned with the guidelines presented in (4) and (22), which emphasize the importance of providing rural communities with appropriate conditions for the management, execution, and monitoring of community projects related to the construction and maintenance of infrastructure such as drainage systems, bridges, roads, pathways, and public buildings. Insufficient management of these projects may lead to duplicated efforts, increased costs, and a lack of accurate information regarding the needs of Community Action Boards (CABs) (10).

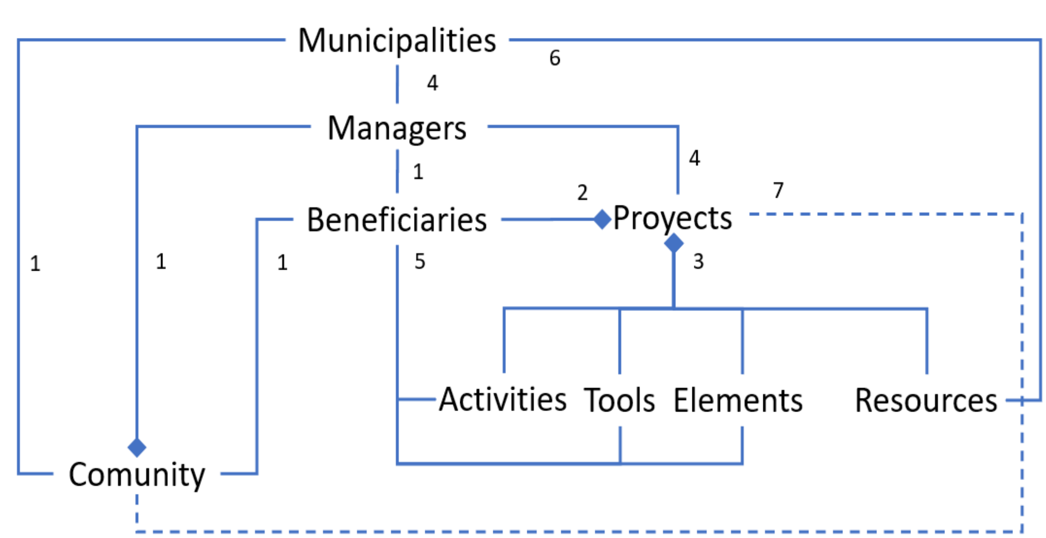


Figure 2. Structure of the Management System

SARA Cloud Architecture

SARA is supported by cloud-based architecture that underpins the proposed management system and is intended to be extended toward future technology adoption processes within rural communities. SARA integrates applications for project management. Initially, the architecture integrates applications for community project management and climate variable monitoring.

doi: 10.25100/iyc.v28i2.15488

The containerization and deployment of the architecture, together with its Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) component, were described in (6). Its configuration follows the practical implications discussed by (37), who address methods, objectives, and outcomes associated with service models according to the specific needs of users and organizations.

The architectural requirements are summarized below and were described in greater detail in (6). They are illustrated in Figure 3:

1. Manage communities, beneficiaries, tools, municipalities, resources, and activity types. These entities are master data and constitute the primary source of information for projects and activities.
2. Manage projects.
3. Manage activities, including the registration and management of digital geographic locations.
4. Generate activity reports with filters based on project, date range, activity type, community, and other criteria.
5. Generate consolidated reports and graphical summaries related to communities, activities, participants, and executed financial resources.

