

Selection of mobile payment systems for the bottom of the pyramid: methodology and application to the payment of energy provision in Ngäbe-Buglé

Carlos Cuenca-Enrique, Laura Del-Río-Carazo, Ignacio Elvira-Cruz & Ramón Fisac-García

To cite this article: Carlos Cuenca-Enrique, Laura Del-Río-Carazo, Ignacio Elvira-Cruz & Ramón Fisac-García (2025) Selection of mobile payment systems for the bottom of the pyramid: methodology and application to the payment of energy provision in Ngäbe-Buglé, Cogent Business & Management, 12:1, 2466814, DOI: [10.1080/23311975.2025.2466814](https://doi.org/10.1080/23311975.2025.2466814)

To link to this article: <https://doi.org/10.1080/23311975.2025.2466814>



© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 20 Feb 2025.



Submit your article to this journal [↗](#)



Article views: 862



View related articles [↗](#)







View Crossmark data [↗](#)



Citing articles: 2 View citing articles [↗](#)

Selection of mobile payment systems for the bottom of the pyramid: methodology and application to the payment of energy provision in Ngäbe-Buglé

Carlos Cuenca-Enrique^a , Laura Del-Río-Carazo^a , Ignacio Elvira-Cruz^a  and Ramón Fisac-García^b 

^aDepartamento de Ingeniería de Organización, Administración de Empresas y Estadística, Universidad Politécnica de Madrid, Madrid, Spain; ^bDepartment of Sustainability, ESCP Business School Madrid, Madrid, Spain

ABSTRACT

Financial inclusion remains a significant challenge, particularly in developing countries and among low-income populations. Mobile payments present a potential solution by offering affordable and secure financial services. This study investigates the selection of mobile payment technologies for the bottom-of-the-pyramid population and introduces a methodology tailored to their specific needs. The proposed approach includes a detailed analysis of user characteristics, geographic constraints, and a hierarchy of selection criteria. These criteria consist of three main decision elements—user base, technical features, and economic costs—along with five technical sub-elements: ease of integration, scalability, real-time operation capabilities, security, and provider trustworthiness. The methodology's practical application is demonstrated through a case study in Panama's Ngäbe-Buglé region, where mobile payments are being considered for energy provision services. The case study employs the analytic hierarchy process to prioritize criteria using responses from four different stakeholder groups. The findings highlight that while economic factors are critical, the size of the user base and technical aspects, such as solution scalability, also influence decision-making.

ARTICLE HISTORY

Received 1 October 2024
Revised 5 December 2024
Accepted 8 February 2025

KEYWORDS

Mobile payments; bottom of the pyramid; technology selection; analytic hierarchy process; case study

SUBJECTS

Management of Technology & Innovation; Information Technology; Development Studies; Mobile Systems; Decision Analysis

1. Introduction

1.1. Financial inclusion and the bottom of the pyramid (BOP)

In 2021, an estimated 24 percent of adults—most residing in developing countries—lacked access to the banking system (The World Bank, 2021). Despite its key role in economic growth, financial inclusion—which is defined as access to useful and affordable financial services (World Bank Group, 2022)—continues to face significant challenges. These include inefficient processes, fraud, and limited financial literacy (Yasir et al., 2022), all of which contribute to the exclusion of this segment of the global economy.

The digitization of banking processes can enhance the security of financial transactions and reduce costs, making it a viable solution to foster financial inclusion (Zhang et al., 2023). For instance, the Borsá Familia program in Brazil (Rasella et al., 2013) demonstrated the transformative potential of digital banking. This cash transfer initiative for low-income households increased financial inclusion from 20 to 68 percent over fourteen years in the early 21st century (Lund et al., 2017).

In recent years, mobile payments—which involve transactions conducted via mobile devices (Antovski & Gusev, 2003)—have furthered this transformation by providing affordable and convenient methods to improve financial inclusion. This is particularly evident in developing countries, where mobile payments reduce costs compared to traditional payment methods (Mallat & Tuunainen, 2008), leverage increased connectivity (Klapper, 2022), and benefit from the widespread adoption of mobile devices. For instance,

CONTACT Carlos Cuenca-Enrique  carlos.cuenca@upm.es  Departamento de Ingeniería de Organización, Administración de Empresas y Estadística, Universidad Politécnica de Madrid, Av. Complutense 30, 28040 Madrid (Spain)

© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

seven out of ten households in the bottom 20% income bracket own at least one mobile phone. Additionally, mobile money accounts in Africa have grown by approximately 20% annually in recent years (GSMA, 2024).

This growth has coincided with increased complexity and fragmentation within the mobile payment ecosystem (Rolfe, 2018). The ecosystem involves numerous intermediaries between merchants and end users, such as third-party payment providers, mobile network operators, financial institutions, and over-the-top providers (Guo & Bouwman, 2016). For instance, in the two largest Latin American markets—Brazil and Mexico—four mobile payment (m-payment) applications are widely used, yet over 30% of the market share is held by smaller payment applications (Boku, 2021). Navigating this fragmented landscape requires companies to adopt a clear digital strategy to meet their customer needs and expectations (Haj, 2018).

To address the exclusion of the bottom of the pyramid (BOP)—also referred to as the ‘base of the pyramid’, encompassing populations earning less than \$2 per day (Hammond & Prahalad, 2002)—the digitization of mobile banking services is critical. However, no established guidelines currently exist for selecting appropriate m-payment technologies or applications for the BOP. This study aims to fill this gap by developing a methodology for selecting m-payment solutions tailored to the BOP. The methodology includes an analysis of current m-payment technologies and identifies key decision-making elements. Additionally, the study demonstrates the application of the methodology through a case study involving the implementation of m-payment services for energy provision in Panamá Ngäbe-Buglé region.

1.2. Mobile payments and the bottom of the pyramid

Mobile payments encompass a variety of technologies, each with distinct functionalities, as well as unique advantages and disadvantages. The following provides an overview of existing m-payment technologies.

SMS was one of the first technologies used for mobile payments, laying the groundwork for future innovations in wireless payment solutions (Aziz, 2006). SMS messages are noted for their high click-through rates—over 19%, compared to 1% for other popular technologies such as Facebook in the social media domain (Pereira, 2023). However, global adoption of SMS for payments, including in developing countries, has declined significantly due to associated costs and security concerns (de Luna et al., 2019).

QR (quick-response) codes have emerged as a fast and convenient method for mobile payments, making them highly relevant in the mobile payments ecosystem. For instance, up to 84% of mobile users have scanned at least one QR code (Chambers, 2020). While QR codes are particularly popular in China, their use is also expanding in developing countries across Asia and Latin America, driven by public and private initiatives (Purnell, 2023). This makes them well-suited for proximity-based business models.

Near-field communication (NFC) technologies, supported by RFID standard infrastructure, have grown tenfold over the last decade and are now the de facto standard for short-distance mobile payments (Grand View Research, 2023). However, their adoption in developing countries remains limited due to their reliance on proximity between devices and NFC-enabled tools, as well as the availability of NFC-enabled devices.

Finally, app-based payments—typically developed and managed by banks and financial institutions—enable real-time transactions (Hyman, 2023) and overcome the range limitations of QR codes and NFC technologies.

As noted earlier, the BOP refers to populations earning less than \$2 a day and it is estimated to encompass over 4 billion consumers (Prahalad, 2004). The term has gained prominence as an indicator of human inequality and also as a business opportunity for the private sector—e.g., Ver Loren van Themaat et al. (2013).

A prevailing view suggests that innovations provide effective means to deliver products and services to the BOP (Jagtap & Kandachar, 2009). With the increased adoption of mobile devices and the rise of m-payments among BOP users, these technologies have become key enablers for delivering BOP-oriented products and services (Hasan et al., 2019).

The field is currently dominated by ‘super-apps’; a technology that integrates multiple functionalities under one umbrella applications (Salehi et al., 2024). Examples include Alipay and WeChat Pay in China, with over one billion users (de Best, 2023). Their success is attributed to factors such as service quality,

perceived ease of use, perceived risk, perceived security, social influence, and compatibility (Tang et al., 2021). Other notable m-payment platforms include PicPay, with 62 million users in Brazil (Menezes, 2022) and MoMo, with 69 active users in Africa (Statista Research Department, 2023). Consequently, this study focuses on identifying key elements for selecting the most suitable app-based m-payment technology.

2. M-payment technology selection for the BOP: a methodology

2.1. Elements for m-payment technology selection

To identify the key elements for selecting a mobile payment technology, this study builds on the scoping review by Del-Río-Carazo et al. (2024). Using Arksey and O'Malley's (2005) framework, the authors analyzed 99 documents on factors influencing m-payment technology selection, narrowing these to 14 documents categorized under the STOF (Service, Technology, Organization, and Finance) model (Bouwman et al., 2008). These elements address a range of considerations, including the type of technology employed (e.g., SMS, RFID, NFC, m-payment apps), integration complexity, payment infrastructure accessibility, scalability, security, payment timing options (e.g., real-time, pre-paid, post-paid), and usability. Other factors include the target market (e.g., user characteristics and geographic reach), transaction fees and constraints, provider trustworthiness, independence from financial institutions, interoperability, and the size of the user base.

2.2. Proposed methodology

Building on this foundation, this study adapts Del-Río-Carazo et al.'s (2024) framework to propose a methodology accounts for both general and specific contexts. While the STOF model provides a robust classification, the methodology contextualizes the 14 factors to prioritize criteria most relevant to the BOP demographic, such as ease of integration and affordability. For instance, m-payment apps are recommended for the BOP whenever possible, given their scalability and functionality. Alternatives, such as SMS-based solutions, are considered only when technical infrastructure is severely constrained—for example, in remote areas with limited mobile phone signals (e.g., 2G networks like GSM) or where smartphones and advanced mobile devices are unavailable.

The first step of the methodology involves conducting a detailed analysis of the end-users' characteristics and the geographic area. This step has two primary outcomes: first, a comprehensive list of all available m-payment solutions in the region; and second, a detailed profile of the target market. For BOP users, certain factors are particularly critical, such as the availability and type of mobile devices, connectivity plans or hotspots, income levels, and financial inclusion status. For example, if most end users already have a bank account, their specific bank could dictate the technology selection. Thus, the process begins with a thorough *characterization of potential users* within the BOP demographic, including their financial situation, technological familiarity, and access to mobile network connectivity. This information is essential for tailoring the m-payment solution to meet the unique needs and constraints of BOP users.

After characterizing users, the next step is to *prioritize* predefined criteria. This involves evaluating the relevance of key factors to help decision-makers assess the suitability and effectiveness of different technologies for the BOP population. Important considerations include the current *user base*, as well as *technical aspects* such as ease of integration, scalability, security, provider trustworthiness, and real-time operation capabilities. Given the BOP focus, transaction fees are particularly important to ensure both profitability and affordability. Therefore, the *cost of the service*, including commissions and minimum fees, must align with the financial constraints of the BOP demographic. Finally, using insights from the user characterization, and recognizing that app-based payments may face limited coverage limitations due to existing agreements, *all feasible mobile payment technologies* available in the area should be identified.

The final step involves evaluating the *usability* of the top candidates. This includes assessing ease of use and perceived usefulness to ensure accessibility for individuals with limited technological literacy. Prioritizing intuitive and user-friendly solutions is essential to facilitate adoption among users with varying levels of familiarity with mobile technology. Therefore, since user adoption is a prerequisite for

effective implementation, the process concludes with an evaluation of key factors influencing user acceptance, such as perceived usefulness and ease of use (Davis, 1989; Makholwa et al., 2020).

3. Implementation of the methodology: m-payment of energy provision services in Ngäbe-Buglé

3.1. Context of the study

This case study illustrates the application of the proposed methodology through the implementation of an m-payment solution for energy provision in Panama's Ngäbe-Buglé region. Since 2013, the Acciona.org foundation has worked to provide modern energy access for low-income populations in rural Panamanian communities through its 'Luz en Casa Ngäbe-Buglé' project. Energy is supplied by third-generation solar home systems that operate on a pay-as-you-go model, allowing user to access the service for a small, affordable fee. Most system owners have very low incomes and literacy levels and must travel long distances to pay their monthly fees. As many of their children have relocated to urban areas, where they earn higher incomes, and possess better digital skills, these children increasingly seek a remote payment solution to pay the fees on behalf of their parents.

The Ngäbe-Buglé comarca—provincial-level Indigenous regions in Panama—was established in 1997 and enjoys relative autonomy. It is governed by Indigenous communities with a collective political and social structure. Located in western Panama, this mountainous region is challenging to access due to its numerous rivers and valleys and features a tropical rainy climate. Through the 'Luz en Casa Ngäbe-Buglé' program, over 3,600 households and 20,600 beneficiaries have gained access to renewable energy via isolated photovoltaic systems, preventing the emission of more than 1,500 tons of CO₂ (Acciona.org, 2024).

3.2. User characterization

The analysis begins with a financial and social characterization of the users. Financial inclusion in Panama is relatively low, with only 45% of adults having a bank account—below the Latin American average (Garcimartín et al., 2022). Additionally, the 2021 Global Findex Database (Demirgüç-Kunt et al., 2021) highlights a significant disparity in account ownership between the richest 60% and the poorest 40% of the population (53.3% versus 32.4%).

The primary use of banks or financial institution accounts in Panama is wage receipt (45.8%), with only 14% of users keeping savings in these accounts and 13% using them for any kind of payments (Garcimartín et al., 2022). The disparity is even greater in rural areas, where account ownership drops by 14% compared to urban regions. Financial inclusion indicators are particularly low in the four Panamanian comarcas. For example, of the more than \$5 billion dollars loaned to small or micro enterprises in Panama, less than \$300,000 were allocated to these areas (SBP, 2021).

The Ngäbe-Buglé comarca is the most impoverished comarca in Panama, with 93.4% of the population experiencing multidimensional poverty, which severely deprives education, health, and living standards (Cecchini et al., 2020). Over 63% of the population lives below the poverty line, with average salaries in the districts of Müna and Nole Duima—where the m-payment solution is planned—ranging between \$63.70 and \$66.60. Around 70% of the population over the age of 10 is literate, with an average of four years of schooling. In 2014, access to water and electricity reached just 0.3%, improving to 13.5% by 2017 due to the efforts by Acciona.org, state initiatives, and other NGOs. Regarding mobile access, only about 27% of the population had used a cell phone and 11% of the population had used Internet as of 2023 (INEC, 2023). Connection often requires accessing limited WiFi points, climbing to high ground for a signal, or traveling to central areas. Prepaid SIM cards are the most common way to access the network, offering unlimited data for specific periods—e.g., \$3 for four days or \$5 for seven days (Peñuelas Peñarroya, 2022).

3.3. Prioritization: analytic hierarchy process (AHP)

The prioritization step for selecting an m-payment technology for the BOP must ensure that the chosen alternative effectively addresses this population's unique challenges. Multi-criteria decision analysis

(MCDA) offers a structured and systematic approach to assessing and prioritizing available technologies based on the critical elements identified in this study. MCDA encompasses various techniques and tools that allow multiple objectives and decision criteria to be formally incorporated into the problem analysis (Dean, 2022). By applying MCDA, decision-makers can evaluate each alternative against predefined criteria, ensuring that the selected technology aligns well with the needs, constraints, and preferences of the target users.

Although many MCDA techniques exist—e.g., Guitouni & Martel (1998)—, there is no universally accepted method for comparing them to identify the most suitable one for a specific problem (Bandyopadhyay, 2021). Among these, the analytic hierarchy process (AHP) (Saaty, 1980; Saaty & Vargas, 2012) stands out for its robust framework in handling complex decision-making scenarios involving multiple criteria and sub-criteria. This is particularly relevant to our methodology, which incorporates three main dimensions—financial, user base, and technical—along with a set of technical subdimensions, including ease of integration, scalability, security, trustworthiness of the provider, and real-time operation capabilities. AHP provides a systematic approach by breaking the decision problem into a hierarchy of manageable sub-problems, enabling decision-makers to focus on specific elements at different levels. The method's capacity to integrate both quantitative and qualitative data (Ramík, 2020) makes it highly applicable for evaluating m-payment technologies tailored to the BOP demographic.

The procedure (Figure 1) follows a series of well-defined steps (Saaty & Vargas, 2012), starting with the decomposition of the decision problem into a hierarchical structure. At the top of this hierarchy is the overall goal—in this case, selecting the most suitable m-payment technology for the BOP demographic. The next level comprises the main criteria. As noted earlier, the selection of criteria and sub-criteria was informed by a combination of literature review and expert consultation. The framework proposed by Del-Río-Carazo et al. (2024) provided a theoretical foundation for categorizing relevant factors, such as service costs, technical features, and user base. These were further refined to ensure contextual relevance to the BOP demographic by integrating insights from stakeholders with expertise in mobile payment systems and financial inclusion. Each dimension reflects critical factors influencing the adoption and success of m-payment technologies.

Once the hierarchy is established, pairwise comparisons are performed at each level, enabling decision-makers, who can belong to different stakeholder groups (Simons & Wiegel, 2009), to assess the relative importance of each element. This process involves assigning numerical values to express the strength of preference between pairs of elements. In this study, equal weights were assigned to all decision-makers to ensure balanced representation and consider all stakeholder perspectives equally.