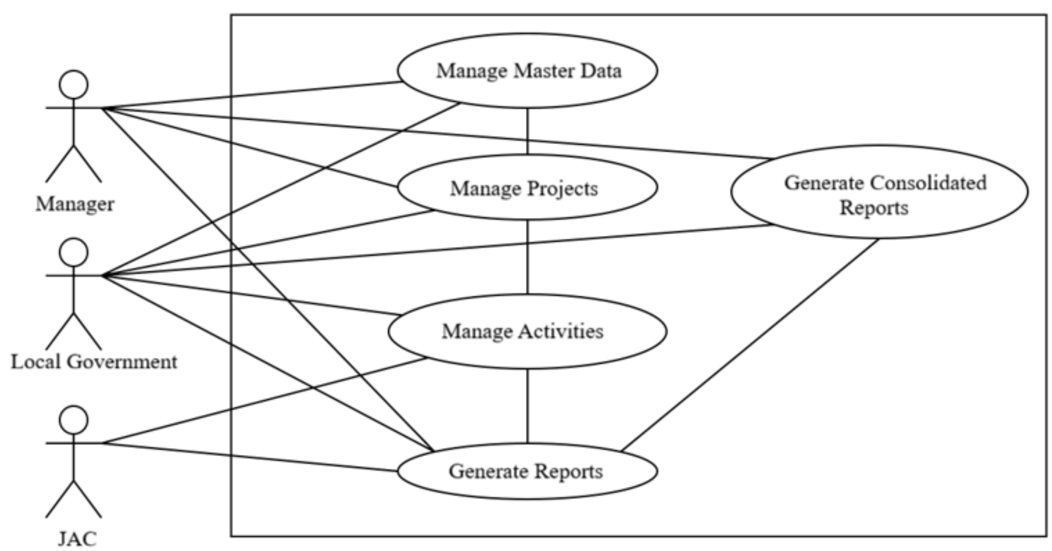


Figure 3. Simplified Use Case Diagram

To support activity registration, any member of the community may temporarily assume the role of the Com-munity Action Board (CAB) representative when necessary. It should also be noted that requirements 3 and 4 can be managed through both the web platform and the mobile application. The project management process carried out by the CAB was presented in (6) using an activity diagram. The most relevant stages of the process are summarized as follows:

1. The community identifies a need and submits a request to the municipal government.
2. The municipal government evaluates the request and, if approved, assigns the project.
3. The CAB president registers the activities, infrastructure elements, participants, and tools required during project execution.

It should be noted that the actions performed by the CAB and other community members can be carried out through the mobile application after project synchronization. Activities registered

doi: 10.25100/iyc.v28i2.15488

on the mobile device must subsequently be synchronized to allow consultation by stakeholders. Multimedia files such as photographs, videos, and audio recordings may also be associated with activities.

The architectural components illustrated in Figure 4 are:

1. Web Platform: Supports the configuration of communities, projects, and report generation. It is described in Section 4.2.1.
2. Mobile Application: Consumes the REST API services, enabling activity registration and transmission to the backend for storage and processing. It incorporates a local database to support asynchronous operation and is described in Section 4.2.2.
3. REST API: Facilitates communication among the backend, front-end, and applications, enabling data exchange and the registration of community project activities. It is described in Section 4.2.3.
4. IoT Devices: Used to collect information related to stream flow, temperature, and rainfall. These devices are described in Section 4.2.4.
5. Digital Geographic Location Module: Enables the identification of infrastructure elements on a digital map using the Google Maps component. Examples include locating rural road pavement sections or water collection structures associated with community aqueduct systems. A technical description is provided in (6).
6. MySQL Database: Stores master records and project activity information. The database is replicated on a secondary server as a security and backup mechanism.