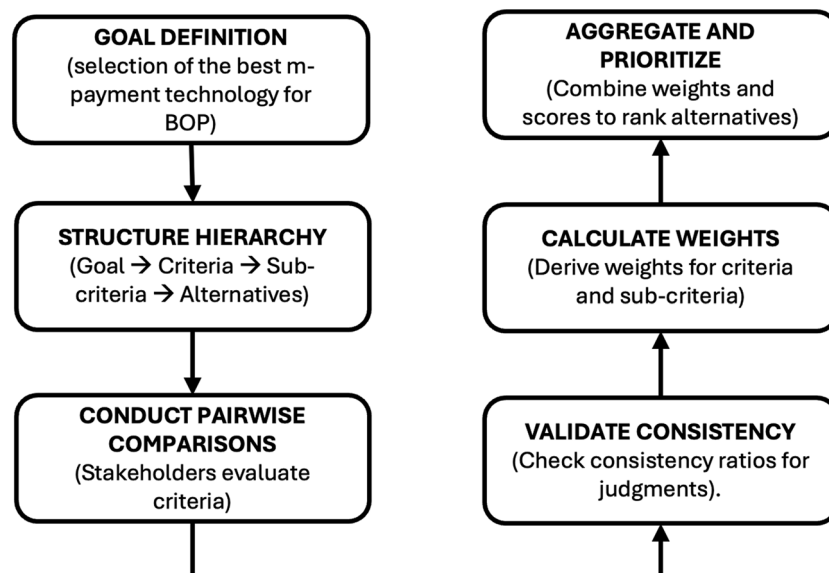


Figure 1. Procedure of AHP implemented in this study.

After completing the pairwise comparisons, the next step is calculating the weight of each criterion and sub-criterion. This is done by constructing comparison matrices and applying eigenvalue calculations to derive priority vectors. These vectors represent the relative weights of the criteria and sub-criteria, indicating their importance in achieving the overall goal. Consistency ratios are then calculated to verify the reliability of the judgments made during pairwise comparisons. If the consistency ratio exceeds the acceptable threshold (typically 0.1), the comparisons must be revisited and adjusted (Saaty & Vargas, 2012). A key feature of AHP is its use of value functions (Belton & Stewart, 2002) to translate qualitative assessments into quantitative scores. These functions assign numerical values to different performance levels for each criterion, enabling more nuanced and precise evaluations.

The final step in the AHP process is synthesizing the results to determine the overall priority of each m-payment technology alternative. This step involves aggregating the weighted scores of each alternative across all criteria and sub-criteria to generate a composite score. In this study, the alternative with the highest composite is identified as the best candidate for implementing m-payment technology for the BOP demographic.

However, according to our proposed methodology, the selection process does not end here. Ensuring adoption by the BOP population requires the best candidates to undergo usability testing with BOP users before selecting the most suitable m-payment technology. This final testing phase falls outside the scope of the present study.

To clarify the application of AHP in this study, Figure 2 illustrates the specific hierarchical model developed. The hierarchy is structured as follows: at the top is the overall goal of selecting the most suitable m-payment technology for the BOP demographic. Below this are the criteria and sub-criteria, which include economic factors (e.g., costs associated with implementation and usage), the user base (current adoption levels among the population), and technical factors (further divided into sub-criteria such as ease of integration, scalability, security, trustworthiness, and real-time operation capabilities). Finally, the main m-payment technology alternatives evaluated in this study are Yappy, Nequi, Zinli, and PayPal. These alternatives are analyzed in detail in the next section.

3.4. Technology identification

In Panama, the three primary m-payment technologies are Zinli, Nequi, and Yappy (La Prensa, 2024). These technologies were selected for their relevance and usability in the Ngäbe-Buglé region, considering the specific financial and social characteristics of the local population.

- Zinli is a virtual wallet offering both virtual and physical cards and operates in US dollars. It supports instant mobile payments to contacts and can be recharged with cash through Punto Pago kiosks,

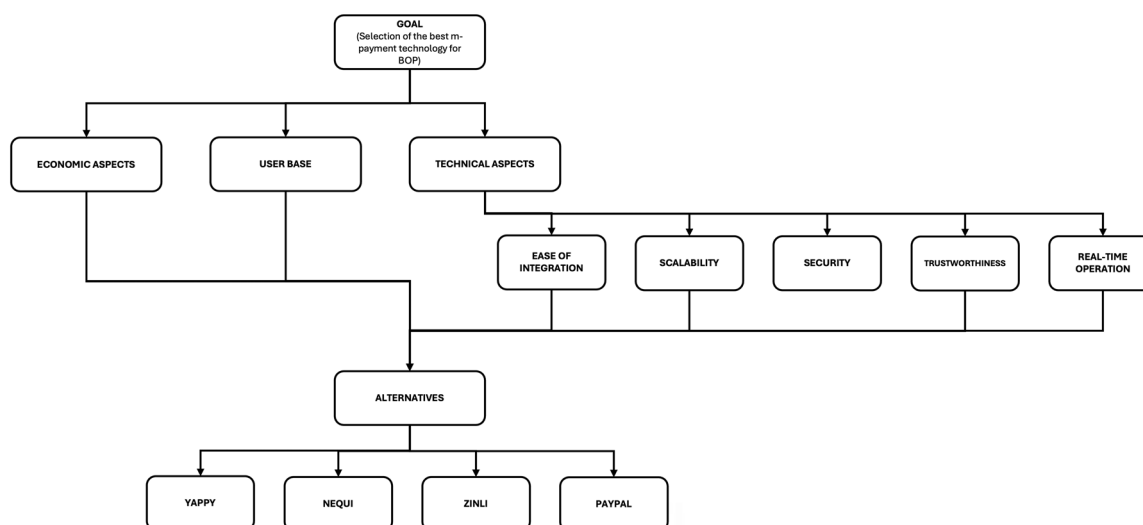


Figure 2. Specific hierarchical model developed.

- making it particularly useful in areas with low bank account usage. Linked to Banco Mercantil Panamá, Zinli has a strong presence in Venezuela, although its user base in Panama remains smaller.
- Nequi, a digital bank founded in Colombia, expanded to Panama in 2017. It provides virtual cards, supports physical recharges via Punto Pago, and facilitates instant payments to Nequi or bank accounts. Backed by Bancolombia, a major Colombian bank, Nequi benefits from strong financial support. It currently serves more than 190,000 users in Panama (Nequi, 2024).
 - Yappy, developed by Banco General, Panama's largest private bank, is designed for peer-to-peer payments and small to medium-sized businesses. It enables instant digital payments using phone numbers and provides integration tools for web use. Yappy is currently the leading national m-payment provider, with 1.3 million users (Yappy, 2024).

Alongside local mobile payment technologies, global providers like PayPal also operate in Panama, offering unique features and advantages. PayPal facilitates online purchases, money transfers, and payment processing for e-commerce businesses. It is widely recognized for its security features, buyer protection policies, and seamless integration with various online platforms. While PayPal's strong international presence and reputation make it a trusted option for users, its transaction fees are higher than those of local alternatives.

3.5. Decision-makers: a description of the stakeholder groups

As noted earlier, stakeholder identification is a critical component of AHP and can even be viewed as an MCDA problem in itself. Involving the right stakeholders ensures that diverse perspectives and expertise are incorporated into the decision-making process, enhancing the validity and acceptance of the final decision (Peykani et al., 2022). Relevant stakeholders in this context include individuals and groups directly or indirectly affected by the m-payment technology's implementation, as well as those with valuable insights and expertise. Examples include BOP users, local community leaders, financial service providers, technology developers, NGOs working with BOP populations, and government representatives (Comisión Nacional de los Mercados y la Competencia (CNMC), 2017).

For this study, certain simplifications and assumptions were made to reduce the number of stakeholder groups. For example, BOP users were excluded from the analysis as they are already considered in the first step (user characterization) and serve as the ultimate validators of the selected technology during usability testing. Similarly, financial service providers were excluded because the methodology focuses on implementing and adapting existing solutions rather than developing new m-payment applications in collaboration with them.

Based on these considerations, this study included four specific stakeholder groups involved in the energy provision projects: strategic, operational (field workers), technical, and consulting levels. These groups provide distinct yet complementary perspectives that collectively address strategic vision, field-level expertise, technical feasibility, and external insights essential for informed decision-making. Strategic stakeholders focus on long-term goals and project sustainability, ensuring the chosen technology aligns with broader organizational objectives and can scale to meet future demands. Operational stakeholders, who engage with the technology and users daily, provide practical insights into factors that facilitate adoption and sustained use within BOP communities. Technical stakeholders contribute a deep understanding of the technology's requirements; ensuring the selected solution is robust, secure, and compatible with existing systems. Consulting stakeholders offer an external perspective that integrates insights from all groups, delivering balanced recommendations that consider strategic, operational, and technical constraints.

3.6. Quantitative analysis

For the quantitative analysis, decision-makers from the stakeholder groups—two strategic, three operational, two technical, and two consulting participants—were asked to perform pairwise comparisons at two levels: the first level covered economic factors, user base, and technical factors; the second level included the five technical subdimensions. Before data collection, each decision-maker was briefed on the study's objectives and data collection procedures, ensuring they understood both. The briefing

outlined the nature of the questions, the approximate time required to complete the survey, and the confidentiality measures in place to protect their responses. Participants were also encouraged to ask questions. After providing informed consent in verbal form, the decision-makers received the questionnaire via email as a digital document. Completed questionnaires, which contained no personal information, were returned via email and aggregated into a unified, anonymized data file.

The comparison scale ranged between -9 and 9, in one-point increments (1=equal preference for both options; -3 or 3=moderate preference; -5 or 5=strong preference; -7 or 7=very strong preference; -9 or 9=extremely strong preference). As the data collection did not involve obtaining, storing, or processing personal data, it was exempt from further review and approval by the Universidad Politécnica de Madrid Ethics Committee Institutional Review Board.

The unified data set was analyzed using the *ahpsurvey* package in R (Cho, 2018). Four individual analyses were conducted for each stakeholder group, along with an aggregated analysis to identify differences among decision-makers and compute the final weights.

First, arithmetic aggregation and dominant eigenvalue methods were compared to detect inconsistencies and heterogeneous responses. In all cases and at both levels, differences were below 0.05, indicating consistent and homogeneous responses. Next, aggregated preference weights were calculated using the arithmetic mean method and the consistency ratio (CR). Since all CR values were below the 0.1 threshold, the judgements were deemed consistent across all cases. The calculated weight distributions for top-level and second-level technical criteria are shown in Tables 1 and 2, respectively.

As shown in Table 1, economic and technology-related aspects have nearly identical importance across all stakeholder groups, each receiving nearly double the priority of the user base. Individual preferences can be visualized graphically to gain deeper insights into prioritization by stakeholder group. For instance, Figure 3 illustrates the weight distributions for top level criteria across the four stakeholder groups, using the dominant eigenvalue method (Saaty, 2003). Figure 4 provides a summary of the aggregated weight distributions. Similarly, Figures 5 and 6 present the corresponding information for second-level technical criteria.

Figures 3 and 4 reveal distinct priorities among stakeholder groups. Consultants show a clear preference for economic factors, assigning moderate priority to the user base and minimal importance to technical aspects. As expected, technical staff prioritize technology-related factors, reflecting their primary focus on implementation. They show little concern for current market penetration, likely due to their long-term perspective on the technology's potential rather than its current adoption levels. Operational staff place significant emphasis on economic factors, prioritizing cost-effectiveness. Lastly, strategic staff also focus on technology-related aspects, consistent with their need to align the chosen solution with long-term organizational goals and scalability. When observing the aggregated results, consultants and operational staff prioritize economic aspects, while technical and strategic staff place the greatest emphasis on technology-related factors. The existing customer base receives some consideration, but generally remains secondary to cost or technical feasibility. Technical and strategic stakeholders focus on ensuring that the selected technology can scale effectively and align with long-term goals. In contrast, consultants and operational staff emphasize economic feasibility, viewing the customer base primarily as an indicator of potential financial sustainability rather than a decisive factor.

Figures 5 and 6 display the weights assigned by the four stakeholder groups to the technical criteria. Each group's unique roles and responsibilities shape their weight distributions. Consultants prioritize scalability and

Table 1. Mean and standard deviations of the aggregated weights for top-level criteria (arithmetic mean method).

Level 1	User base	Technology	Economic
Mean	0.214	0.391	0.395
Std. Dev.	0.111	0.262	0.201

Table 2. Mean and standard deviations of the aggregated weights for technical (second-level) criteria (arithmetic mean method).

Level 2	Integration	Scalability	Security	Trustworthiness	RealTime
Mean	0.171	0.316	0.243	0.137	0.133
Std. Dev.	0.149	0.143	0.141	0.080	0.146

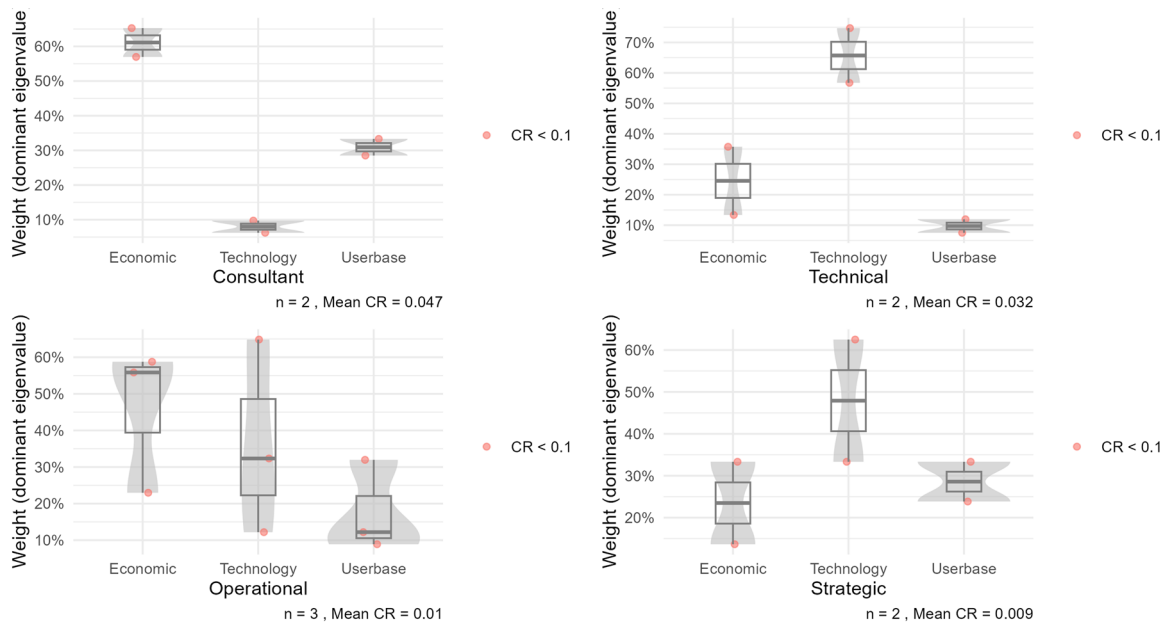


Figure 3. Distributions of individual priorities across the four stakeholder groups (top-level criteria, dominant eigenvalue method).

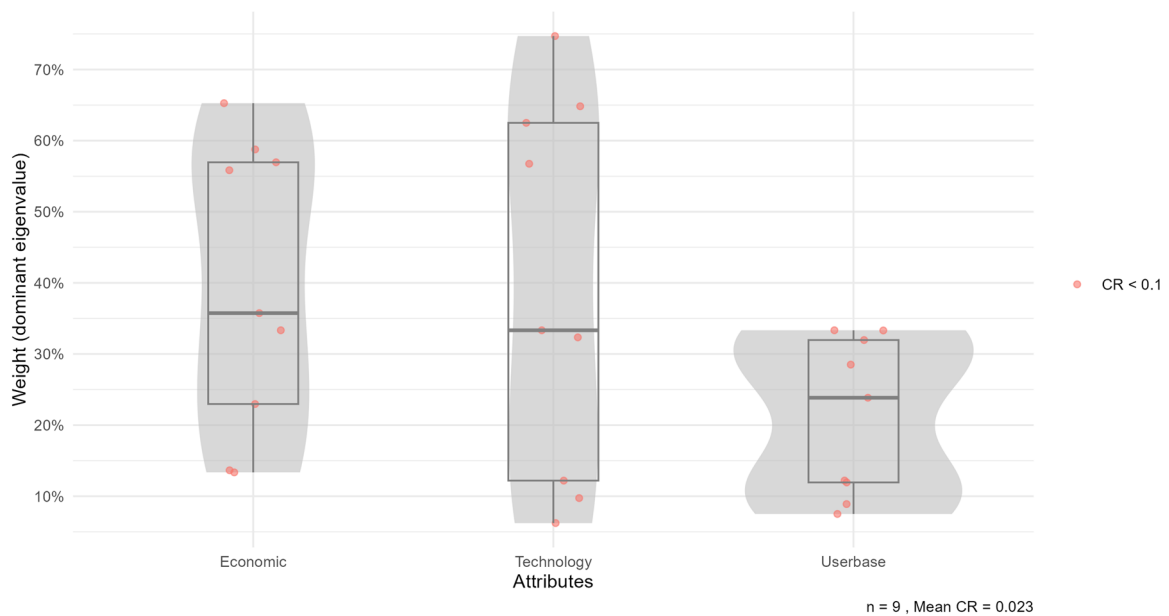


Figure 4. Global distributions of individual priorities (top-level criteria; dominant eigenvalue method).

real-time capabilities but assign relatively low weights to provider trustworthiness and security. These rankings suggest that consultants view these factors as less critical for successfully implementing the m-payment technology. Technical staff rank security as their highest priority, reflecting a focus on selecting robust and reliable solutions. Their lower emphasis on integration suggests confidence in managing technical deployment effectively. Operational staff strongly prioritize scalability and security, highlighting the need for rapid adoption and user financial safety. Finally, strategic staff focus on scalability and integration, emphasizing long-term goals, project sustainability and seamless incorporation of new stakeholders.