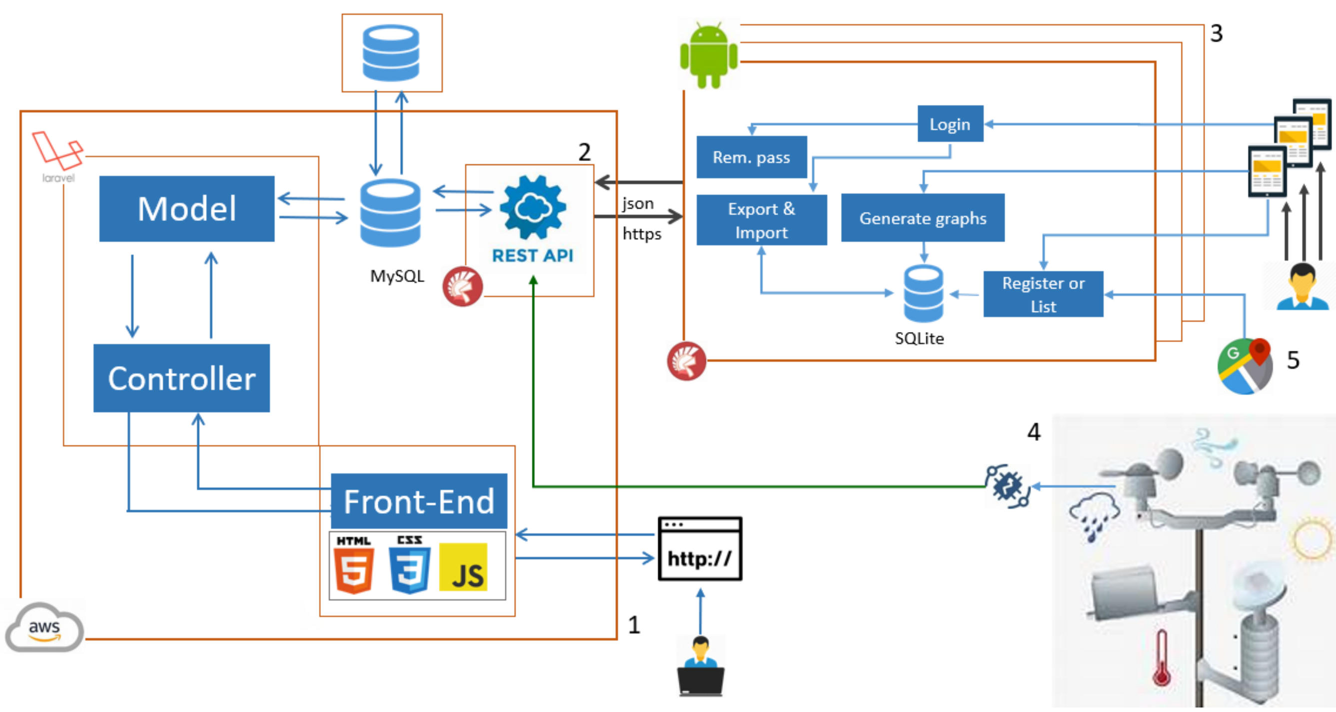


Figure 4. SARA Architecture

Figure 4 also illustrates, following the direction of the arrows, the generation of reports and graphical summaries and the migration process used to transfer records from the application to central system.

doi: 10.25100/iyc.v28i2.15488

Updated mobile records may require the use of a backup communication channel, which is planned to improve system availability during Internet outages. This channel will be supported by Low-Power Wide-Area (LPWA) communication technologies capable of transmitting small amounts of data over long distances with low energy consumption.

The migration process is performed as follows:

1. The mobile application generates a JSON file containing activity records pending migration from the local SQLite database, there are transmitted to the REST API using the HTTP protocol and subsequently marked as migrated. The application also includes a graphical authentication option based on image combinations associated with agricultural activities, functioning similarly to a password mechanism.
2. The REST API exports master data and receives validates, and stores activity records in database.

Web Application

As previously presented in (6), the web application manages master data and reporting functionalities. It consists of two main components: the Front-End, corresponding to the presentation layer with which users inter-act, and the backend, responsible for the business logic, including activity management, assignment of responsible participants, deadline definition, and other administrative functions.

Some of the reports generated by the system include:

1. Project Activity Report, which displays a list of activities together with information such as record number, project, activity type, event dates, number of participants, hours contributed, observations, and associated multimedia content. Each multimedia item is interactive and can be viewed in an enlarged format (see Figure 5). Some of these records are created through the mobile application and subsequently migrated to the cloud platform, allowing both the registration date and migration date to be tracked.
2. Consolidated Expenditure Report, which visually presents the distribution of project costs according to the selected reporting period.
3. Additional Reports, including consolidated records by month, project, or user, and a participation report that displays, in calendar format, the dates on which each user recorded information.

doi: 10.25100/iyc.v28i2.15488

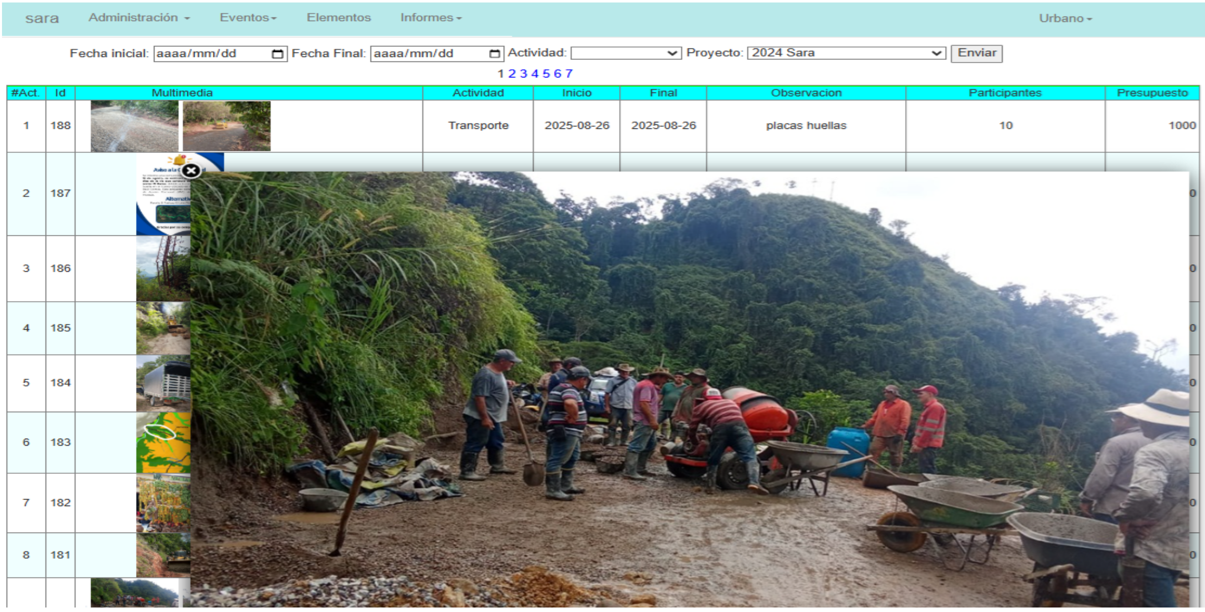


Figure 5. Project Activity Report

Mobile Application

According to (6), the mobile application is "software designed to record information related to project processes and synchronize it for consultation through the web platform". The application supports asynchronous communications, operates on medium- and high-range smartphones, automatically detects network availability, and synchronizes data with the server. These capabilities ensure that data remains updated and accessible while allowing users to record activities in areas with limited connectivity.