When aggregated, scalability stands out as the highest-priority technical criterion across all groups. This consensus reflects a shared recognition of the need for technology that can handle increasing demand and support long-term growth. Security ranks as a moderately important factor—except for consultants, who assign it lower priority. This ranking highlights security’s critical role in safeguarding

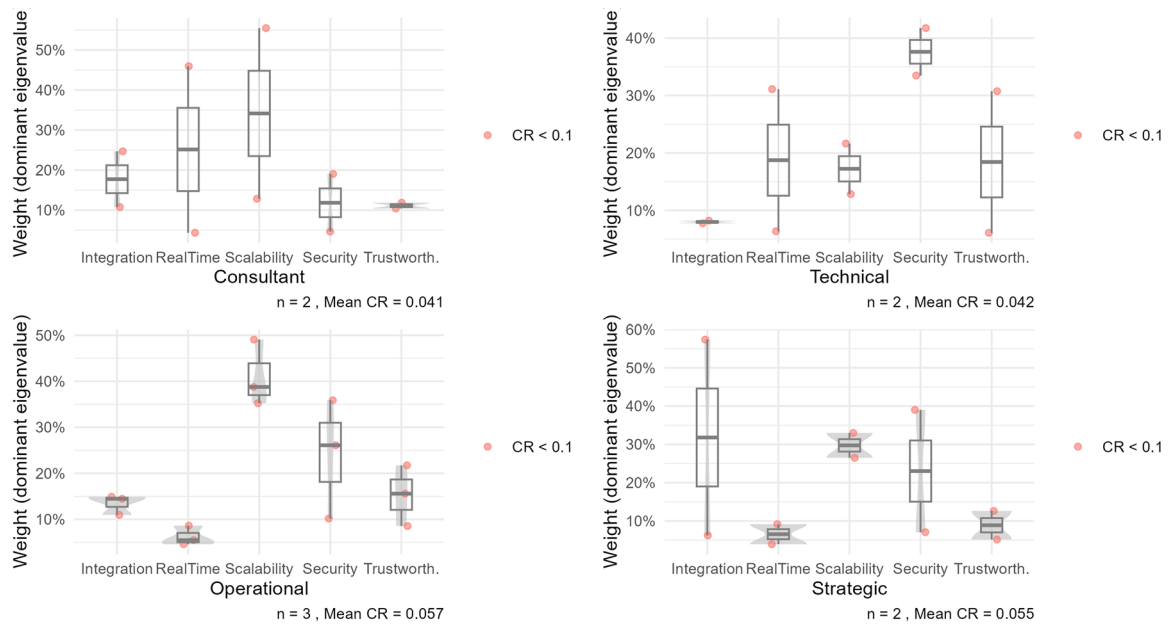


Figure 5. Distributions of individual priorities across the four stakeholder groups (technical criteria; dominant eigenvalue method).

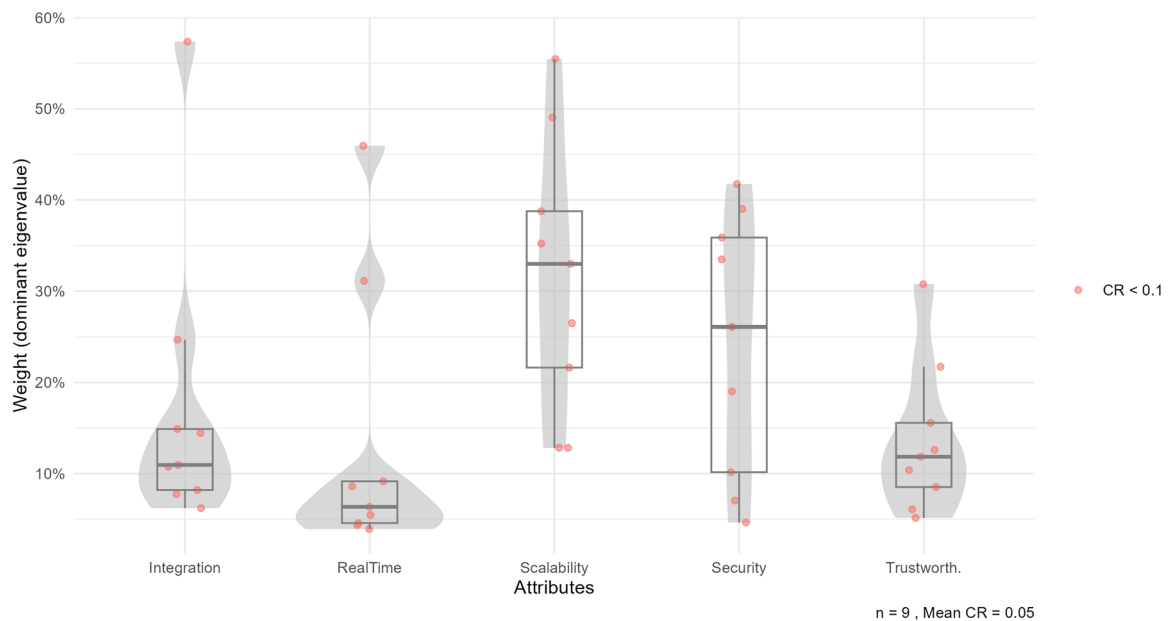


Figure 6. Global distributions of individual priorities (technical criteria; dominant eigenvalue method).

user data and ensuring safe transactions. Despite some variability among stakeholders, the moderate emphasis on security suggests a balanced approach to risk management, ensuring it does not overshadow scalability or other relevant project criteria.

Finally, the calculated weights for both levels were aggregated to produce the final weights, as shown in Table 3.

From Table 3, economic factors—specifically, the cost of the service—emerge as the most critical element in selecting an m-payment technology for the BOP. These are followed by the user base and scalability-related factors.

The final step involves assigning quantitative scores to each alternative. To ensure effective comparisons, we created linear and monotonic value functions (Edwards, 1977) and normalized the values using the Max-Min normalization technique, which is best suited for AHP (Vafaei et al., 2020). Scores ranged from 0 to 10.

The calculations for each criterion were as follows. The user base was estimated using data from providers' websites; for PayPal, due to the lack of Panamanian data, we estimated values based on its global user base weighted by Panama's population. Economic aspects were measured using service costs, commissions, and minimum fees obtained from company websites. Integration was defined by three levels of interoperability—open source (1), well-documented APIs (0.5), and no APIs (0). Scalability was based on the maximum number of transactions allowed. Security was defined by four levels of authentication methods, ranked from least to most secure: personal identification number (PIN, 0), password (1/3), two-factor authentication (2FA, 2/3) and biometric access (1). Trustworthiness was represented by a composite score using five equally weighed aspects: user rating (from app stores), the number of countries where the solution is present, whether it is backed by a bank, user financial protection availability, and the number of bank partners supporting the technology. Finally, real-time operation was measured using the maximum transaction processing time reported by vendors.

The research team conducted the scoring process using the objective data described above. Each criterion and sub-criterion were evaluated according to the established scoring framework to ensure consistency. An external expert with extensive experience in m-payment technologies reviewed the final results to validate the process's robustness and objectivity. The expert confirmed that the scoring was rigorous, aligned with best practices, and free of discrepancies or inconsistencies. Table 4 presents the normalized scores for each technology alternative, calculated based on the defined criteria and their respective weights.

After calculating the weights and value functions, the research team determined the overall priority of each m-payment technology alternative by computing the composite scores (Table 5). These results are discussed in the next section.

3.7. Usability testing

After evaluating all alternatives, the next step is to assess the usability of the main candidate(s). This process involves conducting a pilot study with end users, which is particularly important for BOP populations, as they often have low levels of digital literacy. Although this step could not be completed within the scope of this research, this limitation does not reduce the value of the current findings. The proposed methodology provides a robust framework for identifying the most suitable candidates based on stakeholder priorities, technical feasibility, and economic considerations. Usability testing should be considered a complementary step that builds on these findings to ensure the selected alternatives align with the practical and behavioral needs of the target population.

To conduct this step, researchers can employ simple and straightforward assessments, such as the System Usability Scale (Brooke, 1996). Although no consensus exists on what constitutes an acceptable

Table 3. Final aggregated weights of the decision criteria (arithmetic mean method).

Total	Userb	Econ	Integ	Scal	Sec	Trustw	RealT
Mean weight	0.214	0.395	0.067	0.124	0.095	0.054	0.052

Table 4. Scores for the different technology alternatives after normalization.

Criterion	Yappy	Nequi	Zinli	PayPal
User base	10.00	0.16	0.00	0.71
Economic	8.15	10.00	10.00	0.00
Integration	10.00	10.00	0.00	10.00
Scalability	0.00	0.00	0.00	0.00
Security	10.00	10.00	0.00	10.00
Trustworthiness	10.00	1.20	0.00	2.14
Real-time	10.00	10.00	10.00	0.00

Table 5. Final composite scores of the different m-payment alternatives.

	Yappy	Nequi	Zinli	PayPal
Score	8.03	6.38	4.47	1.89

SUS score, candidates scoring above 70 are generally considered good, while scores over 85 are considered desirable. Alternatives scoring below 70 should undergo further scrutiny and may be deemed marginal at best (Bangor et al., 2008). Evaluating the top two or three alternatives is generally recommended, particularly if the scores from the calculations explained in Section 3.6 showed minimal differences.

This phase naturally extends the current study and is essential for ensuring that the selected m-payment technology is technically and economically viable, as well as accessible and acceptable to the BOP population. By framing usability testing as a future step, this study establishes a foundation for further research that prioritizes user experience and long-term technology adoption.

4. Discussion of results

4.1. Main findings

This study emphasizes the need for tailored approaches when selecting m-payment technologies for the BOP. While two aspects—the selection criteria and their relative importance—may be generalizable to most contexts, the final technical decision remains highly specific to each case. In other words, although the methodology presented in this study seeks universality, no single technology can address the needs of all the BOP users. A comprehensive understanding of the local context is essential before making the final decision.

The development of the methodology highlights distinct decision areas that decision-makers must evaluate. The results indicate that stakeholders within the same groups often perform similar evaluations of the selection criteria's importance—for instance, technical staff prioritize technology-related aspects. Therefore, incorporating diverse stakeholders groups into the prioritization process is essential to achieve a balanced perspective on the relevance of each factor (Peykani et al., 2022). Engaging diverse stakeholders enables the methodology to address potential barriers and promote the adoption of m-payment technologies that are effective and aligned with BOP needs.

Interestingly, the study finds that strategic decision-makers prioritize technical aspects of m-payment technologies over economic considerations. To understand this result, the researchers consulted one of these stakeholders, who explained NGOs developing such projects often struggle to address technical challenges due to limited expertise. Conversely, they frequently implement economic measures to alleviate the financial burden on BOP users, such as partially or fully covering commission costs or negotiating cross-subsidies with local administrations.

The results reveal that scalability emerges as the most important technical selection criterion. This finding likely reflects the respondents' extensive experience with cooperation projects targeting BOP users. These projects typically begin as pilot initiatives—rather than addressing the entire BOP population in Panama, for example—and expand their reach upon demonstrating success. In this context, adopting a non-scalable solution could limit the effectiveness of NGO efforts, particularly from a long-term perspective.

The final selection results indicate that the best candidate is the most widely used m-payment technology in the country, backed by three major national banks. This endorsement likely enhances user familiarity and trust, even though its associated costs are slightly higher. The second option was another solution backed by one of the three largest banks—albeit owned by a foreign banking group—with cost advantages but a limited user base, which may hinder widespread acceptance. The third option was a local digital wallet offering lower security levels and limited integration capabilities, making it less suitable despite its local origin. Finally, PayPal, the most globally popular payment application, ranked as the least suitable candidate due to higher costs and the lack of local bank support. This outcome underscores the importance of affordability for BOP users and highlights how prohibitive costs can pose a significant barrier.

Overall, these findings highlight the importance of balancing cost, security, integration capabilities, and local support when selecting m-payment technologies. The results align with the concept of appropriate technologies—those that are affordable, simple, adaptable, sustainable for small-scale projects, and reliant on local resources (Del-Río-Carazo et al., 2021)—as offering superior suitability to the needs of the BOP.

4.2. Theoretical contributions

This research makes several theoretical contributions. First, it expands the literature on financial inclusion by focusing specifically on the BOP, a segment often overlooked in financial technology studies. Second, the study fills a critical gap by offering a structured process for selecting m-payment technologies tailored to the BOP. Third, it integrates user characteristics and context-specific factors into the selection process and identifies three main selection criteria from prior literature: user base, technical elements (with five sub-elements) and economic costs. The proposed methodology, therefore, offers a comprehensive framework for technology selection.

4.3. Managerial implications

The findings of this study have practical implications for managers, project promoters, and other stakeholders. The proposed methodology provides a clear framework for selecting technologies best suited to the BOP's needs. By focusing on user-centric factors and local contexts, and using the selection framework as a baseline, managers can facilitate the adoption and effectiveness of m-payment solutions while simultaneously increasing financial inclusion levels. For NGOs and development agencies, the methodology offers a strategic tool for designing and implementing financial inclusion programs that leverage mobile payments, ultimately contributing to poverty alleviation and economic development. Additionally, the initial analysis emphasizes that, whenever possible, m-payment apps should be prioritized over other technologies, except in cases where the technical infrastructure of data services imposes severe constraints.

Policymakers can leverage these insights to develop supportive regulatory frameworks that enable the deployment of m-payment technologies in underserved regions. This includes investing in technical infrastructure and implementing economic measures, such as establishing cross-subsidies or regulating tariffs for protected population segments, in collaboration with financial institutions.

The results suggest that m-payment solution developers and financial services providers should carefully consider the technical elements outlined in the methodology, prioritizing scalability and security for solutions targeting the BOP population. Additionally, local banks and developers can leverage their proximity and familiarity with the BOP population to gain a competitive edge.

4.4. Limitations and further research

This study has limitations, the most notable being the lack of data from the usability testing stage of the methodology. While we provided guidelines for conducting this step, insights directly obtained from BOP users would be invaluable for confirming and refining the analysis results. Nevertheless, this limitation does not diminish the value of the current findings, which offer a robust framework for evaluating m-payment technologies based on stakeholder priorities, technical feasibility, and economic factors. Usability testing should be treated as a complementary subsequent phase to ensure alignment with the practical and behavioral needs of the target population.

Another significant limitation concerns the information used in the prioritization stage. While AHP does not require a large number of participants and the study participants had extensive experience in BOP-related projects, the respondent pool included individuals who work on the same projects. Future research should aim to incorporate a larger and more diverse group of participants. Additionally, operational staff were slightly over-represented, with three respondents compared to two in the other stakeholder groups. Further research should explore whether this minor imbalance might have influenced the results.

By including diverse stakeholder groups in the analysis, this study provides a generalizable approach to selecting m-payment technologies for BOP users. The resulting weights from the analysis can be readily applied in different contexts, requiring only the evaluation of m-payment solutions during the selection process. However, further research is needed to validate the findings of this study.

Despite these limitations, the study's findings offer valuable insights into stakeholder priorities and the feasibility of m-payment technologies. The originality of this work lies in its methodological framework, which combines the AHP with criteria specifically tailored to the needs of BOP populations. By applying

this framework to the Ngäbe-Buglé context, the study demonstrates its practicality and potential for replication. However, as this application is context-specific, the results are not intended for generalization but rather serve as an illustrative example of the methodology's effectiveness. Future studies should validate and adapt this framework across diverse settings to evaluate its broader applicability.

5. Concluding remarks

The study develops a methodological framework based on the AHP, tailored to the unique needs and constraints of BOP populations. The originality of this work lies in adapting the AHP to include criteria relevant to financial inclusion, digital literacy, and infrastructure challenges, offering a structured approach to evaluating m-payment technologies for underserved communities. Applying this framework to the Ngäbe-Buglé region serves as an illustrative example, demonstrating its potential to enhance financial inclusion, facilitate access to essential services such as energy provision, and offer practicality and replicability in similar contexts. While the results provide valuable insights into stakeholder preferences and technology feasibility, they are not intended for generalization beyond this specific case. Future studies should apply the proposed methodology in diverse BOP settings to validate its effectiveness and explore its adaptability to other scenarios.

Although usability testing with BOP users was not conducted in this study, the methodology offers a robust framework for identifying the most suitable candidates based on technical, economic, and stakeholder priorities. Usability testing serves as a natural extension of this research and is critical for ensuring that the selected m-payment technology aligns with the practical and behavioral needs of the target population. Framing usability testing as a complementary step underscores the importance of the current findings as a foundational first phase in the decision-making process.