The project is expected to evolve through the incorporation of additional applications and functionalities. These future applications will maintain a similar structure and configuration of options to minimize perceived differences between systems. This approach seeks to mitigate resistance to change, which is often significant in rural environments, as highlighted by (38) and (39).

In general, the applications are expected to provide the following functions:

1. Registering and listing activities.
2. Generating consolidated graphical reports.
3. Exporting and importing records, which require user authentication.

An example of the mobile application is presented in Figure 6, corresponding to the mobile component of the architecture illustrated in Figure 4. Each screen represents a specific step within the operational process (also described in (6)):

1. Activity registration, following the generic activity-recording process.
2. Project selection.
3. Activity report, including filtering options, summary indicators (participants, financial resources, and hours contributed), and a detailed list of records.
4. Monthly consolidated report, including totals for records, hours, participants, and financial resources, together with their corresponding graphical visualizations.

doi: 10.25100/iyc.v28i2.15488

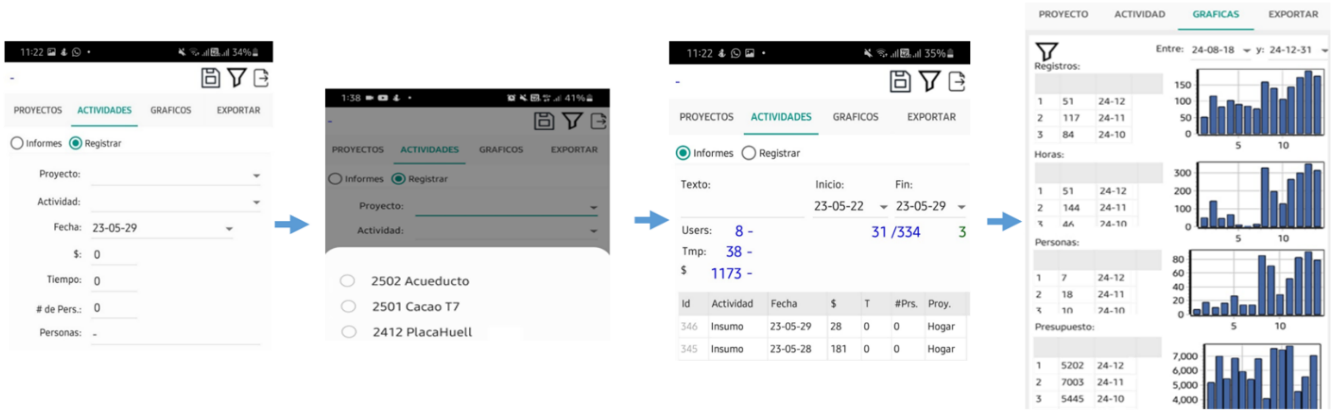


Figure 6. Project Activity Management through Mobile Application

REST API

As previously described in (6), REST API is a service deployed on the server whose purpose is to establish communication between the mobile applications and the database. It acts as an intermediary layer that manages information exchange through JSON formats and exposes the methods required for applications to send and retrieve data.

IoT Devices

The Internet of Things (IoT) refers to technologies that connect physical objects to the Internet to collect, process, and share environmental data, thereby providing benefits to users (40). Within SARA and considering that some municipalities still rely on manual procedures for recording climatic variables, two IoT components have been incorporated into the architecture to automate the collection of temperatures and rainfall data. These devices operate through GPRS, 3G, and 4G communication networks. In future stages, the collected information is expected to support decision-making related to infrastructure projects, such as planning construction activities according to rainfall periods and environmental conditions.

This approach is inspired by (41), who employed low-cost single-board computers to provide cloud services in rural and remote areas, improving service availability while enabling the efficient and cost-effective execution of local digital services.

Evaluation

The tests conducted and the use of SARA by beneficiaries indicate a positive perception of the system, particularly within the municipal Infrastructure Secretariat. To assess this perception, a survey adapted from (39) was administered to evaluate the perceived usefulness of the system functionalities and its ease of use through a five-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5).