A key finding of this research is that no single optimal m-payment solution exists; the final decision must be based on a thorough understanding of the local context. The study underscores the importance of involving diverse stakeholder groups in the prioritization process to ensure a balanced, inclusive perspective on the key priorities for technology selection. It highlights how factors such as service costs, current technology adoption, scalability, and security can play decisive roles in the final acceptance of m-payment solutions by the BOP population. By offering both theoretical insights and practical guidelines, this study makes a significant contribution to ongoing efforts to bridge the financial inclusion gap, providing a viable pathway for practitioners in other developing regions.

Acknowledgements

An earlier version of this research was presented at IFKAD 2024, held in Madrid between June 12 and 14, 2024. We appreciate the constructive feedback received in this forum.

Author contributions

Carlos Cuenca-Enrique: Conceptualization, Formal analysis, Data curation, Validation, Writing original draft, Writing – review & editing. **Laura del-Río-Carazo:** Conceptualization, Formal analysis, Validation, Writing – review & editing. **Ignacio Elvira-Cruz:** Conceptualization, Data curation, Formal analysis, Writing – review & editing. **Ramón Fisac-García:** Validation, Writing – review & editing. All authors have approved the final manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

About the authors

Carlos Cuenca-Enrique is MSc in Telecommunication Engineering and Master in Business Administration (MBA) by Universidad Politécnica de Madrid (Spain). Currently, he is a PhD candidate at the UPM, and Lecturer at the Departamento de Ingeniería de Organización, Administración de Empresas y Estadística (Escuela Superior de Ingenieros de Telecomunicación, Universidad Politécnica de Madrid). His research interests include digital

transformation processes in access to universal basic services, with a focus on the sustainability of IT-based rural electrification interventions.

Laura Del-Río-Carazo holds a PhD in Economics and Innovation Management, an MSc in Telecommunication Engineering and an MBA by Universidad Politécnica de Madrid (Spain). She is Assistant Professor at the Departamento de Ingeniería de Organización, Administración de Empresas y Estadística (Escuela Superior de Ingenieros de Telecomunicación, Universidad Politécnica de Madrid). Her research interests include digital transformation processes in access to universal basic services.

Ignacio Elvira-Cruz holds a BSc degree in Telecommunication Technologies and Services Engineering by Universidad Politécnica de Madrid (Spain). He is currently pursuing a Dual Master's Degree Program in Telecommunication Engineering at Universidad Politécnica de Madrid, and in Information Technology and Management at the Illinois Institute of Technology in Chicago.

Ramón Fisac-García holds a PhD in Management Engineering (2014) from Universidad Politécnica de Madrid (UPM). In recent years, he has taught in postgraduate programs at various international universities and business schools. At ESCP, he serves as a Teaching Professor specializing in sustainability, entrepreneurship, and innovation. His research focuses on innovative business models, sustainable management, and frugal innovation.

ORCID

Carlos Cuenca-Enrique  <http://orcid.org/0000-0002-2024-7284>

Laura Del-Río-Carazo  <http://orcid.org/0000-0002-0947-3539>

Ignacio Elvira-Cruz  <http://orcid.org/0009-0007-5286-503X>

Ramón Fisac-García  <http://orcid.org/0000-0002-5024-827X>

Data availability statement

The data that support the findings of this study are available from the corresponding author, C.C.-E., upon reasonable request.

References

- Acciona.org. (2024). *Luz en casa Ngäbe-Buglé*. <https://www.acciona.org/es/Panama/luz-en-casa-ngabe-bugle/>
- Antovski, L., & Gusev, M. (2003). *M-payments*. Proceedings of the [Paper presentation]. International Conference on Information Technology Interfaces, ITI (pp. 95–100). <https://doi.org/10.1109/ITI.2003.1225328>
- Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology*, 8(1), 19–32. <https://doi.org/10.1080/1364557032000119616>
- Aziz, Q. (2006). *Payments through mobile phone* [Paper presentation]. Proceedings - 2nd International Conference on Emerging Technologies 2006, ICET 2006 (pp. 50–52). <https://doi.org/10.1109/ICET.2006.335987>
- Bandyopadhyay, S. (2021). Comparison among multi-criteria decision analysis techniques: a novel method. *Progress in Artificial Intelligence*, 10(2), 195–216. <https://doi.org/10.1007/s13748-021-00235-5>
- Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *International Journal of Human-Computer Interaction*, 24(6), 574–594. <https://doi.org/10.1080/10447310802205776>
- Belton, V., & Stewart, T. J. (2002). *Multiple criteria decision analysis*. Springer US. <https://doi.org/10.1007/978-1-4615-1495-4>
- Boku. (2021). *Mobile Wallets Report*. https://d15k2d11r6t6rl.cloudfront.net/public/users/Integrators/ca93d1a2-15c8-4dba-b10a-ca6349c6a6d1/ap-boku2/Boku - 2021 Mobile Wallets Report.pdf?utm_campaign=Mobile+Wallets+Report + 2021+Download&utm_medium=email&utm_source=autopilot
- Brooke, J. (1996). SUS: A "Quick and Dirty" usability scale. In P. W. Jordan, B. Thomas, I. L. McClelland, & B. Weerdmeester (Eds.), *Usability evaluation in industry*. CRC Press.
- Cecchini, S., Holz, R., & Mojica, A. R. (2020). *La matriz de la desigualdad social en Panamá 236 POLÍTICAS SOCIALES*. www.cepal.org/apps
- Chambers, B. (2020). *MobileIron research reveals QR codes pose significant security risks to enterprises and end users*. <https://www.businesswire.com/news/home/20200915005151/en/MobileIron-Research-Reveals-QR-Codes-Pose-Significant-Security-Risks-to-Enterprises-and-End-Users>
- Cho, F. (2018). Analytic hierarchy process for survey data in R. <https://doi.org/10.13140/RG.2.2.25278.13125>
- Comisión Nacional de los Mercados y la Competencia (CNMC). (2017). *El acceso universal a la energía. La electrificación rural aislada. Visión en Iberoamérica*. Editorial Aranzadi.
- Davis, F. D. (1989). Perceived usefulness, Perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- de Best, R. (2023). *Number of users of Alipay and WeChat Pay in China in 2020, with forecasts from 2021 to 2025*. <https://www.statista.com/statistics/1271130/mobile-wallet-user-forecast-in-china/>