The results, presented in Figure 7, show that all participants perceived the reporting and activity traceability functionalities as useful, while 90% considered the system easy to use. These findings suggest that the developed artifact satisfies usability and usefulness criteria within the evaluated context. However, further evaluation involving a larger number of users and additional deployment

doi: 10.25100/iyc.v28i2.15488

scenarios is required to strengthen the validity of these findings.

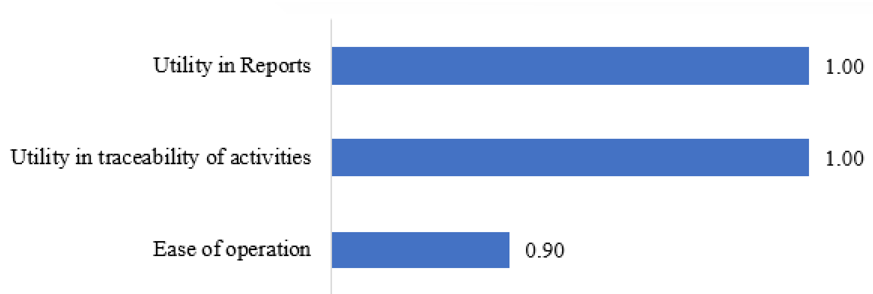


Figure 7. Evaluation of perceived usefulness and ease of use.

Discussion

From a technological perspective, the cloud-based architecture proposed in SARA incorporates characteristics widely recognized in the literature, including scalability, ease of operation, low maintenance and update costs, and security (25), (42), (43), (44) y (45)However, its contribution extends beyond these technical aspects by incorporating a simplified interface design approach intended to reduce operational complexity. This design decision responds to the characteristics of rural environments, where resistance to change and strong cultural traditions may limit technology adoption (38) y (39).

From a functional perspective, SARA provides a structured process and systematization tools that support the management of public resources in community projects and contribute to local governance, addressing needs identified in previous studies (22), (46) y (47). This approach is particularly relevant in territories with limited local planning capacities, such as rural areas of Santander (Colombia), where the system is currently being piloted. In this context, coordination between local communities and government institutions constitutes critical success.

The results also highlight the importance of considering factors such as educational level, economic conditions, and digital literacy, since neglecting these aspects may lead to resistance or system abandonment, as reported in previous studies (47) y (48).

In this regard, a future line of work involves incorporating complementary functionalities, such as access to social programs and health-related services, with the aim of increasing community participation and engagement, in accordance with recommendations found in the literature (32).

SARA differs from existing solutions by focusing on local governance, transparency, and the comprehensive management of rural community projects, covering phases such as planning, funding, execution, and accountability. In contrast, many existing platforms focus primarily on agricultural productivity.

The results obtained during the preliminary evaluation suggest that the system effectively addresses these needs, particularly in terms of perceived usefulness and ease of use. These findings are consistent with studies emphasizing the importance of involving beneficiaries in the design and evaluation of technological solutions for rural environments (49) (50) y (51). In this sense, the methodology adopted in SARA, based on iterative cycles and community participation, contributes to strengthening the relevance and suitability of the artifact.

doi: 10.25100/iyc.v28i2.15488

From a social perspective, SARA promotes sustainability and is aligned with the Sustainable Development Goals (SDGs) (5), particularly Goal 11 related to sustainable communities. It also contributes indirectly to other goals associated with poverty reduction, inequality reduction, and institutional strengthening. SARA was also conceived in accordance with OECD recommendations for rural development in Colombia, which highlight the importance of territorial governance, institutional coordination, and community participation as key drivers of local development (52).

Finally, the adoption process should consider behavioral models that incorporate factors such as trust, social influence, and perceived usefulness, particularly among rural youth populations (13). These elements, together with previous experiences in technology appropriation within similar contexts (39), provide a foundation for guiding future implementation and sustainability strategies for the system (53).

Conclusions

This paper presented SARA, a system designed to support the management of rural community projects, developed through a methodological approach that integrates exploratory research, Design Science Research (DSR), and iterative processes of construction and evaluation.

Unlike solutions primarily focused on agricultural productivity, SARA addresses project governance by incorporating planning, execution, monitoring, and accountability mechanisms that respond to specific needs within rural contexts.

The results obtained during the pilot implementation indicate that the system satisfies usability and usefulness criteria. Furthermore, its process-oriented design and cloud-based architecture support scalability and adaptability across different communities. The incorporation of a participatory development approach also contributes to improving its relevance in environments characterized by technological limitations and resistance to change.

Nevertheless, the study presents limitations related to the scope of the evaluation, which was conducted within a specific context and involved a limited number of users. As future work and considering that the system currently corresponds to a Technology Readiness Level (TRL) 4, further validation in new deployment scenarios is planned, together with the development of technology appropriation strategies, including training pro-grams, incentive mechanisms, and integration with public policies. These actions are expected to strengthen the long-term impact of SARA on the management of rural community projects.

Author Contributions

The author conducted observations within the beneficiary community, developing a deep understanding of the study area and its rural dynamics through participation in various projects. This involvement provided valuable insights into the specific needs, challenges, and limitations faced by rural communities. Given the current stage of technological maturity of the proposed solution, the author seeks to engage relevant stakeholders who may contribute to its adoption, validation, and future deployment.

doi: 10.25100/iyc.v28i2.15488

Acknowledgments

The author gratefully acknowledges the support provided by the VIE of the Universidad Industrial de Santander (UIS) for the development of Project No. 4271.

The author developed all the items comprising the CRediT authorship contribution statement.

Financiación: Universidad Industrial de Santander

Conflict of interest: does not declare. Ethical aspect: does not declare.

References

1. Dirven M, Candia D (Internet). Medición de lo rural para el diseño e implementación de políticas de desarrollo rural. 2020 (cited 2026 Jun 3). Available from: https://repositorio.cepal.org/handle/11362/45317

2. Parra-Peña R, Puyana R (Internet). Análisis de la productividad del sector agropecuario en Colombia y su impacto en temas como: encadenamientos productivos, sostenibilidad e internacionalización, en el marco del programa Colombia más competitiva. 2021 (cited 2026 Jun 3). Available from:

https://repository.fedesarrollo.org.co/handle/11445/4092

3. Ndlela S, Worth S. Creating self-reliance and sustainable livelihoods amongst small-scale sugarcane farmers. J Agric Educ Ext. 2021;27(3):325-339.

https://doi.org/10.1080/1389224X.2020.1851268

4. Rincón-Zapata C, Restrepo-Ruiz A, Izate-Cárdenas M, Zabala-Salazar H, Arboleda-Álvarez O. Desigualdades rurales en Colombia: aportaciones para el logro de los Objetivos de Desarrollo Sostenible. Rev La Sallista Investig. 2021;18(2):178-200.

https://doi.org/10.22507/rli.v18n2a13

5. United Nations (Internet). Sustainable Development Goals. 2023 (cited 2026 Jun 3). Available from:

https://www.un.org/sustainabledevelopment/es/sustainable-development-goals

6. Gómez-Prada U. Arquitectura de nube para la gestión rural comunitaria con aplicaciones web y móvil. Encuentro Internacional de Educación en Ingeniería. 2025.

https://doi.org/10.26507/paper.4844

7. Natarajan N, Newsham A, Rigg J, Suhardiman D. Sustainable livelihoods framework for the 21st century. World Dev. 2022;155:105898.

https://doi.org/10.1016/j.worlddev.2022.105898

8. Condori J. Ventajas y desventajas de cloud computing. Rev Inf Tecnol Soc. 2012;7:86-87. Available from:

http://revistasbolivianas.umsa.bo/pdf/rits/n7/n7a35.pdf

9. Soldani J, Tamburri D, Van Den Heuvel W. The pains and gains of microservices: a systematic grey literature review. J Syst Softw. 2018;146:215-232.

https://doi.org/10.1016/j.jss.2018.09.082

10. Ríos A, Palacio J, Giraldo D, Villegas D, Cubillos S. Desarrollo rural sostenible: una mirada desde la Ingeniería Agroindustrial. Medellín: UPB; 2019. Available from:

http://hdl.handle.net/20.500.11912/4934

11. Hoyos A, Verhelst K. La innovación social como herramienta para la transformación social de comunidades rurales. Rev Virtual Univ Catol Norte. 2019;57:87-99.

https://doi.org/10.35575/rvucn.n57a7

12. Whitacre B, Meadowcroft D, Gallardo R. Firm and regional economic outcomes associated with a new, broad measure of business innovation. Entrepreneurship & Regional Development. 2019;31(9-10):930-952.

https://doi.org/10.1080/08985626.2019.1630486

13. Zaremohzzabieh Z, Abu Samah B, Muhammad M, Omar S, Bolong J, Hassan M, Mohamed Shaffril H. A test of the technology acceptance model for understanding the ICT adoption behavior of rural young entrepreneurs. Int J Bus Manag. 2015;10(2):158-169.

https://doi.org/10.5539/ijbm.v10n2p158

14. Álvarez E, Bernal C. Modelo de innovación abierta: énfasis en el potencial humano. Inf Tecnol. 2017;28(1):65-76.

https://doi.org/10.4067/S0718-07642017000100007

15. Hernández Sampieri R, Mendoza Torres C. Metodología de la investigación: las rutas cuantitativa, cualitativa y mixta. España: McGraw-Hill; 2018.