- de Luna, I. R., Liébana-Cabanillas, F., Sánchez-Fernández, J., & Muñoz-Leiva, F. (2019). Mobile payment is not all the same: The adoption of mobile payment systems depending on the technology applied. *Technological Forecasting and Social Change*, 146, 931–944. <https://doi.org/10.1016/j.techfore.2018.09.018>
- Dean, M. (2022). *A practical guide to multi-criteria analysis*. University College London. <https://doi.org/10.13140/RG.2.2.15007.02722>
- Del-Río-Carazo, L., Cuenca-Enrique, C., Acquila-Natale, E., Iglesias-Pradas, S., Chaparro-Peláez, J., & Elvira-Cruz, I. (2024). Application based mobile payments technology selection: A scoping review. In J. Bautista Valhondo, M. Mateo Doll, A. Lusa García, & R. Pastor Moreno (Eds.), *17th International Conference on Industrial Engineering and Industrial Management (ICIEIM)? XXVII Congreso de Ingeniería de Organización (CIO2023) (ICIEIM-CIO2023)*. Springer.
- Del-Río-Carazo, L., Iglesias-Pradas, S., Acquila-Natale, E., & Martín-Fernández, J. G. (2021). Appropriate technology for access to universal basic services: A case study on basic electricity service provision to remote communities in the Napo River Basin. *Sustainability*, 14(1), 132. <https://doi.org/10.3390/su14010132>
- Demirgüç-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2021). *The global finindex database 2021: Financial inclusion, digital payments, and resilience in the age of COVID-19*. <https://www.worldbank.org/en/publication/globalindex/Data>
- Edwards, W. (1977). How to use multiattribute utility measurement for social decisionmaking. *IEEE Transactions on Systems, Man, and Cybernetics*, 7(5), 326–340. <https://doi.org/10.1109/TSMC.1977.4309720>
- Garcimartín, C., Astudillo, J., & Schneider, C. (2022). *Inclusion-financiera-en-Panamá.-La-importancia-de-la-calidad-institucional-y-las-brechas-territoriales-de-ingreso-y-de-genero*.
- Grand View Research . (2023). *QR code payment market size, share & trends analysis report by offerings, by solution, by payment type, by transaction channel, by end-user, by region, and segment forecasts, 2023 - 2030*. <https://www.grandviewresearch.com/industry-analysis/qr-code-payment-market-report>
- GSMA. (2024). *The state of the industry report on mobile money*.
- Guitouni, A., & Martel, J.-M. (1998). Tentative guidelines to help choosing an appropriate MCDA method. *European Journal of Operational Research*, 109(2), 501–521. [https://doi.org/10.1016/S0377-2217\(98\)00073-3](https://doi.org/10.1016/S0377-2217(98)00073-3)
- Guo, J., & Bouwman, H. (2016). An analytical framework for an m-payment ecosystem: A merchants' perspective. *Telecommunications Policy*, 40(2-3), 147–167. <https://doi.org/10.1016/j.telpol.2015.09.008>
- Haj, R. A. E. (2018). *Overcoming fragmentation-the payments platform challenge*.
- Hammond, A., & Prahalad, C. K. (2002). Serving the world's poor, profitably. *Harvard Business Review*, 80(9), 48–57, 124.
- Hasan, R., Liu, Y., Kitchen, P. J., & Rahman, M. (2019). Exploring consumer mobile payment adoption in the bottom-of-the-pyramid context: A qualitative study. *Strategic Change*, 28(5), 345–353. <https://doi.org/10.1002/jsc.2289>
- Hyman, V. (2023). *Your real-time guide to real-time payments*. <https://www.mastercard.com/news/perspectives/2023/real-time-payments-what-is-rtp-and-why-do-we-need-instant-payments/>
- INEC. (2023). *Resultados Finales Básicos XII Censo Nacional de Población y VIII de Vivienda 2023*. Instituto Nacional de Estadística y Censo - Panamá. Resultados Finales Básicos XII Censo Nacional de Población y VIII de Vivienda 2023
- Jagtap, S., & Kandachar, P. (2009). *Towards linking disruptive innovations and BOP markets*.
- Klapper, L. (2022). How “financial inclusion” can help lift millions of people out of poverty - on Radio Davos. <https://www.weforum.org/agenda/2022/09/financial-inclusion-findex-radio-davos-world-bank-economist/>
- Prensa, L. (2024). Yappy, Nequi, Zinli y Ahora Kuara Compiten en el Mercado de Los Pagos Digitales en Panamá, Yappy, Nequi, Zinli y ahora Kuara compiten en el mercado de los pagos digitales en Panamá.
- Lund, S., White, O., & Lamb, J. (2017). The value of digitalizing government payments in developing economies. Chapter 13.
- Makholwa, C., Budree, A., & Kabanda, S. (2020). Mobile financial services for bottom of pyramid users: Reality or pipe dream? *The Journal for Transdisciplinary Research in Southern Africa*, 16(1), a809, 1–10. <https://doi.org/10.4102/td.v16i1.809>
- Mallat, N., Tuunainen, V. K. (2008). Exploring merchant adoption of mobile payment systems: An empirical study. *E-Service Journal*, 6(2), 24. <https://doi.org/10.2979/esj.2008.6.2.24>
- Menezes, F. Z. (2022). *PicPay, Latin America's largest digital wallet, is now a bank*. <https://brazilian.report/liveblog/2022/07/13/picpay-digital-wallet-bank/#:~:text=PicPay%2C Latin America's largest digital wallet with over 62 million,to become a licensed bank>
- Nequi. (2024). *Somos Nequi*. <https://www.nequi.com.pa/somos-nequi>
- Peñuelas Peñarroya, A. (2022). Impacto de los celulares e internet en la movilidad de los indígenas ngäbe entre panamá y costa rica (2021-2022). *Odisea. Revista de Estudios Migratorios*, 9, 30–54.
- Pereira, J. (2023). *25+ SMS marketing statistics for 2023: Stats, Facts & Trends*. <https://startupbonsai.com/sms-marketing-statistics/>
- Peykani, P., Namazi, M., & Mohammadi, E. (2022). Bridging the knowledge gap between technology and business: An innovation strategy perspective. *PLOS One*, 17(4), e0266843. <https://doi.org/10.1371/journal.pone.0266843>
- Prahalad, C. K. (2004). *The fortune at the bottom of the pyramid: Eradicating poverty through profits*.
- Purnell, M. (2023). *QR code payments: Market expansion and high-growth areas*. <https://www.juniperresearch.com/blog/august-2023/qr-code-payments-market-expansion-growth>
- Ramík, J. (2020). Applications in decision-making: Analytic hierarchy process—AHP revisited. In *Pairwise Comparisons Method. Lecture Notes in Economics and Mathematical Systems* (vol. 690, pp. 189–211). Springer. https://doi.org/10.1007/978-3-030-39891-0_6

- Rasella, D., Aquino, R., Santos, C. A. T., Paes-Sousa, R., & Barreto, M. L. (2013). Effect of a conditional cash transfer programme on childhood mortality: A nationwide analysis of Brazilian municipalities. *Lancet (London, England)*, 382(9886), 57–64. [https://doi.org/10.1016/S0140-6736\(13\)60715-1](https://doi.org/10.1016/S0140-6736(13)60715-1)
- Rolfe, A. (2018). *PCM Report: Payment fragmentation is the “new normal” across all markets*. <https://www.paymentscardsandmobile.com/pcm-report-payment-fragmentation-is-the-new-normal-across-all-markets/>
- Saaty, T. L. (1980). *The analytic hierarchy process*. McGraw-Hill.
- Saaty, T. L. (2003). Decision-making with the AHP: Why is the principal eigenvector necessary. *European Journal of Operational Research*, 145(1), 85–91. [https://doi.org/10.1016/S0377-2217\(02\)00227-8](https://doi.org/10.1016/S0377-2217(02)00227-8)
- Saaty, T. L., & Vargas, L. G. (2012). *Models, methods. Concepts & applications of the analytic hierarchy process* (Vol. 175). Springer US. <https://doi.org/10.1007/978-1-4614-3597-6>
- Salehi, S., Miremadi, I., Ghasempour Nejati, M., & Ghafouri, H. (2024). Fostering the adoption and use of super app technology. *IEEE Transactions on Engineering Management*, 71, 4761–4775. <https://doi.org/10.1109/TEM.2023.3235718>
- SBP. (2021). *Informe de Bancarización 2021*.
- Simons, L. P. A., & Wiegel, V. (2009) *Evaluating AHP as multi-stakeholder decision tool* [Paper presentation]. 2009 IEEE International Technology Management Conference (ITMC) (pp. 1–9). <https://doi.org/10.1109/ITMC.2009.7461367>
- Statista Research Department. (2023). *Number of MTN Mobile Money (MoMo) active users from 2018 to 2023, by quarter*. [https://www.statista.com/statistics/1139539/mtn-mobile-money-active-accounts/#:~:text=MTN Mobile Money \(MoMo\) active,users 2018-2023%2C by quarter&text=As of the third quarter,compared to the previous quarter](https://www.statista.com/statistics/1139539/mtn-mobile-money-active-accounts/#:~:text=MTN Mobile Money (MoMo) active,users 2018-2023%2C by quarter&text=As of the third quarter,compared to the previous quarter)
- Tang, Y. M., Chau, K. Y., Hong, L., Ip, Y. K., & Yan, W. (2021). Financial innovation in digital payment with wechat towards electronic business success. *Journal of Theoretical and Applied Electronic Commerce Research*, 16(5), 1844–1861. <https://doi.org/10.3390/jtaer16050103>
- The World Bank. (2021). *Global Findex database 2021*. <https://www.worldbank.org/en/publication/globalindex/interactive-executive-summary-visualization>
- Vafaei, N., Ribeiro, R. A., & Camarinha-Matos, L. M. (2020). Selecting normalization techniques for the analytical hierarchy process. In: Camarinha-Matos, L., Farhadi, N., Lopes, F., Pereira, H. (eds), *Technological Innovation for Life Improvement. DoCEIS 2020. IFIP Advances in Information and Communication Technology* (vol. 577, pp. 43–52). Springer. https://doi.org/10.1007/978-3-030-45124-0_4
- Ver Loren van Themaat, T., Schutte, C. S. L., Lutters, D., & Kennon, D. (2013). Designing a framework to design a business model for the “bottom of the pyramid” population. *South African Journal of Industrial Engineering*, 24(3), 190–204. <https://doi.org/10.7166/24-3-633>
- World Bank Group. (2022). *Financial Inclusion*. <https://www.worldbank.org/en/topic/financialinclusion/overview>
- Yappy. (2024). *Benefícios*. <https://www.yappy.com.pa/comercial/beneficios/>
- Yasir, A., Ahmad, A., Abbas, S., Inairat, M., Al-Kassem, A. H., & Rasool, A. (2022) *How artificial intelligence is promoting financial inclusion? A study on barriers of financial inclusion* [Paper presentation]. International Conference on Business Analytics for Technology and Security, ICBATS 2022. <https://doi.org/10.1109/ICBATS54253.2022.9759038>
- Zhang, X., Li, J., Xiang, D., & Worthington, A. C. (2023). Digitalization, financial inclusion, and small and medium-sized enterprise financing: Evidence from China. *Economic Modelling*, 126, 106410. <https://doi.org/10.1016/j.econmod.2023.106410>