16. Hevner A, March S, Park J, Ram S. Design science in information systems research. Management Information Systems. 2004;28(1):75-105.

https://doi.org/10.2753/mis0742-1222240302

17. Jacobson I, Booch G, Rumbaugh J. El Proceso Unificado de Desarrollo de Software (RUP). Madrid: Pearson; 2000.

18. Koelmel A, Borsch M, Bulander R, Waidelich L, Brugger T, Kuehn A, Krutwig M. Quantifying the economic and financial viability of NB-IoT and LoRaWAN technologies: a comprehensive life cycle cost analysis using pragmatic computational tools. FinTech. 2023;2(3):510-526.

https://doi.org/10.3390/fintech2030029

19. Walmsley B, Oddy V. Modelling systems to describe maternal productivity, with the aim of improving beef production efficiency by eliciting practice change. Anim Prod Sci. 2018;58(1):193-205.

https://doi.org/10.1071/AN14874

20. Guarín-Manrique L, Martínez-Ardila H. La intermediación en los sistemas de innovación agroindustrial. Cuad Desarro Rural. 2022;19:1-23.

https://doi.org/10.11144/Javeriana.cdr19.isia

21. Sierra J (Internet). Uso TIC agrícola: ajustes en la cosecha. El Colombiano. 2017 (cited 2026 Jun 3). Available from:

https://www.elcolombiano.com/negocios/uso-tic-agricola-aun-tiene-ajustes-en-la-cosecha-FX7752304

22. Daza L, Hernández C, Quijano A, Serna J. Plan estratégico del Departamento de Santander. 2017. Tesis de Maestría en Administración de Empresas. Pontificia Universidad Católica del Perú.

doi: 10.25100/iyc.v28i2.15488

https://tesis.pucp.edu.pe/repositorio/handle/20.500.12404/8864

23. Somers S, Stapleton L. E-agricultural innovation using a human-centred systems lens: proposed conceptual framework. AI Soc. 2014;29(2):193-202.

https://doi.org/10.1007/s00146-013-0475-x

24. Ramírez I, de Aguas J (Internet). Configuración territorial de las provincias en Colombia. Bogotá; 2022 (cited 2026 Jun 3). Available from:

https://hdl.handle.net/11362/48021

25. Podeschi R. The future of digital entrepreneurship in a global economy: the case for cloud services. In: Digital Entrepreneurship and the Global Economy. Routledge; 2022. p 127-137.

https://doi.org/10.4324/9781003194798-11

26. Wittig A, Wittig M. Amazon Web Services in Action: an in-depth guide to AWS. Simon and Schuster; 2023.

https://surl.li/rbpwfk

27. Ministerio TIC de Colombia (Internet). Plan TIC. 2018 (cited 2026 Jun 3). Available from:

https://lc.cx/X_26lc

28. Jiménez D, Delerce S, Dorado H, Cock J, Muñoz LA, Agamez A, Jarvis A. A scalable scheme to implement data-driven agriculture for small-scale farmers. Glob Food Secur. 2019;23:256-266.

https://doi.org/10.1016/j.gfs.2019.08.004

29. Gómez U, Pérez J, Ramírez J. Sistema de Información Agrícola para la disminución de brechas entre oferta y demanda: AGROCRAFT. Inf Tecnol. 2016;27(3):215-220.

https://doi.org/10.4067/S0718-07642016000300020

30. Collado A, Heras V, Rodas P, Delgado A, Carrión C, Mora-Navarro G, Lerma J. Geomatics documentation techniques as monitoring tools for rural built heritage in Nabón (Ecuador). ISPRS Ann Photogramm Remote Sens Spatial Inf Sci. 2021;8:65-72.

https://doi.org/10.5194/isprs-annals-VIII-M-1-2021-65-2021

31. Romani L, Evangelista S, Vacari I, Apolinário D, Vaz G, Speranza E, Barbosa L, Drucker D, Massruhá S. AgroAPI platform: an initiative to support digital solutions for agribusiness ecosystems. Smart Agric Technol. 2023;5:100247.

https://doi.org/10.1016/j.atech.2023.100247

32. Aker J, Ksoll C. Can mobile phones improve agricultural outcomes? Evidence from a randomized experiment in Niger. Food Policy. 2016;60:44-51.

https://doi.org/10.1016/j.foodpol.2015.03.006

33. Cíceri M. Introducción a Laravel: aplicaciones robustas y a gran escala. Routledge. 2019.

https://books.google.com/books?id=sPylDwAAQBAJ

34. Lazurchak I, Vdovychyn T, Zhydyk V. The use of the RAD Studio integrated environment in the future teachers' training. Phys Math Educ. 2020;2(24):80-86

35. Embarcadero Technologies (Internet). REST Debugger. 2022 (cited 2026 Jun 3).

https://docwiki.embarcadero.com/RADStudio/Sydney/en/REST_Debugger

36. Guo A, Zhang Y. Research on software architecture base on Data Snap technology. 2012.

https://link.springer.com/chapter/10.1007/978-3-642-25349-2_61

doi: 10.25100/iyc.v28i2.15488

37. Mohammed A, Zeebaree S. Sufficient comparison among cloud computing services: IaaS, PaaS, and SaaS: a review. Int J Sci Bus. 2021;5(2):17-30.

https://doi.org/10.5281/zenodo.4450129

38. Berman-Arévalo A, Ojeda D. Ordinary geographies: care, violence, and agrarian extractivism in post-conflict Colombia. Antipode. 2020;52(6):1583-1602.

https://doi.org/10.1111/anti.12667

39. Gómez-Prada U, Orellana M, Salinas J. Strategy for the appropriation of a DSS in small bovine producers using simulation and a serious video game. Information. 2020;11(12).

https://doi.org/10.3390/info11120566

40. Xu J, Gu B, Tian G. Review of agricultural IoT technology. Artif Intell Agric. 2022;6:10-22.

https://doi.org/10.1016/j.aiia.2022.01.001

41. Helmer S, Pahl SJ, Miori L, Brocanelli S, Cardano F, Gadler D, Morandini D, Piccoli A, Salam S, Mahabub S, Ventura A, Abrahamsson P, Oyetoyan T. Bringing the cloud to rural and remote areas via cloudlets. In: Proc 7th Annual Symposium on Computing for Development. 2016.

https://doi.org/10.1145/3001913.3001918

42. Joshi P, Islam S. E-Government maturity model for sustainable E-Government services from the perspective of developing countries. Sustainability. 2018;10:1882.

https://doi.org/10.3390/su10061882

43. Vera-Rivera A, Gaona C, Astudillo H. Desarrollo de aplicaciones basadas en microservicios: tendencias y desafíos de investigación. Rev Ib Sist Tecnol Inf. 2019;E23:107-120. Available from:

https://repositorio.ufps.edu.co/handle/ufps/1646

44. Adéchian S, Baco M, Olarinde I, Natcher C. Social ties development as competitive strategies in vegetables marketing: evidence from small-scale farmers in Benin. Eur J Dev Res. 2021.

https://doi.org/10.1057/s41287-021-00415-y

45. Iles I, Ma Z, Nixon R. Multi-dimensional motivations and experiences of small-scale farmers. Soc Nat Resour. 2021;34(3):352-372.

https://doi.org/10.1080/08941920.2020.1823540

46. Acquaah I. Business strategy and competitive advantage in family businesses in Ghana: the role of social networking relationships. J Dev Entrep. 2011;16(1):103-126.

https://doi.org/10.1142/S1084946711001744

47. Slamet A, Nakayasu A, Ichikawa M. Small-scale vegetable farmers' participation in modern retail market channels in Indonesia: the determinants of and effects on their income. Agriculture. 2017;7(2):11.

https://doi.org/10.3390/agriculture7020011

48. Kabbiri R, Dora M, Kumar V, Elepu G, Gellynck X. Mobile phone adoption in agri-food sector: are farmers in Sub-Saharan Africa connected? Technol Forecast Soc Change. 2018;131:253-261.

https://doi.org/10.1016/j.techfore.2017.12.010

49. Lundström C, Lindblom J. Considering farmers' situated knowledge of using agricultural decision support systems to foster farming practices. Agric Syst. 2018; 159:9-20.

https://doi.org/10.1016/j.agsy.2017.10.004

50. González-Bañales DL, Bermeo Andrade HP. Integración de sistemas de información para la innovación en la gestión operativa de unidades productivas agrícolas: un caso de estudio en Colombia. In: INNODOCT 2020. Valencia: Editorial Universitat Politècnica de València; 2020.

https://doi.org/10.4995/INN2020.2020.11798

51. Sheikh J, Dar H, Sheikh F. Usability guidelines for designing knowledge base in rural areas: towards women empowerment. 2014.

https://link.springer.com/chapter/10.1007/978-3-319-07635-5_45

52. OECD. Rural Policy Review of Colombia 2022. OECD Rural Studies. Paris: OECD Publishing; 2022.

https://doi.org/10.1787/c26abeb4-en

53. Gómez-Prada U. Propuesta de formación guiada con dinámica de sistemas para promover el desarrollo de software orientado por modelos en sistemas productivos rurales que requieren asociatividad. Formación Universitaria. 2022;15(1):153-162.

https://doi.org/10.4067/S0718-50062022000100153